संघ, प्रदेश तथा स्थानिय लोकसेवा आयोग र संघसंस्थानको नयाँ पाठ्यक्रम अनुसार

(Complete Note)

(CIVIL SUB-ENGINEER AND ASS. SUB-ENGINEER)

Prepared By: Navin Bumi (Bumi Sir)

नेपाल इन्जिनियरिङ्ग सेवा, सिभिल समूह अन्तर्गतका जनरल, हाईवे, स्यानीटरी, इरिगेशन, हाइड्रोपावर, हाइड्रोलोजी र एयरपोर्ट
उप-समूह, राजपत्र अनंकित प्रथम श्रेणीका पदहरुको खुला प्रतियोगितात्मक परीक्षाको पाठ्यक्रम

यस पाठ्यक्रम योजनालाई दुई चरणमा विभाजन गरिएको छ :

प्रथम चरण :–	लिखित परीक्षा (Written Examination)	पूर्णाङ्क :– २००
द्वितीय चरण :-	अन्तर्वार्ता (Interview)	पूर्णाङ्क :– ३०

परीक्षा योजना (Examination Scheme)

प्रथम चरण : लिखित परीक्षा (Written Examination)   पूर्णाङ्क :– २००

पत्र	विषय	पूर्णाङ्क	उर्तीणाङ्क	परीक्षा प्रणाली		प्रश्नसंख्या ×अङ्क	समय
प्रथम	सामान्य ज्ञान र सार्वजनिक व्यवस्थापन (General Awareness & Public Management)	१००	४०	वस्तुगत (Objective)	बहुवैकल्पिक प्रश्न (MCQs)	२० प्रश्न ×२ अङ्क	४५ मिनेट
	सेवा सम्बन्धित कार्य-ज्ञान (Job Based - knowledge)					३० प्रश्न ×२ अङ्क	
द्वितीय	सेवा सम्बन्धित कार्य-ज्ञान (Job Based - knowledge)	१००	४०	विषयगत (Subjective)	छोटो उत्तर (Short Answer) लामो उत्तर (Long Answer)	१२ प्रश्न × ५ अङ्क ४ प्रश्न ×१० अङ्क	२ घण्टा १५ मिनेट

द्वितीय चरण : अन्तर्वार्ता (Interview)   पूर्णाङ्क :– ३०

पत्र / विषय	पूर्णाङ्क	उर्तीणाङ्क	परीक्षा प्रणाली
अन्तर्वार्ता (Interview)	३०		मौखिक (Oral)

द्रष्टव्य :

१. यो पाठ्यक्रमको योजनालाई प्रथम चरण र द्वितीय चरण गरी दुई चरणमा विभाजन गरिएको छ ।

२. लिखित परीक्षाको प्रश्नपत्रको माध्यम भाषा पाठ्यक्रमको विषयवस्तु जुन भाषामा दिइएको छ सोही भाषाको आधारमा नेपाली वा अंग्रेजी मध्ये कुनै एक मात्र भाषा हुनेछ । तर विषयवस्तुलाई स्पष्ट गर्नुपर्ने अवस्थामा दुवै भाषा समेत प्रयोग सकिने छ ।

३. लिखित परीक्षाको माध्यम भाषा नेपाली वा अंग्रेजी अथवा नेपाली र अंग्रेजी दुवै हुनेछ ।

४. प्रथम पत्र र द्वितीय पत्रको लिखित परीक्षा छुट्टाछुट्टै हुनेछ । तर एकैदिनमा परीक्षा लिइनेछ ।

५. वस्तुगत बहुवैकल्पिक (Multiple Choice) प्रश्नको गलत उत्तर दिएमा प्रत्येक गलत उत्तर बापत २० प्रतिशत अङ्क कट्टा गरिनेछ । तर उत्तर नदिएमा त्यस बापत अङ्क दिइने छैन र अङ्क कट्टा पनि गरिने छैन ।

६. वस्तुगत बहुवैकल्पिक हुने परीक्षामा परीक्षार्थीले उत्तर लेख्दा अंग्रेजी ठूलो अक्षरहरु (Capital letters): A, B, C, D मा लेख्नुपर्नेछ । सानो अक्षरहरू (Small letters): a, b, c, d लेखेको वा अन्य कुनै सङ्केत गरेको भए सबै उत्तरपुस्तिका रद्द हुनेछ ।

७. बहुवैकल्पिक प्रश्न हुने परीक्षामा कुनै प्रकारको क्याल्कुलेटर (Calculator) प्रयोग गर्न पाइने छैन ।

८. विषयगत प्रश्नहरुको हकमा तोकिएको अंकको एउटा लामो प्रश्न वा एउटै प्रश्नका दुई वा दुईभन्दा बढी भाग (Two or more parts of a single question) वा एउटा प्रश्न अन्तर्गत दुई वा बढी टिप्पणीहरू (Short notes) सोध्न सकिने छ ।

९. विषयगत प्रश्न हुनेका हकमा प्रत्येक खण्डका लागि छुट्टाछुट्टै उत्तरपुस्तिकाहरू हुनेछन् । परिक्षार्थीले प्रत्येक खण्डका प्रश्नको उत्तर सोहीखण्डको उत्तरपुस्तिकामा लेख्नुपर्नेछ ।

१०. परीक्षामा सोधिने प्रश्नसंख्या, अङ्क र अङ्कभार यथासम्भव सम्बन्धित पत्र ∕विषयमा दिइए अनुसार हुनेछ ।

लोक सेवा आयोग

नेपाल इञ्जिनियरिङ्ग सेवा, सिभिल समूह अन्तर्गतका जनरल, हाईवे, स्यानीटरी, इरिगेशन, हाइड्रोपावर, हाइड्रोलोजी र एयरपोर्ट उप-समूह, राजपत्र अनंकित प्रथम श्रेणीका पदहरुको खुला प्रतियोगितात्मक परीक्षाको पाठ्यक्रम

११. यस पाठ्यक्रम योजना अन्तर्गतका पत्र/विषयका विषयवस्तुमा जेसुकै लेखिएको भए तापनि पाठ्यक्रममा परेका कानून, ऐन, नियम तथा नीतिहरू परीक्षाको मिति भन्दा ३ महिना अगाडि (संशोधन भएका वा संशोधन भई हटाईएका वा थप गरी संशोधन भई) कायम रहेकालाई यस पाठ्यक्रममा परेको सम्झनु पर्दछ ।

१२. प्रथम चरणको परीक्षाबाट छनोट भएका उम्मेदवारलाई मात्र द्वितीय चरणको परीक्षामा सम्मिलित गराइनेछ ।

१३. यस भन्दा अगाडि लागू भएको माथि उल्लेखित सेवा, समूहको पाठ्यक्रम खारेज गरिएको छ ।

१४. **पाठ्यक्रम लागू मिति : - २०८०/१०/२२**

नेपाल इन्जिनियरिङ्ग सेवा, सिभिल समूह अन्तर्गतका जनरल, हाईवे, स्यानीटरी, इरिगेशन, हाइड्रोपावर, हाइड्रोलोजी र एयरपोर्ट उप-समूह, राजपत्र अनंकित प्रथम श्रेणीका पदहरुको खुला प्रतियोगितात्मक परीक्षाको पाठ्यक्रम

प्रथम पत्र (Paper I) :-
सामान्य ज्ञान र सार्वजनिक व्यवस्थापन तथा सेवा सम्बन्धित कार्य-ज्ञान
भाग (Part I) :
सामान्य ज्ञान र सार्वजनिक व्यवस्थापन
(General Awareness and Public Management)

खण्ड (Section - A) : (१० प्रश्न× २ अङ्क = २० अङ्क)

1. **सामान्य ज्ञान (General Awareness)**
   1.1 नेपालको भौगोलिक अवस्था, प्राकृतिक स्रोत र साधनहरू
   1.2 नेपालको ऐतिहासिक, सांस्कृतिक र सामाजिक अवस्था सम्बन्धी जानकारी
   1.3 नेपालको आर्थिक अवस्था र चालु आवद्धिक योजना सम्बन्धी जानकारी
   1.4 जैविक विविधता, दिगो विकास, वातावरण, प्रदुषण, जलवायु परिवर्तन र जनसंख्या व्यवस्थापन
   1.5 मानव जीवनमा प्रत्यक्ष प्रभाव पार्ने विज्ञान र प्रविधिका महत्वपूर्ण उपलब्धिहरू
   1.6 जनस्वास्थ्य, रोग, खाद्य र पोषण सम्बन्धी सामान्य जानकारी
   1.7 नेपालको संविधान (भाग १ देखि ५ सम्म र अनुसूचीहरू)
   1.8 संयुक्त राष्ट्रसंघ र यसका विशिष्टीकृत संस्था सम्बन्धी जानकारी
   1.9 क्षेत्रीय संगठन (सार्क, बिमस्टेक, आसियान र युरोपियन संघ) सम्बन्धी जानकारी
   1.10 राष्ट्रिय र अन्तर्राष्ट्रिय महत्वका समसामायिक गतिविधिहरू

खण्ड (Section - B) : (१० प्रश्न× २ अङ्क = २० अङ्क)

2. **सार्वजनिक व्यवस्थापन (Public Management)**
   2.1 कार्यालय व्यवस्थापन (Office Management)
       2.1.1 कार्यालय (Office) : परिचय, महत्व, कार्य र प्रकार
       2.1.2 सहायक कर्मचारीका कार्य र गुणहरु
       2.1.3 कार्यालय स्रोत साधन (Office Resources): परिचय र प्रकार
       2.1.4 कार्यालयमा सञ्चारको महत्व, किसिम र साधन
       2.1.5 कार्यालय कार्यविधि (Office Procedure) : पत्र व्यवहार (Correspondence), दर्ता र चलानी (Registration & Dispatch), फाइलिङ (Filing), परिपत्र (Circular), तोक आदेश (Order), टिप्पणी लेखन र टिप्पणी तयार पार्दा ध्यान दिनुपर्ने कुराहरू
       2.1.6 अभिलेख व्यवस्थापन (Record Management)
   2.2 निजामती सेवा ऐन र नियमावलीमा भएका देहायका व्यवस्थाहरू
       2.2.1 निजामती सेवाको गठन, संगठन संरचना, पदपूर्ति गर्ने तरिका र प्रक्रियाहरू
       2.2.2 कर्मचारीको नियुक्ति, सरुवा, बढुवा, बिदा, विभागीय सजाय र अवकाश
       2.2.3 कर्मचारीले पालन गर्नुपर्ने आचरण, नैतिक दायित्व र कर्तव्यहरू
   2.3 संघीय मामिला तथा सामान्य प्रशासन मन्त्रालय सम्बन्धी जानकारी
   2.4 संवैधानिक निकाय सम्बन्धी जानकारी
   2.5 सरकारी बजेट, लेखा र लेखापरीक्षण प्रणाली सम्बन्धी सामान्य जानकारी
   2.6 सार्वजनिक सेवा प्रवाहको अर्थ, सेवा प्रवाह गर्ने निकाय, तरिका र माध्यमहरू
   2.7 मानव अधिकार, सुशासन र सूचनाको हक सम्बन्धी सामान्य जानकारी
   2.8 सार्वजनिक बडापत्र (Public Charter)
   2.9 व्यवस्थापनको अवधारणा तथा सार्वजनिक व्यवस्थापनमा निर्देशन, नियन्त्रण, समन्वय, निर्णय प्रक्रिया, उत्प्रेरणा र नेतृत्व सम्बन्धी जानकारी
   2.10 मानवीय मूल्य मान्यता (Human Values), नागरिक कर्तव्य र दायित्व तथा अनुशासन

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भाग (Part II) :-
सेवा सम्बन्धित कार्य-ज्ञान (Job Based - Knowledge)
(३० प्रश्न× २ अङ्क = ६० अङ्क)

1. **Surveying**
   1.1 General
      1.1.1 Classifications
      1.1.2 Principle of surveying
      1.1.3 Selection of suitable method
      1.1.4 Scales, plans and maps
      1.1.5 Entry into survey field books and level books
   1.2 Levelling
      1.2.1 Methods of levelling
      1.2.2 Levelling instruments and accessories
      1.2.3 Principles of levelling
   1.3 Plane Tabling
      1.3.1 Equipments required
      1.3.2 Methods of palne tabling
      1.3.3 Two and three point problems
   1.4 Theodolite and Traverse surveying
      1.4.1 Basic difference between different theodolites
      1.4.2 Temporary adjustments of theodolites
      1.4.3 Fundamental lines and desired relations
      1.4.4 Tacheometry: stadia method
      1.4.5 Trigonometrical levelling
      1.4.6 Checks in closed traverse
   1.5 Contouring
      1.5.1 Characteristics of contour lines
      1.5.2 Method of locating contours
      1.5.3 Contour plotting
   1.6 Setting Out
      1.6.1 Small buildings
      1.6.2 Simple curves

2. **Construction Materials**
   2.1 Stone
      2.1.1 Formation and availability of stones in Nepal
      2.1.2 Methods of laying and construction with various stones
   2.2 Cement
      2.2.1 Different cements: Ingredients, properties and manufacture
      2.2.2 Storage and transport
      2.2.3 Admixtures
   2.3 Clay and Clay Products
      2.3.1 Brick: type, manufacture, laying, bonds
   2.4 Paints and Varnishes
      2.4.1 Type and selection
      2.4.2 Preparation techniques
      2.4.3 Use
   2.5 Bitumen
      2.5.1 Type

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2.5.2   Selection
2.5.3   Use

3. Mechanics of Materials and Structures
3.1   Mechanics of Materials
   3.1.1   Internal effects of loading
   3.1.2   Ultimate strength and working stress of materials
3.2   Mechanics of Beams
   3.2.1   Shear force and bending moment
   3.2.2   Thrust, shear and bending moment diagrams for statically determinate beams under various types of loading
3.3   Simple Strut Theory

4. Hydraulics
4.1   General
   4.1.1   Properties of fluid: mass, weight, specific weight, density, specific volume, specific gravity, viscosity
   4.1.2   Pressure and Pascal's law
4.2   Hydro-Kinematics and Hydro-Dynamics
   4.2.1   Energy of flowing liquid: Kinetic energy, potential energy, internal energy
4.3   Measurement of Discharge
   4.3.1   Weirs and notches
   4.3.2   Discharge formulas
4.4   Flows
   4.4.1 Characteristics of pipe flow and open channel flow

5. Soil Mechanics
5.1   General
   5.1.1   Soil types and classification
   5.1.2   Three phase system of soil
   5.1.3   Unit Weight of soil mass: bulk density, saturated density, submerged density and dry density
   5.1.4   Interrelationship between specific gravity, void ratio, porosity, degree of saturation, percentage of air voids air content and density index
5.2   Soil Water Relation
   5.2.1   Terzaghi's principle of effective stress
   5.2.2   Darcy's law
   5.2.3   Factors affecting permeability
5.3   Compaction of soil
   5.3.1   Factors affecting soil compaction
   5.3.2   Optimum moisture content
   5.3.3   Relation between dry density and moisture content
5.4   Shear Strength of Soils
   5.4.1   Mohr-Coulomb failure theory
   5.4.2   Cohesion and angle of internal friction
5.5   Earth Pressures
   5.5.1   Active and passive earth pressures
   5.5.2   Lateral earth pressure theory
   5.5.3   Rankine's earth pressure theory
5.6   Foundation Engineering

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नेपाल इन्जिनियरिङ सेवा, सिभिल समूह अन्तर्गतका जनरल, हाईवे, स्यानीटरी, इरिगेशन, हाइड्रोपावर, हाइड्रोलोजी र एयरपोर्ट उप-समूह, राजपत्र अनंकित प्रथम श्रेणीका पदहरुको खुला प्रतियोगितात्मक परीक्षाको पाठ्यक्रम

        5.6.1   Terzaghi's general bearing capacity formulas and their application

6. Structural Design
6.1 R.C. Sections in Bending
    6.1.1   Under reinforced, over reinforced and balanced sections
    6.1.2   Analysis of single and double reinforced rectangular sections
6.2 Shear and Bond for R.C. Sections
    6.2.1   Shear resistance of a R.C. section
    6.2.2   Types of Shear reinforcement and their design
    6.2.3   Determination of anchorage length
6.3 Axially Loaded R.C. Columns
    6.3.1   Short and long columns
    6.3.2   Design of a rectangular column section
6.4 Design and Drafting of R.C. Structures
    6.4.1   Singly and doubly reinforced rectangular beams
    6.4.2   Simple one-way and two-way slabs
    6.4.3   Axially loaded short and long columns

7. Building Construction Technology
7.1 Foundations
    7.1.1   Subsoil exploration
    7.1.2   Type and suitability of different foundations: Shallow, deep
    7.1.3   Shoring and dewatering
    7.1.4   Design of simple brick or stone masonry foundations
7.2 Walls
    7.2.1   Type of walls and their functions
    7.2.2   Choosing wall thickness, Height to length relation
    7.2.3   Use of scaffolding
7.3 Damp Proofing
    7.3.1   Source of Dampness
    7.3.2   Remedial measures to prevent dampness
7.4 Concrete Technology
    7.4.1   Constituents of cement concrete
    7.4.2   Grading of aggregates
    7.4.3   Concrete mixes
    7.4.4   Water cement ratio
    7.4.5   Factors affecting strength of concrete
    7.4.6   Form work
    7.4.7   Curing
7.5 Wood work
    7.5.1   Frame and shutters of door and window
    7.5.2   Timber construction of upper floors
    7.5.3   Design and construction of stairs
7.6 Flooring and Finishing
    7.6.1   Floor finishes: brick, concrete, flagstone
    7.6.2   Plastering

8. Water Supply and Sanitation Engineering
8.1 General
    8.1.1   Objectives of water supply system

8.1.2 Source of water and its selection: gravity and artesian springs, shallow and deep wells; infiltration galleries.
8.2 Gravity Water Supply System
   8.2.1 Design period
   8.2.2 Determination of daily water demand
   8.2.3 Determination of storage tank capacity
   8.2.4 Selection of pipe
   8.2.5 Pipe line design and hydraulic grade line
8.3 Design of Sewer
   8.3.1 Quantity of sanitary sewage
   8.3.2 Maximum, Minimum and self cleaning velocity
8.4 Excreta Disposal and Unsewered Area
   8.4.1 Pit latrine
   8.4.2 Design of septic tank

9. Irrigation Engineering
9.1 General
   9.1.1 Advantages and Disadvantages of irrigation
9.2 Crop Water Requirement
   9.2.1 Crop season and crop water requirement for principal crops
   9.2.2 Duty delta and base period
9.3 Irrigation Canals
   9.3.1 Canal losses and their minimization
   9.3.2 Maximum and minimum velocities
   9.3.3 Design of irrigation canal section using Manning's formula
   9.3.4 Need and location of weir/barrage
   9.3.5 Head works for small canals

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10.1 General
   10.1.1 Introduction to transportation systems
   10.1.2 Historic development of roads in Nepal
   10.1.3 Classification of road in Nepal
   10.1.4 Basic requirements of road alignment
10.2 Geometric Design
   10.2.1 Basic design control and criteria for design
   10.2.2 Elements of cross section, typical cross-section for all roads in filling and cutting
   10.2.3 Camber
   10.2.4 Determination of radius of horizontal curves
   10.2.5 Super elevation
   10.2.6 Sight distances
   10.2.7 Gradient
   10.2.8 Use of Nepal Road Standard and subsequent revision in road design
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   10.3.1 Importance of drainage system and requirements of a good drainage system
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   10.4.1 Pavement structure and its components: subgrade, sub-base, base and surface courses
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10.5.1 Earth moving and compacting machines
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    10.7.1 T-beam bride
    10.7.2 Timber bridges
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    10.8.1 Type of maintenance Works
10.9 Tracks and Trails

11. Estimating and Costing

11.1 General
    11.1.1 Main items of work
    11.1.2 Units of measurement and payment of various items of work and material
    11.1.3 Standard estimate formats of government offices
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    11.2.1 Basic general knowledge on the use of rate analysis norms of Government of Nepal and approved district rates
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    11.3.1 Interpretation of specifications
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    11.4.1 Methods of valuation
    11.4.2 Basic general knowledge of standard formats used by commercial banks and NIDC for valuation

12. Construction Management

12.1 Organization
    12.1.1 Need for organization
    12.1.2 Responsibilities of a civil sub-engineer
    12.1.3 Relation between Owner, Contractor and Engineer
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    12.2.1 Preparation of site plan
    12.2.2 Organizing labor
    12.2.3 Measures to improve labor efficiency
    12.2.4 Accident prevention
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    12.3.1 Contracts
    12.3.2 Force account and day- works
    12.3.3 Types of contracts
    12.3.4 Tender and tender notice
    12.3.5 Bid security
    12.3.6 Preparation before inviting tender
    12.3.7 Agreement
    12.3.8 Conditions of contract
    12.3.9 Construction supervision
12.4 Accounts
    12.4.1 Administrative approval and technical sanction
    12.4.2 Familiarity with standard account keeping formats used in governmental organizations
    12.4.3 Muster roll

12.4.4 Completion report

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12.5.1 Construction schedule
12.5.2 Equipment and materials schedule
12.5.3 Construction stages and operations
12.5.4 Bar chart

13. Airport Engineering
13.1 General
13.1.1 Introduction to Air Transport System
13.1.2 Historic development of Airports in Nepal
13.1.3 Classification of Airports
13.1.4 Airport terminologies
13.2 Design
13.2.1 Basic design control and criteria for design
13.2.2 General items contained in ANNEX 14 (ICAO Publication)
13.2.3 Planning of Airport and its elements
13.2.4 Terminal Building and Control Tower
13.2.5 Drainage System
13.2.6 Geometric design, pavement structure and its component
13.2.7 Basic knowledge of Heliport and Hangers
13.3 Airport Maintenance
13.3.1 Types of maintenance
13.3.2 Methods of maintenance

प्रथम पत्रको लागि यथासम्भव निम्नानुसार प्रश्नहरू सोधिने छ ।

भाग	खण्ड	विषयबस्तु	परीक्षा प्रणाली	अङ्कभार	प्रश्न संख्या × अङ्क
प्रथम पत्र (वस्तुगत)					
I	**(A)**	सामान्य ज्ञान (General Awareness)	बहुवैकल्पिक प्रश्न (MCQs)	२०	१० प्रश्न × २ अङ्क = २०
	(B)	सार्वजनिक व्यवस्थापन (Public Management)		२०	१० प्रश्न × २ अङ्क = २०
II	-	सेवा सम्बन्धित कार्य-ज्ञान (Job Based -knowledge)		६०	३० प्रश्न × २ अङ्क = ६०

प्रथम पत्रको **भाग (Part II)** सेवा सम्बन्धित कार्य-ज्ञान (Job based -knowledge) को पाठ्यक्रमका इकाईबाट परीक्षामा यथासम्भव देहाय बमोजिम प्रश्नहरू सोधिने छ ।

इकाई	1	2	3	4	5	6	7	8	9	10	11	12	13
प्रश्न संख्या	3	3	3	3	2	2	2	2	2	2	2	2	2

द्वितीय पत्र (Paper II) :-
सेवा सम्बन्धित कार्य-ज्ञान (Job Based -Knowledge)
खण्ड (Section) (A) : - ५० अङ्क

1. **Surveying**
   1.1 General
      1.1.1 Classifications
      1.1.2 Principle of surveying
      1.1.3 Selection of suitable method
      1.1.4 Scales, plans and maps
      1.1.5 Entry into survey field books and level books
   1.2 Levelling
      1.2.1 Methods of levelling
      1.2.2 Levelling instruments and accessories
      1.2.3 Principles of levelling
   1.3 Plane Tabling
      1.3.1 Equipments required
      1.3.2 Methods of palne tabling
      1.3.3 Two and three point problems
   1.4 Theodolite and Traverse surveying
      1.4.1 Basic difference between different theodolites
      1.4.2 Temporary adjustments of theodolites
      1.4.3 Fundamental lines and desired relations
      1.4.4 Tacheometry: stadia method
      1.4.5 Trigonometrical levelling
      1.4.6 Checks in closed traverse
   1.5 Contouring
      1.5.1 Characteristics of contour lines
      1.5.2 Method of locating contours
      1.5.3 Contour plotting
   1.6 Setting Out
      1.6.1 Small buildings
      1.6.2 Simple curves

2. **Construction Materials**
   2.1 Stone
      2.1.1 Formation and availability of stones in Nepal
      2.1.2 Methods of laying and construction with various stones
   2.2 Cement
      2.2.1 Different cements: Ingredients, properties and manufacture
      2.2.2 Storage and transport
      2.2.3 Admixtures
   2.3 Clay and Clay Products
      2.3.1 Brick: type, manufacture, laying, bonds
   2.4 Paints and Varnishes
      2.4.1 Type and selection
      2.4.2 Preparation techniques
      2.4.3 Use
   2.5 Bitumen
      2.5.1 Type

लोक सेवा आयोग

नेपाल इञ्जिनियरिङ्ग सेवा, सिभिल समूह अन्तर्गतका जनरल, हाईवे, स्यानीटरी, इरिगेशन, हाइड्रोपावर, हाइड्रोलोजी र एयरपोर्ट उप-समूह, राजपत्र अनंकित प्रथम श्रेणीका पदहरुको खुला प्रतियोगितात्मक परीक्षाको पाठ्यक्रम

   2.5.2 Selection

   2.5.3 Use

3. Mechanics of Materials and Structures

 3.1 Mechanics of Materials

   3.1.1 Internal effects of loading

   3.1.2 Ultimate strength and working stress of materials

 3.2 Mechanics of Beams

   3.2.1 Shear force and bending moment

   3.2.2 Thrust, shear and bending moment diagrams for statically determinate beams under various types of loading

 3.3 Simple Strut Theory

4. Hydraulics

 4.1 General

   4.1.1 Properties of fluid: mass, weight, specific weight, density, specific volume, specific gravity, viscosity

   4.1.2 Pressure and Pascal's law

 4.2 Hydro-Kinematics and Hydro-Dynamics

   4.2.1 Energy of flowing liquid: Kinetic energy, potential energy, internal energy

 4.3 Measurement of Discharge

   4.3.1 Weirs and notches

   4.3.2 Discharge formulas

 4.4 Flows

   4.4.1 Characteristics of pipe flow and open channel flow

5. Soil Mechanics

 5.1 General

   5.1.1 Soil types and classification

   5.1.2 Three phase system of soil

   5.1.3 Unit Weight of soil mass: bulk density, saturated density, submerged density and dry density

   5.1.4 Interrelationship between specific gravity, void ratio, porosity, degree of saturation, percentage of air voids air content and density index

 5.2 Soil Water Relation

   5.2.1 Terzaghi's principle of effective stress

   5.2.2 Darcy's law

   5.2.3 Factors affecting permeability

 5.3 Compaction of soil

   5.3.1 Factors affecting soil compaction

   5.3.2 Optimum moisture content

   5.3.3 Relation between dry density and moisture content

 5.4 Shear Strength of Soils

   5.4.1 Mohr-Coulomb failure theory

   5.4.2 Cohesion and angle of internal friction

 5.5 Earth Pressures

   5.5.1 Active and passive earth pressures

   5.5.2 Lateral earth pressure theory

   5.5.3 Rankine's earth pressure theory

 5.6 Foundation Engineering

      5.6.1   Terzaghi's general bearing capacity formulas and their application

6. Structural Design
  6.1 R.C. Sections in Bending
      6.1.1   Under reinforced, over reinforced and balanced sections
      6.1.2   Analysis of single and double reinforced rectangular sections
  6.2 Shear and Bond for R.C. Sections
      6.2.1   Shear resistance of a R.C. section
      6.2.2   Types of Shear reinforcement and their design
      6.2.3   Determination of anchorage length
  6.3 Axially Loaded R.C. Columns
      6.3.1   Short and long columns
      6.3.2   Design of a rectangular column section
  6.4 Design and Drafting of R.C. Structures
      6.4.1   Singly and doubly reinforced rectangular beams
      6.4.2   Simple one-way and two-way slabs
      6.4.3   Axially loaded short and long columns

<div align="center">

खण्ड (Section) (B) : - ५० अङ्क

</div>

7. Building Construction Technology
  7.1 Foundations
      7.1.1   Subsoil exploration
      7.1.2   Type and suitability of different foundations: Shallow, deep
      7.1.3   Shoring and dewatering
      7.1.4   Design of simple brick or stone masonry foundations
  7.2 Walls
      7.2.1   Type of walls and their functions
      7.2.2   Choosing wall thickness, Height to length relation
      7.2.3   Use of scaffolding
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      7.4.1   Constituents of cement concrete
      7.4.2   Grading of aggregates
      7.4.3   Concrete mixes
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      7.5.1   Frame and shutters of door and window
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    8.1.1 Objectives of water supply system

    8.1.2 Source of water and its selection: gravity and artesian springs, shallow and deep wells; infiltration galleries.

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    8.2.1 Design period

    8.2.2 Determination of daily water demand

    8.2.3 Determination of storage tank capacity

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    8.4.2 Design of septic tank

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    9.2.1 Crop season and crop water requirement for principal crops

    9.2.2 Duty delta and base period

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    9.3.1 Canal losses and their minimization

    9.3.2 Maximum and minimum velocities

    9.3.3 Design of irrigation canal section using Manning's formula

    9.3.4 Need and location of weir/barrage

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10.1 General

    10.1.1 Introduction to transportation systems

    10.1.2 Historic development of roads in Nepal

    10.1.3 Classification of road in Nepal

    10.1.4 Basic requirements of road alignment

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    10.2.1 Basic design control and criteria for design

    10.2.2 Elements of cross section, typical cross-section for all roads in filling and cutting

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    10.2.4 Determination of radius of horizontal curves

    10.2.5 Super elevation

    10.2.6 Sight distances

    10.2.7 Gradient

    10.2.8 Use of Nepal Road Standard and subsequent revision in road design

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    10.3.1 Importance of drainage system and requirements of a good drainage system

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       10.4.1 Pavement structure and its components: subgrade, sub-base, base and surface courses
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  - 10.5.1 Earth moving and compacting machines
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  - 10.8.1 Type of maintenance Works
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  - 11.1.3 Standard estimate formats of government offices
- 11.2 Rate Analysis
  - 11.2.1 Basic general knowledge on the use of rate analysis norms of Government of Nepal and approved district rates
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  - 12.1.2 Responsibilities of a civil sub-engineer
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  - 12.2.3 Measures to improve labor efficiency
  - 12.2.4 Accident prevention
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  - 12.3.2 Force account and day- works
  - 12.3.3 Types of contracts
  - 12.3.4 Tender and tender notice
  - 12.3.5 Bid security
  - 12.3.6 Preparation before inviting tender
  - 12.3.7 Agreement
  - 12.3.8 Conditions of contract
  - 12.3.9 Construction supervision
- 12.4 Accounts
  - 12.4.1 Administrative approval and technical sanction

लोक सेवा आयोग

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उप-समूह, राजपत्र अनंकित प्रथम श्रेणीका पदहरुको खुला प्रतियोगितात्मक परीक्षाको पाठ्यक्रम

12.4.2 Familiarity with standard account keeping formats used in governmental organizations
12.4.3 Muster roll
12.4.4 Completion report

12.5 Planning and Control
12.5.1 Construction schedule
12.5.2 Equipment and materials schedule
12.5.3 Construction stages and operations
12.5.4 Bar chart

13. **Airport Engineering**
13.1 General
13.1.1 Introduction to Air Transport System
13.1.2 Historic development of Airports in Nepal
13.1.3 Classification of Airports
13.1.4 Airport terminologies
13.2 Design
13.2.1 Basic design control and criteria for design
13.2.2 General items contained in ANNEX 14 (ICAO Publication)
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द्वितीय पत्रको लागि यथासम्भव निम्नानुसार प्रश्नहरू सोधिनेछ ।

द्वितीय पत्र (विषयगत)					
पत्र	विषय	खण्ड	अङ्कभार	छोटो उत्तर	लामो उत्तर
द्वितीय	सेवा सम्बन्धित कार्य-ज्ञान (Job Based-Knowledge)	(A)	५०	६ प्रश्न × ५ अङ्क = ३०	२ प्रश्न × १० अङ्क = २०
		(B)	५०	६ प्रश्न × ५ अङ्क = ३०	२ प्रश्न × १० अङ्क = २०

प्राविधिक तर्फ इञ्जिनियरिङ्ग सेवा, सिभिल समूह, चौंथो तह, असिस्टेण्ट सव-इञ्जिनियर पदको प्रतियोगितात्मक परीक्षाको लागि पाठ्यक्रम

पाठ्यक्रमको रुपरेखाः– यस पाठ्यक्रमको आधारमा निम्नानुसार चरणमा परीक्षा लिइने छ :

प्रथम चरण :– लिखित परीक्षा   पूर्णाङ्क :– १००
द्वितीय चरण :– अन्तर्वार्ता   पूर्णाङ्क :– २०

प्रथम चरण – लिखित परीक्षा योजना(Examination Scheme)

विषय	पूर्णाङ्क	उत्तीर्णाङ्क	परीक्षा प्रणाली	प्रश्न संख्या x अङ्कभार	समय
सेवा सम्बन्धी	१००	४०	वस्तुगत बहुवैकल्पिक (Multiple Choice)	५० प्रश्न x २ अङ्क = १००	४५ मिनेट

द्वितीय चरण

विषय	पूर्णाङ्क	परीक्षा प्रणाली
अन्तर्वार्ता	२०	मौखिक

द्रष्टव्य :

१. यो पाठ्यक्रम योजनालाई **लिखित परीक्षा र अन्तर्वार्ता** गरी दुई चरणमा विभाजन गरिएको छ ।

२. प्रश्नपत्र अंग्रेजी भाषामा हुनेछ ।

३. वस्तुगत बहुवैकल्पिक (Multiple Choice) प्रश्नहरुको गलत उत्तर दिएमा प्रत्येक गलत उत्तर बापत २० प्रतिशत अङ्क कट्टा गरिनेछ । तर उत्तर नदिएमा त्यस बापत अङ्क दिइने छैन र अङ्क कट्टा पनि गरिने छैन ।

४. परीक्षामा कुनै प्रकारको क्याल्कुलेटर (Calculator) प्रयोग गर्न पाइने छैन । आयोगबाट संचालन हुने परीक्षामा परीक्षार्थीले मोबाइल वा यस्तै प्रकारका विद्युतीय उपकरण परीक्षा हलमा लैजान पाइने छैन ।

५. लिखित परीक्षामा यथासम्भव निम्नानुसार प्रश्नहरु सोधिनेछ ।

पाठ्यक्रमका एकाइ	1	2	3	4	5	6	7	8	9	10
प्रश्न संख्या	5	5	6	8	8	3	8	3	2	2

६. यस पाठ्यक्रम योजना अन्तर्गतका पत्र/विषयका विषयवस्तुमा जेसुकै लेखिएको भएतापनि पाठ्यक्रममा परेका कानून, ऐन, नियम तथा नीतिहरु परीक्षाको मिति भन्दा ३ महिना अगाडि (संशोधन भएका वा संशोधन भई हटाईएका वा थप गरी संशोधन भई) कायम रहेकालाई यस पाठ्यक्रममा परेको सम्झनु पर्दछ ।

७. प्रथम चरणको लिखित परीक्षाबाट छनौट भएका उम्मेदवारहरुलाई मात्र द्वितीय चरणको अन्तर्वार्तामा सम्मिलित गराइनेछ ।

८. पाठ्यक्रम लागू मिति :-

प्राविधिक तर्फ इञ्जिनियरिङ्ग सेवा, सिभिल समूह, चौंथो तह, असिस्टेण्ट सव-इञ्जिनियर पदको प्रतियोगितात्मक परीक्षाको लागि पाठ्यक्रम

पत्र/ विषय :– सेवा सम्बन्धी

1. Engineering Drawing
1.1 Unit, Dimension and their conversion with special reference to SI system
1.2 Elementary idea of drawing (object); Building drawings
1.3 Drafting techniques and methods in common practice
    1.3.1 Different types of lines and effects
    1.3.2 Vertical line, horizontal line & inclined line (thick, thin, dark, light)
    1.3.3 Representation of different materials: stone, timber, glass, metal, brick, concrete, sand, earth, tile, plaster
    1.3.4 Dimensioning : element to element, centre to centre and overall dimensioning
1.4 Measured Drawing
    1.4.1 Methods of measurement of horizontal and vertical dimensions
    1.4.2 Sectional measurements
    1.4.3 Scales: choice, use and conversion
1.5 Working Drawing
    1.5.1 Significance of detailing in terms of accuracy of estimation, bill of quantities and construction supervision
    1.5.2 Structural working drawings and structural detail: column, beam, slab, foundation, and other structural elements

2. Estimating, Costing and Supervision
2.1 Purpose of estimating
2.2 Methods of estimate
2.3 Types of estimates (preliminary estimate, approximate quantity estimate, detailed estimate, revised estimate)
2.4 Standard estimate formats of government of Nepal
2.5 Rate analysis and Norms
2.6 Estimating items of construction works
2.7 Estimate of civil works, and site development work
2.8 Specifications: purpose, types and necessity
2.9 Concept and purpose of property valuation
2.10 Supervision

3. Engineering Survey
3.1 Basics of surveying, its importance and types
3.2 Scale, plans, maps
3.3 Conventional signs and system of field booking of surveying
3.4 Basics of Chain, Compass, Plane table, Levelling and Theodolite

4. Construction Materials
4.1 Rocks/stone: types of rocks, their characteristics & properties of good stone
4.2 Aggregates (fine & coarse)
4.3 Cement : Different types of cement and its properties; Admixtures
4.4 Metal and alloys
4.5 Brick: types of bricks & sizes of bricks available in Nepal
4.6 Lime and Surkhi: types, properties and its uses
4.7 Mortar: types, properties and its uses along with proportions
4.8 Paints and varnishes : constituents, types and its uses
4.9 Floor finishes-punning, tiles, mosaic, clay, concrete, vinyl, marble, flagstones, wooden boarding, parquet

4.10 Wall finishes : plasters (cement, lime and mud), punning and cladding (wooden, stone, tiles, marbles)

4.11 Roofing materials

5. Construction Technology

5.1 Description and Objectives

5.2 Types of construction works

    5.2.1 Masonry works; Concrete works; Flooring works; Finishing works

    5.2.2 Construction of building components

    5.2.3 Earthquake Resistant Building Construction

    5.2.4 Temporary constructions

    5.2.5 Rural technology and alternative energy

5.3 Concrete technology and management

    5.3.1 Constituents of cement concrete (cement, aggregate, water, admixture)

    5.3.2 Grading of aggregates

    5.3.3 Water cement ratio

    5.3.4 Workability and strength of concrete

    5.3.5 Concrete mix, laying, pouring, and compaction

    5.3.6 Reinforcement laying

    5.3.7 Formwork

    5.3.8 Curing of concrete

    5.3.9 Storage and management of construction material

    5.3.10 Record keeping at construction site (daily work done, manpower mobilized, material storage)

    5.3.11 Construction safety

    5.3.12 Scheduling tool (bar chart)

6. Building Services

6.1 Water supply, Types of storage (underground, overhead), types of water supply pipes and its fitting

6.2 Septic tank, soak pit, vents, manhole, types of sewerage pipes

6.3 General principle of electrical installation and distribution, types of wiring systems (surface, conceal), safety precautions (earthing, lightening arrestors)

6.4 Lighting : General principle of lighting & Lighting fixtures

7. Local Infrastructures

7.1 **Roads and Bridges** : Types of roads and bridges; Development of road network in Nepal; Layout and construction of trails, rural roads and motorable roads; Cross drains (bridges, culverts, causeways) and Side drains for roads; Retaining walls; Road signs and Traffic signals; and River training works

7.2 **Irrigation** : Need for irrigation; Methods of irrigation; Head works and canal network; operation and maintenance of irrigation system

7.3 **Water Supply** : Community based water supply system; Selection of water source with adequate quantity; Water demand analysis; operation and maintenance of water supply

8. General information about legislations

8.1 नेपालको संविधान (भाग १, २, ३, १७ र १८ तथा अनुसूचीहरू) (The Constitution of Nepal (From Parts 1, 2, 3, 17 & 18, and Schedules))

8.2 स्थानीय सरकार सञ्चालन ऐन, २०७४ मा पूर्वाधार विकास सम्बन्धी व्यवस्था (Local Government Operation Act, 2074 (related to local infrastructures development))

9. अंग्रेजीः Knowledge on writing correct English sentence, letter, and report according to English grammar based on the following syntactic functions:

a. Part of Speech:
   i. Noun
   ii. Pronoun
   iii. Adjective
   iv. Determiner
   v. Verb
   vi. Adverb
   vii. Preposition
   viii. Conjunction and
   ix. Interjection

b. Infinitive and gerund, reported speech and tense

10. नेपालीः नेपाली भाषामा स्तरीय लेखनको लागि आवश्यक पर्ने व्याकरण अनुरूप शुद्धा शुद्धि बनाउने । यसका लागि निम्न विषयमा ध्यान केन्द्रित गर्नेः

वर्णविन्यास, पदसङ्गति, नाम, सर्वनाम, क्रियापद, विशेषण, काल, वाच्य, पदवर्ग, अनुकरणात्मक शब्द, कारक र विभक्ति, वचन, पुरुष, लिङ्ग, उल्टो अर्थ आउने शब्द, पर्यायवाची शब्द, तत्सम शब्द, तद्भव शब्द, आगन्तुक शब्द, उपसर्ग लागेर निर्मित शब्दहरू, प्रत्यय लागेर निर्मित शब्दहरू, समास भएर निर्मित शब्दहरू, द्वित्व भएर निर्मित शब्दहरू, ह्रस्व दीर्घ, श, ष, स लगायतका व्याकरणगत शुद्ध लेखनशैलीमा केन्द्रित विषयहरू सहितको नेपाली शुद्धाशुद्धिको ज्ञान

Surveying

Total marks 230

Objectives 100

Subjective 100

Interview 30

1. General awareness and public management सामान्य ज्ञान र सार्वजनिक व्यवस्थापन (section A [general awareness 10] section B [public management 10] 20 question 40 marks
2. Job based knowledge सेवा सम्बन्धि कार्य ज्ञान (section A [surveying,3 construction materials,3 mechanics of materials and structure,3 hydraulics,3 soil mechanics,2 structural design,2] section B[building technology,2 water supply and sanitation engineering,2 irrigation engineering,2 highway engineering,2 estimating and costing,2 construction management,2 airport engineering2]) 30 questions 60 marks

From section A no. of question 6 short 5 marks and 2 question 10 marks
From section B no. of question 6 short 5 marks and 2 question 10 marks

Syllabus
1. Surveying
1.1 General
    1.1.1 Classifications
    1.1.2 Principle of surveying
    1.1.3 Selection of suitable method
    1.1.4 Scales, plans and maps
    1.1.5 Entry into survey field books and level books
1.2 Levelling
    1.2.1 Methods of levelling
    1.2.2 Levelling instruments and accessories
    1.2.3 Principles of levelling
    1.3 Plane Tabling
    1.3.1 Equipments required
    1.3.2 Methods of palne tabling
    1.3.3 Two and three point problems
1.4 Theodolite and Traverse surveying
    1.4.1 Basic difference between different theodolites
    1.4.2 Temporary adjustments of theodolites
    1.4.3 Fundamental lines and desired relations
    1.4.4 Tacheometry : stadia method
    1.4.5 Trigonometrical levelling
    1.4.6 Checks in closed traverse
1.5 Contouring
    1.5.1 Characteristics of contour lines
    1.5.2 Method of locating contours
    1.5.3 Contour plotting
1.6 Setting Out
    1.6.1 Small buildings
    1.6.2 Simple curves
   1. Surveying

1.1 General

Surveying is the science and art of determining the relative positions of any point above or below the surface of the earth by measuring distances, directions and elevations with respect to assumed/fixed datum.

➢ The Main objective of surveying is to prepare map.

A. Importance of surveying

➢ Planning for new engineering construction projects.
➢ Preparation of plans and maps of plots of land**.**
➢ Essential for planning, design and laying out alignments of roads, railways, canals, tunnels, transmission power lines and microwave or television relaying towers.
➢ To collect field data.
➢ Preparing for military operations.
➢ Assessing and recording the boundaries of different properties to determine land ownership**.**

1.1.1 Classification of surveying

A. Primary division of surveying/Based on curvature of earth

a) Plane Survey

The survey in which earth surface is assumed as a plane and the curvature of the earth is ignored is called plane survey.

➢ Earth curvature ignored.
➢ Survey area is less than 260 km^2.
➢ Low degree of accuracy.
➢ The earth surface is assumed to be plane i.e. two dimension.
➢ The level line is considered as straight.
➢ Done locally by the individual organization.
➢ It employs traditional instrument like measuring tape, a chain, theodolite etc.

b) Geodetic survey

The survey in which curvature of the earth is taken in-to account while making measurements on the earth's surface is called geodetic survey.

➢ Earth curvature is taken in-to account.
➢ Survey area is more than 260 km$^2.$
➢ High degree of accuracy.
➢ The earth surface is assumed to be spherical i.e. three dimension.
➢ The level line is considered as curve.
➢ Done by concerned state or government department.
➢ It employs more accurate devices and modern technology like GPS (Global positioning system)

Note:

- Difference between arc and subtended chords on earth surface for a distance of 18.5 km is 1cm.
- Arc ADB-ACB = 10mm, if ADB=18.5km.
- Difference between sum of angle of interior angle of spherical triangle and plane triangle for 195km^2 is 1 second only.

B. Secondary division/general classification of survey

a) Based on nature of field

i) Land survey

The survey in which carried out on the earth (no water bodies) is called land survey. Land survey further sub-divided into following types:

- **Topographical survey:** The survey in which used to indicate the natural features of the country such as mountain, river, forest lakes etc.
  Scale : 1:25000 to 1:000000 (1:10 lakhs)
- **Cadastral survey:** The survey in which used for demarcate the property lines of personal, municipalities, states etc.
  Scale: 1:1000 to 1:5000
- **City survey:** The surveys in which done for the construction of roads, parks, water supply, sewer, electricity etc.

ii) Hydrographic or Marine survey

The survey in which carried out for the studies of large water bodies for the purpose of navigation, construction of harbor, prediction of tides and determination of mean sea level.

iii) Astronomical survey

The survey in which determination of absolute location and absolute direction of heavenly bodies like sun, moon, the planets and the stars.

b) Based on purpose of the survey

i) Engineering survey

the survey in which determining and collecting data for the design of engineering works such as road, railways, water supply etc.

ii) Military survey

the survey in which preparation of maps of the area of military importance.

iii) Geological survey

the survey in which determining different strata in the earth crust (types of rock in site).

iv) Mine survey

the survey in which used for the exploring the earth minerals.

v) Archaeological survey

the survey in which prepared map of ancient culture. प्राचिन संस्कृति

c) Based on instruments used

i) **Chain survey:** the survey in which only linear measurement are dine with the help of chain or tape.

ii) **Compass survey**: The survey in which horizontal angles and direction of lines are measured by compass and length of line are measured with chain or tape.

iii) **Plane table survey:** The survey in which plan or map is produced by determining direction of various point stand a king linear measurement with chain or tape.

iv) **Levelling:** The survey in which elevation of various points are measured with a levelling instrument and vertical staff.

v) **Theodolite survey:** The survey in which horizontal and vertical angle are measured with theodolite and distance are measured with chain or tape.

vi) **Tachometric survey (total station survey):** The survey in which horizontal and vertical distance measured with a instrument.
Suitable for broken grounds.(undulating and steeps slopes)

vii) Photometric survey: The survey in which photographs are taken for an area which are inaccessible or time available is less and area to be survey is large.

viii)   **Aerial survey** The survey in which air planes, helicopters, balloons, or any other air media is used to draw top view.

d) Based on methods of surveying

i) Triangulation survey

the survey in which measures the angles in a triangle formed by three survey control points.

ii) Traverse survey

the survey in which number of connected survey lines form the frame work and the direction and lengths of the survey lines are measured with the help of an angle measuring instrument and tape or chain respectively.

1.1.2   Principle of surveying

A) Working from whole to part
- ➤ The working from whole to part is done in surveying in order to ensure that errors and mistake of one portion do not affect the remaining portion.
- ➤ The main objective of this principle if to prevent the accumulation (संचय) of error and to localize minor error with in the frame of work. कार्य ढाचाँमा भएका सानातिना त्रुतिहरुलाई स्थानिकरण गर्ने।

B) Location of a point by measured from two control point
- ➤ To fix or locate a new point of station by at least two independent measurement or reference of two already fixed control points.
- ➤ The measurement can be : angular and linear or both.
- ➤ Figure

C) Consistency work स्थिरता

The instrument and methods used should be same, otherwise, errors may arise. In addition the symbols used should be same in particular survey works.

D) Independent check
- ➤ Every survey operation should be subjected to a check, as far as possible, a completely independent check and not repetition of the operation.
- ➤ Check distance measurement in forward and backward direction.

E) Accuracy and Economy
- ➤ Survey work generally done in certain standard of accuracy.
- ➤ High degree of accuracy depends upon accuracy of instrument, time, effort applied, methods etc. which increase the cost of works.
- ➤ Achieving higher accuracy is investing high money for small works is worthless.

1.1.3 Selection of suitable methods

It depends upon the types of area to be served. For example
- ➤ Chain survey is used for small area having fairly level ground.
- ➤ Compass survey is used where there is no effects of electric field.
- ➤ Plane table survey is used for the area having open ground.
- ➤ Tachometric survey is used for broken ground, deep ravines etc.

1.1.3 scales, plan and maps

A) Scales
- ➤ Scale is the ratio of linear dimension of objects as represented in a drawing to the actual dimension.

➢ Scale is defined as the fixed proportion.
➢ For example:
   1cm = 50m (1cm in map equals to 50m in ground)

Types of scale;
   a) Numerical scale
   i)   Engineering scale
        - A specified distance on the map represents the corresponding distance on the
   ground. For example: 1cm = 50m means 1 cm on the map represents 50m on the ground.
   ii)   R.F./fraction scale (representative fraction)
         - the representative fraction is the ratio of the distance on the map to the
   corresponding distance on the ground. For example: scale 1cm=50m ,means 1 cm
   on the map represents 50m on ground.
         - 1cm=50m (5000cm)
         - 1cm=5000cm
         - 1:5000
   Further divided into:
   ➢ 1:1 scale same size (full size)
   ➢ 1:100 reducing scale (reducing scale)
   ➢ 100:1 enlarging scale (enlarging scale) (machine parts, mechanical/electronic
      instruments, watches, etc)

   b) Graphical scale (There are four types of scale)
   i)   Plain scale
        A plain scale is possible to measure only two dimensions, i.e. unit or tenth. Meters
           and decimeter (1m =10decimeter), kilometer and hectameters (1m = 10
           hectameters) , feet and inch (1 ft = 12 inch), miles and furlongs (1 miles = 8
           furlongs) etc.
   ii) Diagonal scale
        A diagonal scale is possible to three dimensions, i.e. unit, tenth and hundred.
           meter, decimeter, centimeter, kilometers, hectameter and decameters.
   iii) Scale of chords
        A scale of chords may be used to set or read an angle in the absence of a
        protractor.
   ➢   To measures and set off angles.
   iv) Vernier scale
        A Vernier scale is a device for measuring accurately the fractional (केहि अंश) part
        of the smallest division on graduated scale.
   ➢   There are two types of Vernier scale:
            Direct Vernier
   ➢   In direct Vernier smallest division of Vernier scale is less than the
        smallest division of Main scale.
   ➢   Extend in same direction.(i.e single direction)
   ➢   Least count(L.C.)=value of one division of Primary scale / Total number
        of division in Vernier scale = s/n=1/10=0.1
            Indirect scale/retrograde Vernier

➢ In retrograde Vernier smallest division of Vernier scales is greater then the smallest division of main scales.

➢ Extend in opposite direction.(i.e. both direction)

➢ Least count (L.C.)=Value of one division of primary scale / Total number of division in Vernier scale = s/n=1/10=0.1

Note:

Large scale - 1:10
Medium scale - 1:100
Small scale - 1:1000

large-scale map" भन्ने शब्दले बढी विवरण भएको सानो क्षेत्र प्रतिनिधित्व गर्छ, जबकि

"small-scale map" ले कम विवरण भएको विशाल क्षेत्र देखाउँछ

*Shrinkage factor:- the ratio of shrunk length and actual length of a drawing is known as shrinkage factor. It's also known as shrinkage ratio.

i.e. shrinkage ratio = shrunk length/actual length

*Least count: it's the difference between smallest division of main scale and smallest division of secondary scale is called least count. भनेको कुनै मापन उपकरणले मापन गर्नसक्ने सबैभन्दा सानो इकाइ हो

LC=s/n

where,

S=division of primary scale

N=total no. of division of Vernier scale

B) **plan**

A plan graphically represents the features on or near the earth's surface as projected on a horizontal plane.

➢ A plan is drawn on a relatively large scale.

C) Maps

If the scale of the graphical representation on a horizontal plane is small, the plan is termed map.

a) **Guide map:** for the tourist purpose.

b) **Geographical map**; map prepare on small scale.

c) **Topographical map**: natural feature's (scale larger than geographical map)

d) **Cadastral map:** to fix property line of large scale.

e) **Climate map**: climate of different area.

f) **Resource map:** resources present in different localities.

Difference between plan and maps

S.N.	Plan	Maps
1	Plan may be defined as the horizontal projection of any area in horizontal plane.	In the map, detailed are given in the form of symbol words and colours.
2	Plan always two dimensions like distance and direction.	Map is three dimensions like distance, direction and elevation.
3	Considered area is larger than the map.	Considered area is smaller than the area.
4	Scale of plan is larger than map.	Scale of may is less than plan.

5	It shows detail layout of spaces length and breadth in a building etc.	It shows a large area of ground on a small scale or large scale i.e. maps reduced the entire world on its parts to fit on a sheet of paper.

1.1.5 Entry into survey field books and level books

A **survey field book** is a specialized Compact, water-proof covered notebook used by surveyors to record measurements, observations, and sketches during fieldwork. Following data are includes in survey field book:

- ➢ Station name/number
- ➢ BS,IS,FS
- ➢ Chainage
- ➢ Offset, bearing, angle
- ➢ Sketch or diagram
- ➢ Date, weather condition, crew names etc.

Generally types of survey field books are:

- ➢ Level book
- ➢ Compass book
- ➢ Theodolite book
- ➢ Chain survey book

Important point for filed data entry procedure are:

- ➢ In case of field book(chain survey) entry data is start from bottom page of field book to top in upward direction.
- ➢ In chain surveying field book is two types: single line field book (chain line represented single line.).
- ➢ Double line field book (chain line is represented by double line spacing about 1.5 to 2 cm).
- ➢ In case of level book: entry data is started from top page of field book to bottom in downward direction.
- ➢ The size of field book is 20cm*12 cm.

1.1.6 Surveying Instrument and uses

A survey instrument is a tool, used specifically by surveyors for obtaining accurate linear**,** angular, and vertical measurements of terrain, structures, and other features.

S.N.	Instruments	Uses
1	Chain, tape, tacheometer	Horizontal distance measure
2	Total station	Horizontal, vertical, slope) distance and (horizontal, vertical) angle measure
3	Level machine or auto level	Vertical distance measure
4	Abney level	Slopes and vertical angle
5	Theodolite	Horizontal angle, vertical angle
6	Compass	Horizontal angle
7	fathometer	Depth of water bodies
8	Substance bar	Horizontal distance
9	sextant	Vertical angle
10	tellurometer	Distance measurement (radio waves used)
11	Pentagraph	Enlarging or reducing plans

1.1.7 Measurements in surveying

A) **Linear measurement-**Horizontal distance and vertical distance measurement.

B) Angular measurement- Horizontal angle and vertical angle measurement.

1.1.8   Instrument used for linear measurement

A) Pacing: In this method, the number of paces is counted by walking between two points of a line.

B) Passometer: the passometer is a watch like instrument that is carried out the person's packet or tied on the man's leg.

C) Pedometer: Pedometer is a similar device like passometer in which average pace length of person can fixed before walking.

D) Odometer : Odometer is an instrument that measures the number of revolution of a wheel.

E) Speedometer: Speedometer or speed meter is a gauge that measures and displays the instantaneous speed of a vehicle or automobiles.

F) Tape

Tape is used to measure linear distances directly on the ground.

Types of surveying tapes are:

i)   Cloth or linen tape

➢ it's made of closely woven linen and varnished to resist moisture.

➢ It's used for offsets and rough measurements.

ii)   Metallic tape

➢ It's made of varnished strip of waterproof linen interwoven with small wires of brass, copper or bronze.

iii)   Steel tape

➢ It's consists of 6 to 10mm wide strip with metal ring at free end and wound in a corrosion resistant metallic case.

➢ It's more accurate than metallic tape.

iv)   Invar Tape

➢ It's an alloy of nickel 36% and steel 64% .

➢ It's coefficient of thermal expansion is low.

➢ Used for high degree of precision required area.

G) Chain

➢ The chains are composed of large number of links made of galvanized mild steel of 4 mm diameter.

➢ The handle of chain is made of brass and is included in whole length of the chain.

➢ The handles have swivel joint to provide flexibility.

➢ Depending upon the length of the chain, these are divided into following types:

S.N.	Types of chain	Length	Links	Length of each link	use
1	Engineer's chain	100ft	100	1ft	In all engineering surveys
2	Gaunter chain	66ft	100	0.66ft	Use measuring distances in miles or furlong
3	Metric chain	20m	100	20cm	Use for chain surveying
		30m	150	20cm	
4	Revenue chain	33ft	16	2.063ft	In cadastral surveys

*Chain Surveying

- ➢ It's a branch of survey in which only linear measurements are done and no angular measurements are taken.
- ➢ It's simplest and oldest type of surveying.
- ➢ Suitability of Chain survey: fairly level ground, small areas, open area and large scale plans are required.
- ➢ Unsuitability of chain survey: undulating ground, large areas, and crowded areas.
- ➢ The main principle of chain surveying is to divide the area into a number of triangles of suitable sides. Since a tringle is the only simple plane geometrical figure which can be plotted with the lengths of it's sides alone. [triangle should be (30-120°) is called ill-conditional triangle and should not be (30-120°) is called well-conditioned triangle]
- ➢ The best triangle is equilateral triangle for the chain survey.

A) Obstacle of chaining
- ➢ Obstacles in ranging but not in chaining e.g. hill rock.
- ➢ Obstacles in chaining but not in ranging e.g. river and ponds.
- ➢ Obstacles in both ranging and chaining e.g. tall building.

B) Errors in chaining
- ➢ The difference between observed value and true value is known as error.
- ➢ Errors are coming in chaining may be due to manual, instrumental or natural.
- ➢ Errors are classified into three groups depending on nature:

a) Cumulative errors
- ➢ The errors which occurs in the same direction and tend to accumulate is called cumulative errors.
- ➢ The length of chain is shorter than it's standard occur positive cumulative error. So correction for this is always -ve.
- ➢ The length of chain is longer than it's standard occur negative cumulative error. So correction for this is always +ve.
- ➢ Cumulative error are always proportional to the length of the line.

b) Compensating error cumulative त्रुटि जस्तो हानिकारक असर गर्दैन; धेरै पटकको मापनले एकअर्कालाई mitigate गर्छन्
- ➢ The error which occurs in the either direction and tends to compensate are called compensating errors
- ➢ It's occurring due to incorrect holding of the chain, faulty graduation etc.
- ➢ It's proportional to square root of the length.
- ➢ It's not known so correction becomes impossible.

c) Accidental errors (mis writing, reading,digit wrong,Etc)
- ➢ Accidental errors are occurring due to careless of the staffs involved in chaining.
- ➢ It's proportional to square root of the number of observation taken.

C) Permissible errors in chaining
- ➢ For measuring over rough or hilly ground: 1 in 250
- ➢ In an ordinary chain survey, the maximum permissible error is 1 in 1000.
- ➢ In steel tape or steel band chain, maximum permissible error is 1 in 2000.
- ➢ In standardized steel or invar tape and correction for pull, sag, temperature, slope and alignment is applied, the maximum permissible errors is 1 in 2500.

D) Corrections for linear measurements

a) Correction for absolute / standard length
- ➢ Actual length of line = L+- Ca
- ➢ the correction for absolute length (Ca)=(c*L)/l

Where,

    Ca=the correction for absolute length

    l=the standard length of tape

    c=the correction to a tape length

    L=the measured length of a line

b) **Correction for temperature**

    ➤ $C_t = \propto (T_m - T_s)L$

    Where,

    Ct=correction for temperature in m

    ∝=the coefficient of thermal expansion

    Tm=the mean temperature during measurement

    Ts =the temperature at which the tape is standardized

    L=the measured length in m.

c) **Correction for pull**

    ➤ $C_p = (P_m - P_o)/AE$

    Where,

    Cp=correction for pull

    Pm=mean pull applied during measurement

    Ps=pull at which the tape is standardized

    L=measured length

    A=cross sectional area of the tape

    E=modulus of elasticity of the tape material

d) **Correction of sag**

    ➤ $C_s = (W^2 L^3)/24P^2$

    Where,

    W=total weight of tape

    P=applied pull

e) **Correction for slope**

    ➤ Slope correction=$H^2/2L$

    ➤ Slope correction(Cs)= $2L(1 - cos\theta$

    Where,

    L= length measured along slope

    H= vertical distance

    θ=angle of slope

1.2 Levelling

➤ Levelling is the process of determining the relative elevation/altitude of a points below, on and above the surface of earth.

➤ The Main objectives of levelling is to determine the vertical distance of a point on the surface of earth with respect to assumed datum.

*Technical term

A) **Datum:** Reference level from which elevations are measured.

B) **Bench mark (BM)**: A fixed point of known elevation used as a reference for determining relative heights.

    - types:

        i. GTS benchmark- Permanent and highly stable.

        ii. Permanent benchmark- A durable, official reference point set by government bodies for long-term use.

         iii)   **Temporary benchmark-** Temporary or limited-purpose.

         iv)   **Arbitrary benchmark-** Only valid for duration of project/day.

C) Reduced level (RL): The vertical elevation of a point relative to the datum.

D) Back sight: First staff reading taken on a point of known elevation after instrument setup.

E) Fore sight (FS): Final staff reading taken before relocating the instrument to determine elevation of a new point.

F) Intermediate sight (IS): Any staff reading between BS and FS from the same instrument setup on points of unknown elevation.

G) Height of Instrument (HI): Elevation of the instrument's horizontal line of sight (plane of collimation समिकरणको समतल भाग) above datum.

H) Axis of telescope: the line joining the optical center of objective and optical center of eye-pieces is known as axis of telescope.

*fundamental line of leveling telescope

I) line of sight : the line of sight is a line which passes through optical center of objective and traversing the eye pieces and entering the eye.

J) Line of collimation (or): the line passing through the optical center of eye pieces and point of intersection of cross hair of objective and it's continuation is known as line of collimation.

K) Level surface / Level line: A surface or line everywhere perpendicular to the direction of gravity, used as a reference in levelling. The surface still water in lake is taken as example of level surface.

L) Station: the point where levelling staff is held and sighted by a level is called station in levelling.

M) Instrument station/station point: The exact spot where the tripod and instrument are placed for recording observations.

N) Change point and turning point: Point used for both foresight & back sight readings.

1.2.1 Booking and Reduction Methods of levelling

    There are two method of levelling:

A) Height of instrument/line of collimation/collimation method

    ➢ It's quick and simple methods of levelling.

    ➢ It's generally used in profile levelling.

    ➢ Suitable for no. of reading are more required.

    ➢ The height of instrument is calculated for each setting of the instrument by adding the back sight to the elevation of the BM.

    ➢ The reduce level of the first station is obtained by subtracting it's fore sight from the instrument station.

    ➢ the format of level book is shown below

Station	BS	IS	FS	HI	RL	Remarks
1	-					BM
2		-				
3		-				
4	-		-			CP/TP
5		-				
6			-			

अंक गणित Arithmetical check$= \sum BS - \sum FS = last\ RL - First\ RL$

B) **Rise and Fall Method**

- It's slow and laborious मिहेनेति method.
- It's generally used in differential and other precise levelling operation.
- Suitable for no. of reading are less.
- The difference of level between two consecutive points for each setting of instruments, is obtained be comparing their staff readings.
- The difference between their staff reading indicates rise if back staff reading is more than the fore sight and a fall if it is less than the fore sight.
- The format of level book is shown below.

station	BS	IS	FS	Rise (+)	Fall (-)	Rl (m)	Remarks
1	-						BM
2		-					
3		-					
4	-		-				CP/TP
5		-					

Arithmetical check =$\sum BS$-$\sum FS = \sum rise - \sum fall$=**last RL-First Rl.**

Comparison of HI methods and Rise fall method

S.N.	HI	Rise and fall
1	It's quick and simple method of levelling.	It's less quick than HI method.
2	No check on RL of intermediate sight.	Check on RL of intermediate sight,
3	Errors of intermediate RL can not be detected.	Error in any intermediate RL are detected can be corrected
4	There is two check	There is three check
5	$\sum BS - \sum FS = last\ RL - First\ RL$	$\sum BS$-$\sum FS = \sum rise - \sum fall$=**last RL-First Rl.**

1.2.2   levelling instruments and accessories

Level: The instrument used to furnish horizontal line of sight for observing staff readings and determining R.L.s.
* Types of level
i) Dumpy of level
- fixed telescope
- Very stable and accurate.
- Mostly used in traditional leveling
ii) Tilting level
- Telescope can tilt slightly using a tilting screw.
- Faster setup than dumpy level.
- Used where quick leveling is needed.
iii) Digital level
- Uses electronics sensors and digital displays
- Reads bar-coded staff automatically.
- very high accuracy and fast data processing.

iv) Automatic level

- Has a compensator that auto-levels the line of sight.

- Easy to use and time saving.

- Common in

-modern surveying.

V) laser level

- projects a laser beam for leveling.

- common in construction for leveling floors, ceilings, etc.

- Can be rotary or fixed- beam.

vi) water level

- uses water in tubes to measure level difference.

-used in basic or small-scale waorks.

A) **Levelling staff:** It is a straight, Graduated scale rod used with leveling instruments to determine the difference in height between points. types: telescopic staff, folding staff etc.

B) **Tripod:** it is three legged stand used to support the levelling instrument in a stable and level position.

   - Ensures the instrument stays still and level during observations.

C) **Plumb bob:** It is a pointed weight suspended from a string used to find a vertical reference line (plumb line).

   - it helps to center the instrument directly above a survey point.

   - Used especially in setting up the instrument over a point.

D) **Bubble level (for manual adjustment):** It is a small, sealed tube partially filled with liquid, leaving a bubble inside.

   - it helps level the instrument horizontally.

   - when the bubble is centered, the surface is perfectly.

1.2.3 Principle of levelling

➢ Principle of levelling is to find the vertical distance of the point above and below the line of sight with the help of horizontal line of sight.

➢ The line of sight is provided with a level and levelling staff is used for measuring the height of line of sight above the staff positions.

1.2.3   Types of levelling

A. Direct levelling (sprit levelling or most precise levelling)

measuring the difference in elevation between points by establishing a horizontal line of sight and measuring to that line. vertical distances relative to that line.

-Direct method of levelling are :

(a) simple levelling

 Simple levelling is adopted where the difference in elevation between two points that are visible from a single position of a level.

(b) differential levelling:

Differential levelling is adopted where two points are far apart and level difference is high and there are obstacles between them.

(c) fly levelling

Fly levelling is adopted where differential levelling is done in order to connect the bench mark to starting point of the alignment of any object.

➢ it's done when BM is very far from work station.

➢ only BS and FS reading are taken.

➢ It's precise levelling.

(d) profile levelling

profile levelling is the process of determining the elevation of point at short measured intervals along a fixed line such as the center of railway, highway, canal or sewer.

- ➢ Give ground profile along center line (CL) of site.
- ➢ Take IS reading
- ➢ NO Sight balancing
- ➢ Middle hair reading only.

(e) cross-section levelling:-

- ➢ Give ground profile perpendicular to center line at any section (Transverse direction)

(f) Reciprocal levelling:

Reciprocal levelling is necessary to carry levelling across the river, ravine (गल्छी) or any obstacle requiring along sight between two points.

- ➢ Reciprocal levelling must be used to obtain accuracy and to eliminate the following

(i) Error in instrument adjustment

(ii) combined effect of earth's curvature and refraction of the atmosphere.

(iii) Variation in the average refraction.

- ➢   True difference of level, $h=\{(a_1-b_1)+(a_2-b_2)\}/2$
- ➢   Combined Error $e = \{(a_1-b_1)-(a_2-b_2)\}/2$

B. Indirect method of levelling.

(a) Barometric levelling

- ➢ It is based on the difference of atmospheric pressure between the points.
- ➢ This method is little use because atmospheric pressure does not remains constant in the course of day.
- ➢ Aneroid barometer (pressure altimeter) is used for barometric levelling.

(b) Trigonometric levelling:

- ➢ In this method of levelling, elevation of points are computed by measuring the vertical angles and horizontal distance of the top of buildings, chimneys, church spires etc.
- ➢ Also, it may be used to its advantage in difficult terrains like mountainous areas.
- ➢ Combined correction is curvature and refraction.
- ➢ Combined correction = $0.0669 \ D^2$.

Where,

   D=Distance in Km.

If the vertical angle is +ve, the correction is taken as +ve.

If the vertical angle is -ve, the correction is taken as -ve.

*Temporary Adjustments

A. Setting up of the level

B. Leveling Up

C. Elimination of parallax

*Permanent adjustments

A. Axis of bubble tube should be perpendicular to the vertical axis of instrument.

B. Horizontal cross hair should lie in the plane perpendicular to the vertical axis.

C. Line of sight is parallel to bubble tube.

*Curvature correction (Cc)

- ➢ When levelling is done in a large area, the curvature of earth is considered.
- ➢ The effect of curvature is to increase the staff reading that is the error is positive and so the correction is negative.

$$Cc=d^2/2R$$

Where,

R=Radius of earth=6371 Km

$Cc=d^2/2R =d^2/(2*6314)= 0.0785d^2$

➢ True staff reading = observed staff reading - $0.0785d^2$

*Refraction correction (Cr)

➢ The rays of light passing through the atmosphere of different density bend down. It results in this type of correction.

$$Cr= \frac{1}{7}*Cc= 0.0112*d^2 \text{ meters.}$$

➢   True staff reading = observed staff reading + $0.0112 *d^2$

***Curvature and refraction combined correction**

Combined correction (C)= Curvature + refraction correction

$C= -0.0785D^2+0.0112D^2$

$C= -0.673D^2 m$

So, combined correction is always negative (-Ve).

1.   *What is levelling ? explain the methods of levelling.*
2.   *What are the types of levelling ? explain about instrument used in levelling.*
3.   *Explain about curvature and refraction correction for levelling. Derive an expression for curvature correction and for combined curvature and refraction correction.*
4.   *Why reciprocal levelling is done ? also derived the formula for reciprocal levelling.*

What is profile levelling ? Explain the term "balancing of sight" in levelling operation.

1.3 Plane Tabling

The method of surveying in which the field work and plotting are done simultaneously, is called Plane tabling.

➢ Graphical method of surveying.
➢ Suitable for open ground, small area, level ground, preparing small-scale maps.
➢ Plane table survey instruments are heavy, cumbersome (बोझिलो) to carry.
➢ It's not suitable for work in wet climate.

*Principle of plane tabling

"lines drawn on the drawing sheet must be parallel to the corresponding lines on the ground."

1.3.1 Instrument used in plane tabling

A. Plane table with stand
➢ (40cm*30cm or 75cm*60cm)

B. Alidade or sight rule
➢ The alidade is useful for establishing a line of sight.
a. Plane Alidade:- simple and two sighting vane
b. Telescopic alidade:- inclined observation can be done

C. Spirit level
➢ A spirit level is required to ensure levelling the table surface.

D. Magnetic compass
➢ It is primarily used to orient the table by establishing the magnetic north direction, enabling accurate alignment and consistent plotting across all stations

E. Plumbing fork (for large scale surveys only).
➢ U-fork with plumb bob is used for centering
➢ Transferring station in the paper & vice versa

F. Drawing paper.
  ➢ The drawing paper in plane-table surveying serves as the stable plotting surface
  ➢ To record accurate, distortion-free field drawings.

*Setting Up of plane table
  a. Fixing the table
  b. Setting
       - Levelling
       - Centering
       - Orientation (whenever we are using more than one instrument station, orientation is essential. It can be done by using compass or back sighting.)
  c. Sighting

1.3.2 Method of Plane tabling
  The following are four methods of surveying with the plane table:-
  A. Radiation
    ➢ the whole surveying is to be done from one single station
    ➢ It is suitable for the survey of small areas which can be measured from a single station.
  B. Intersection
    ➢ Suitable when points are inaccessible.
    ➢ The objects on the others sides of the river.
    ➢ It is less accurate than radiation.
  C. Traversing
    ➢ It is suitable for congested area like town, forest etc.
    ➢ distances are generally measured by tachometric method,
    ➢ It is combination of intersection and radiation.
  D. Resection
    ➢ Process of determining plotted position of station
    ➢ The details are located either by radiation or intersection.
    ➢ It is done by sighting towards known station
    ➢ It is also known as fixing method. There are four methods of resection.
       - By Compass
       - By back sighting
       - By two-point problem -
       - By three-point problem

*Two point problem and Three point Problem
  ### a. Two Point Problem
  Locating and orienting the plane table at an unknown station by sighting two known points whose positions are already plotted on the drawing. It is less accurate and more tedious in nature.

  Let there be two points A and B whose locations have been plotted as a and b on the sheet. Let C be the instrument position whose location is required. As shown in figure:
  Procedure:
    ➢ While choosing point Q the triangle formed APQ and BPQ should be well-conditioned.
    ➢ Point Q is roughly oriented, and A and B are plotted in it. Similarly, alidade is sighted to P and name it P1.
    ➢ Now orient the plane table back sighting to Q produces the ray from A to intersect which is named p. also, draw the ray PB to intersect at line bp at B1
    ➢ Now, b and b1 points might not coincide due to the presence of angular error in it.

> To correct it, fix the point R along with the AB and rotate the table till the ab line is sighted to R. which is the correct orientation of A and B.
> Again, the resector line aA and bB are drawn to get position p of point P.

b. Three point problem

finding the location of the station occupied by a plane table on the sheet, by means of sighting to three well defined points whose locations have previously been plotted on the sheet, is known as three point resection.

- This can be achieved by any of the following methods:
  a) Mechanical method (tracing paper method)
  b) Graphical method (Bessel's method)
  c) Trial and error (Lehman's method)

1.4   Theodolite and traverse surveying

Theodolite is most precise instrument designed for measurement of horizontal and vertical angles.

> It is widely used in surveying such as laying off horizontal angles locating points on line, prolonging लम्ब्याउने survey lines, establishing grades, determining difference in elevation, setting out curve.
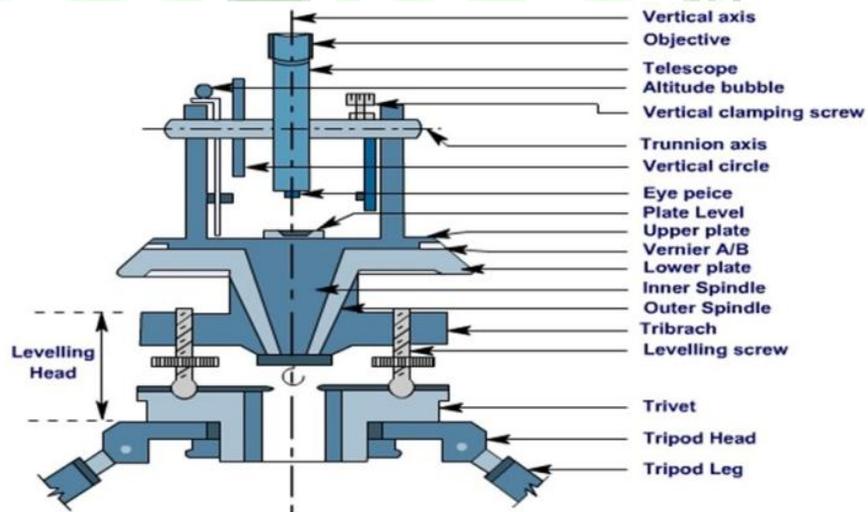
Parts of theodolite

Figure   Sectional view of a Thedolite

*Some terms

*Centering

> It is a process of setting up a theodolite exactly over ground station mark is known as centering.

*Vertical axis

> it's the direction of gravity and is indicated by freely suspended plumb bob.
> The axis about which the theodolite may be rotated in a horizontal plane.
> Axis about which lower & upper plate rotate about vertical axis.

*Horizontal axis

> It is also called the trunnion axis, elevation axis or transverse axis.
> The telescope is turned about the horizontal axis when measuring vertical angles.

.

*Axis of the level tube/bubble line/ Axis of the altitude level

> The straight line which is tangential to longitudinal curve of the level tube at it's center, is called axis of the level tube.

> If the bubble is at center this line is horizontal.

*Direct angle

> The angle measured clockwise from the preceding line in the following line is called direct angle.
> It is also known as azimuth angle. Value is (0-360)°.

*Deflection angle

> The angle which may be survey line makes with the prolongation लम्बाइ of the preceding line is called deflection angle.
> It's value (0-180)°.

*Transiting/reversing/plunging

> The process of turning the telescope in vertical plane through 180 degrees about its horizontal axis is known as transiting
> It's also called reversing and plunging.

*Swing

> The process of rotating the theodolite(telescope) in horizontal plane about vertical axis is known as swing.
> If the theodolite is rotated in clockwise direction is known as right swing otherwise left swing.

*Right face

> When the vertical circle of the theodolite is on the right side of the observer, the instrument is in the **right face** position
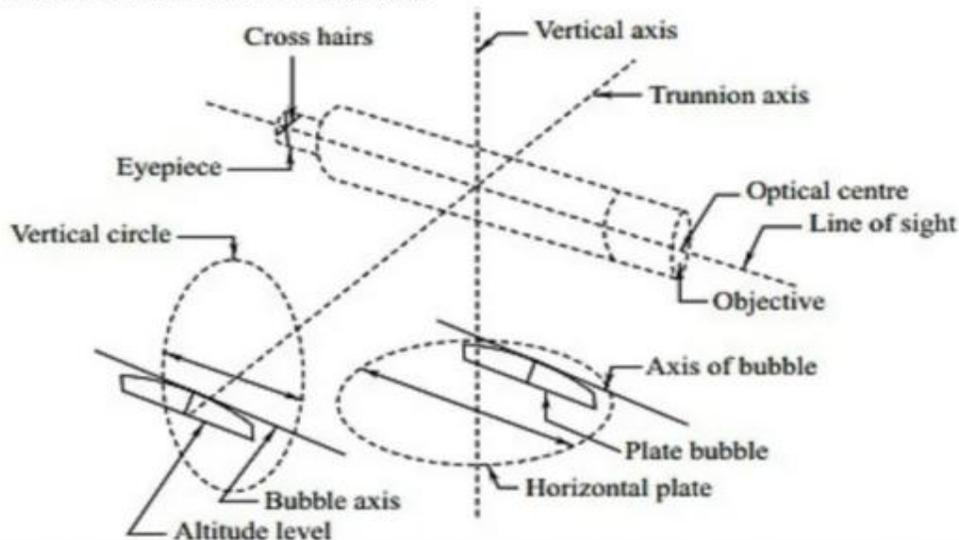
*Left face

> when the vertical circle is on the left side of the observer, the instrument is in the **left face** position.

*Line of sight and Line of collimation

> line passing through intersection of vertical & horizontal cross hair & optical center of objective its continuation.

*Fundamental axis

Fundamental lines & desired relations

> Axis of plate level bubble generates a horizontal plane perpendicular to the vertical axis.
> Horizontal axis should be perpendicular to the vertical axis.
> Line of collimation is perpendicular to the vertical axis.

> ➢ Axis of altitude level (telescope level) is parallel to line of collimation is horizontal.
> ➢ Vertical circle Vernier=0 when line of collimation is horizontal

Note:

*Lower plate:

- Represent size of theodolite (generally 10cm and 12cm), Graduation 0 to 360°.

*Upper plate

- It's in Vernier scale

Test

S.N.	Test	Description
1	Spire test	Horizontal axis perpendicular to vertical axis
2	Plate level test	VA perpendicular to axis of level tube
3	Azimuth test	Line of Collimation perpendicular to VA
4	Vertical arc index test	Axis of level tube parallel to line of collimation
5	Vertical cross hair test	Vertical hair perpendicular to HA

1.4.1 Basic difference between different theodolites

Theodolite may be classified as:

A. Based On telescope movement

a. Transit theodolite

> ➢ A transit theodolite is one in which the line of sight can be reversed by revolving the telescope through 180° in the vertical plane.
> ➢ Inverted position possible.
> ➢ Facilitates error minimization through face changes and averaging angles.
> ➢ Higher precision in angular measurements
> ➢ Widely used in modern surveying for its versatility बहुमुखि प्रतिभा and accuracy.

b. Non-Transit theodolite

> ➢ It's not transit
> ➢ inversion not possible.
> ➢ Limited capability for error reduction due to restricted rotation.
> ➢ Generally lower precision compared to transit theodolites.
> ➢ Less common in contemporary समकालिन surveying practices.

B. Theodolite are also classified

a. Analog theodolite/primary theodolite

In this type of theodolite, graduation are provided for reading horizontal and vertical.

b. Vernier theodolite

Vernier theodolite are provided for reading horizontal and vertical angles in Vernier theodolite.

c. Digital theodolite

Vertical and horizontal angles are directly shown in the digital display box.

1.4.2 Temporary adjustment of theodolite

- It's required to be made at every instrument station before making observation:

A. Setting over the station (centering)

B. Leveling

C. Elimination of parallax

> ➢ It is arised when the image formed by the objective is not in the plane of the cross-hairs.

1.4.3   Tacheometry: Stadia method ट्याकियोमेट्री

- ➢ Tacheometric is a branch of surveying in which horizontal and vertical distances are determined by taking angular observation with an instrument known as a tachometer.
- ➢ Tacheometry also known as telemetry.
- ➢ Tacheometric surveying is adopted in rough and difficult terrain where direct leveling and chaining are either not possible or very tedious. (i.e taping & chaining impossible e.g steep & broken).

*Instrument used in tacheometry survey

- ➢ **Tachometer:** a transit theodolite which contain stadia diaphragm and anallatic lens is known as tachometer.
- ➢ **Levelling staff or stadia rod:** for short distance suitable levelling staff and for long distance suitable stadia rod in tachometry survey.

*tachometry survey method

A. Stadia method

C. Tangential method

A.   Stadia Method

a.   Fixed hair method

- ➢ This method is based on the principle that the ratio of the perpendicular to the base is constant in similar isosceles triangles.
- ➢ Stadia hair is kept constant and where staff intercept is kept variable.
- ➢ This method is Commonly used method.

Case-I

Line of sight horizontal and staff is vertical

Horizontal distance D =(f/i)*s+(f+d)

Or, D=KS+C

Where,

K=f/I = multiplying constant

C=(f+d) = additive constant

F= focal length

S=staff reading (top-bottom)

P= stadia hair interval

Case-II

Line of sight inclined and staff in vertical

i. Horizontal distance D=(f/i)*s $\cos^2\theta^+$ (f+d) $\cos\theta$

D= ks $\cos^2\theta$+ c $\cos\theta$

ii.Vertical distance V=(f/i)* s $\cos\theta \sin\theta$+(f+d)$\sin\theta$

V= (ks* $\sin^2\theta$)/2+ c $\sin\theta$ [$\sin\theta \cos\theta = \sin2\theta/2$]

Case-III

Line of sight is inclined and staff is normal

i.Horizontal distance D=(f/i)*s $^+$ (f+d) $\cos\theta$+h $\sin\theta$

D= ks+c $\cos\theta$+h $\sin\theta$

ii. Vertical distance V=(f/i)*s +(f+d) $\sin\theta$

V= (ks+c) $\sin\theta$

*Anallatic lens: it is a convex lens provided in a telescope between the object lens and eye piece to eliminate the additive constant from the tacheometric equation. - it's fitted in external focusing telescope only.

b. **Movable hair method**
  ➢ In this method stadia hair is kept variable where as staff intercept is kept constant.
  ➢ Stadia hair is kept constant and where staff intercept is kept variable.
  ➢ This methods is not commonly used but now rarely used.

B. Tangential method
  ➢ In this method stadia diaphragm is not required on theodolite. The reading on a staff are taken against the horizontal cross hair.
  ➢ To calculate the horizontal and vertical distance two sets of vertical angle should be required.
  ➢ Generally center wire staff reading are done in whole number.

1.4.4 Trigonometric levelling

Trigonometric levelling is an indirect surveying method that determines the difference in elevation between two points by measuring vertical angle and horizontal distance between the instrument and target.
  ➢ It's generally used in topographical work to find out the elevation of the top of building. Chimneys, tower etc.

*Classification

A. Plain Trigonometric Levelling

Used over short distances where curvature/refraction effects are negligible.

B. Geodetic Trigonometric Levelling

Applied over long distances where curvature and refraction corrections are required.

***Problems of height and distances (plane trigonometry)**

Case-I: base of object accessible (directly method)
Case-II: base of object inaccessible (indirectly method)

1.4.5 Checks in closed traverse

*Traversing

A series of connecting straight line each joining two points on the ground is called traverse. This points are called traverse stations while straight line between two consecutive traverse stations is called traverse leg.
Types of traverse
A. Open traverse
  ➢ Starts at one point and ends at another, does not form a closed loop.
  ➢ Commonly used for route mapping (e.g., roads, pipelines).
  ➢ Accuracy cannot be checked through closure.

B. Closed traverse
  ➢ Begins and ends at the same or another known point, forming a loop.
  ➢ Allows error detection through closure checks (angle and distance sum rules).
  ➢ Suitable for boundary or area surveys like ponds or woods.

*checks in closed traverse

A. Angle Closure Checks
a. Sum of Interior Angles

$$\sum \text{Interior Angles}=(n-2)\times 180$$

Where n is the number of sides or stations.

b. Sum of Exterior Angles

$$\sum \text{Exterior Angles}=(n+2)\times 180$$

c. **Sum of Deflection Angles**

The algebraic sum (with right-turn positive, left-turn negative) should equal **360°**.

2. **Bearing Closure Check**

The **fore bearing** of the final traverse leg should equal the **back bearing** of the initial leg, adjusted by ±180°.

2. Latitude and Departure Closure

*latitude

➢ The latitude (N and S) of a survey line is defined as it's co-ordinates measured parallel to the assumed meridian.

➢ Latitude also called meridian.

➢ It may be positive(measured northward), which is termed as northing and negative (measured southword) which is termed as southing.

➢ The latitude of a survey line is given by

$$\text{Latitude} = l\cos\theta$$

*Departure

➢ The latitude (E and W) of a survey line is defined as it's co-ordinates measured perpendicular to the assumed meridian.

➢ Latitude also called perpendicular.

➢ It may be positive (measured eastward), which is termed as easting and negative (measured westword) which is termed as westing.

➢ The latitude of a survey line is given by

$$\text{Latitude} = l\sin\theta$$

Sum of Latitudes and **Sum of Departures** should both be zero in a perfectly closed loop, since net north-south and east-west displacement cancels out.

$$\sum \text{Latitudes}=0; \quad \sum \text{Departures}=0$$

Linear Misclosure is computed as:

$$\text{Closing error} =\sqrt{[(\sum \text{Latitudes})^2+(\sum \text{Departures})^2]}$$

*Balancing of traverse

a. **Bowditch rule**

➢ linear and angular precision is same or equal.

➢ Correction to any side

Latitude= total error in latitude*length of that side/perimeter of traverse

Departure = total error in departure*length of that side/perimeter of traverse

b. transit rule

➢ Angular measurement are more precise than the linear measurement.

➢ Correction to any side

Latitude= total error in latitude*length of that side/algebraic sum of all LATITUDE

Departure = total error in departure*length of that side/algebraic sum of all departure

*Compass Survey

Compass surveying is the branch of surveying in which the position of an object is located using angular measurements determined by a compass and linear measurements using a chain or tape.

It is used where free from magnetic effect

It is used for area comparatively large with undulations.

If there is a time limit for surveying, compass surveying is usually adopted.

*Technical terms

True meridian

The line passing through the true north and south poles of earth is known as true meridian.

Magnetic meridian

It's the standard reference line shown by freely balanced magnetic needle of compass.

Azimuth

The smaller horizontal angle between TM and survey line.

Magnetic declination/declination

The smaller horizontal angle TM and MM.

Bearing

The smaller horizontal angle MM and survey line.

True Bearing

The bearing of a survey line is measured from true meridian is known as true meridian.

True bearing= magnetic bearing +- declination

Where,

+ve = when declination is in east.

-ve when declination is in west.

Magnetic Bearing

The bearing of a survey line is measured from magnetic meridian is known as magnetic bearing.

*<u>Designation of bearing</u>

A. Whole circle bearing (Azimuthal bearing)

Always Measured from north direction only and run in clockwise direction.

C. Reduced Bearing (Quadrantal Bearing)

Measured from N and S poles which ever is nearer and run in either clockwise or anticlockwise.

*Fore Bearing and Back Bearing

Back bearing = fore bearing +- 180°

Where,

+ve = Fore bearing is less than 180.

-ve = Fore bearing is greater than 180.

*interior angle

Angle A = BB of DA - FB of AB

*<u>Dip</u>

It's the vertical angle θ=Dip.

It's the inclination between longitudinal axis of magnetic needle and horizontal through it pivot.

*Compass traverse

A. Open traverse

B. Close traverse

*Types of compass

A. Prismatic Compass

➢ It consist of circular box about 100mm diameter.

➢ It can be used as a hand instrument or on a tripod.

- ➢ Whole circle bearing system.
- ➢ Inverted (o-360) 0 at south end and run clockwise direction.
- ➢ Scale are attached to the needle.
- ➢ Generally used in survey work.

D. Surveyor's Compass
- ➢ This ring is graduated in quadrantal bearing system having 0° at N & S end, 90° at E & W ends.
- ➢ Tripod be required for observation.
- ➢ Reduced bearing (Quadrantal bearing) system.
- ➢ Erect (0-90) 0 at both north and south poles.
- ➢ Scale are attached to the box.
- ➢ Rarely used in survey work.

*Lines used in compass survey
A. **Agonic line**
   The line joining the point of zero declination is called agonic line.
B. **Isogonic line**
   The line joining the point of equal diclination is called isogonic line.
C. **Isoclinic line**
   The line joining the points of equal dip is called isoclinic line.

*Local Attraction

The sources of local attraction which may be current carrying wire, magnetic materials or metal object etc.

FB-BB=180° no local attraction.

FB-BB 180° local attraction.

***Deflection Angle**

- ➢ Angle between prolongation of preceding line and succeeding line.
- ➢ Algebraic sum of deflection angle =360°
- ➢ Deflection angle = 180 - internal angle
- ➢ Deflection angle varies from 0 to 180°.Clockwise deflection is called right deflection & it is additive.
- ➢ Anticlockwise deflection is left & is subtractive.

1.5 Contouring
- ➢ An Imaginary line on the ground surface joining the points of equal elevation is known as contour.
- ➢ This line on the map represents a contour is called **contour line**.
- ➢ **A** map showing contour lines is known as **contour map.**
- ➢ The process of tracing contour lines on the surface of the earth is called **contouring.**
- ➢ Contour is represented topographical map.

*Technical terms are:
A. Contour interval
   - ➢ The vertical distance between two consecutive contours is called contour interval.
   - ➢ The no. of contour lines are more in hills as compared to plains or same contour interval.
   - ➢ It depends on SANEPA

-scale of map

-availability of time

-nature of ground

-extent of survey

-purpose of map

-amount of permissible error

B. Contour gradient

➤ The imaginary line laying throughout on the surface of earth and preserving constant inclination to the horizontal is known as contour gradient.

➤ it is either as rising or falling gradient.

➤ Contour gradient= Contour interval / horizontal equivalent

C. Horizontal equivalent

➤ The minimum horizontal distance between two contour line is known as horizontal equivalent.

➤ The numerical value of horizontal equipment in hills is less as compare to plains.

D.Index contour

➤ Topography map may have many contour it is not possible to level the elevation of each contour line. To make the map easy to read every fifth contour line vertically in an index index contour.

1.5.1 Characteristic of contour lines

➤ All points in a contour line have the same elevation.

➤ Two contour lines cross each other in case of overhanging cliff

➤ Contour lines unite with each other in case of vertical cliff

➤ If contour lines are close = Steep slope

➤ If contour lines are equal space = Uniform slope

➤ If contour lines are flat = gentle slope

➤ Closed contour with higher value inside = Hill

➤ Closed contour with higher value outside = Depression

➤ Contour lines with U-shape with convexity towards lower = ridge

➤ Contour lines with V-shape with convexity towards higher = valley.

A HILL   A DEPRESSION   OVERHANGING CLIFF

RIDGE LINE   VALLEY LINE   OVERHANGING CLIFF

Prepared
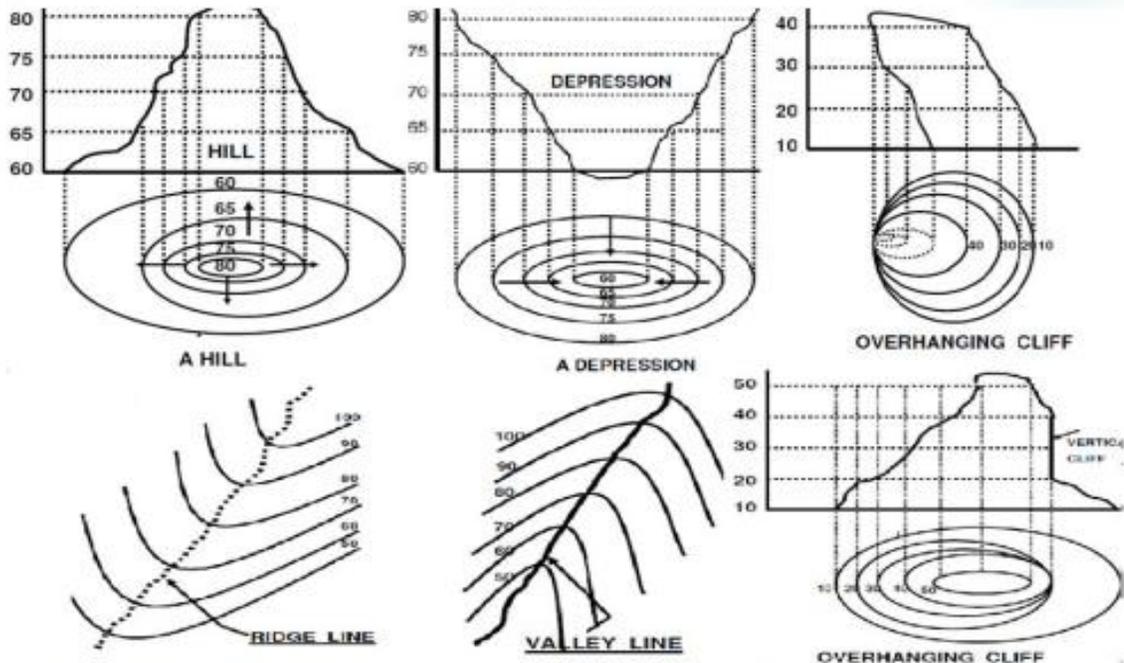
1.5.2   Method of locating contours
A. Direct method
- ➢ The direct method of contouring is a technique used in surveying to accurately trace and map contour lines by physically measuring them on the ground.
- ➢ This method is slow but most accurate.
- ➢ Suitable for small areas, where great/high accuracy is required.

B. Indirect Method
- ➢ In this method, spot level is taken at the regular interval along predetermine line on the ground the work is then plotted on plan by interpolation.
- ➢ This method is fast and not tedious.
- ➢ Suitable for small-scale surveys covering large areas.
- ➢ Also known as contouring by spot levels.

There are three primary approaches to gather spot levels:
- a. **Square(Grid) Method:** for plain/low undulation areas.
- b. **By cross section:** for Route survey -road, canal, railway etc.
- c. **Tacheometric (radial) method:** For high undulating/steep slope/hilly area areas.

*Use of contours
- ➢ **Drawing of sections**
- ➢ **Determination of inter visibility**
- ➢ **Tracing of contour gradient**
- ➢ **Measurement of catchment's area**
- ➢ **Selection of canal alignment**
- ➢ **Calculation of storage capacity of reservoir**

1.5.3   Contour plotting
Contour plotting is a way to display a three-dimensional surface in two dimensions, by drawing contour lines that connect points of equal value.

*How contour plotting works
- ➢ Collecting and preparing data
- ➢ Interpolating values
- ➢ Generating contour lines
- ➢ Refining for visualization

1.6   Setting Out/laying out
Transfer of architecture plan form paper to actual site.
1.6.1 Small building

*Required instrument and equipment are:

Equipment	Purpose	Use Case
Total Station	Measures angles and distances	Establishes control points and layout lines
Measuring Tape	Measures distances	Determines lengths and widths
Theodolite	Measures angles	Establishes precise angles
Dumpy/Laser Level	Establishes horizontal lines	Ensures consistent levels
Ranging Rods	Visual markers	Indicates specific points or lines
Surveying Pegs/Stakes	Marks reference points	Indicates positions of critical points
String Line & Pins	Creates straight lines	Aligns walls and components
Plumb Bob	Ensures vertical alignment	Checks verticality of structures
Cross Staff/Optical Square	Measures and sets right angles	Establishes perpendicular lines
Spirit Level	Checks surfaces	Ensures surfaces are level
Gradient Template	Checks and sets slopes	Ensures proper drainage and slope

*Procedure Setting out small building:

Step	Description
1. Site Preparation	Clear area and establish base control points
2. Baseline Setup	Define reference line from drawings
3. Corner Marking	Fix primary corner, measure adjacent walls
4. Accuracy Checks	Use 3-4-5 rule and compare diagonals
5. Profile Setup	Install rails and strings for guidance
6. Internal Offsets	Mark inner layout and foundation lines
7. Start Excavation	Dig based on precise layout, recheck before work

1.6.2   Setting out of Curves

A curve may be defined as the regular curve path which may be parabolic, circular or elliptical.

The main objective of curve is to change the direction of route. (alignment, road, canal , railway)

*Types of curve

A. Horizontal curve

     a. circular curve

    -simple curve. (when a curve is single arc of circle is known.)

    -compound curve

    -reverse curve

b. Transition curve (a curve of varying radius introduced between straight and circular curve)

c. Combined curve (combination of circular and transition curves)

B. **Vertical curve**

a. Summit curve

b. Valley curve

Radius is infinity at the junction of straight and transition curve.

*Element of Curve

A. **Point of Curvature (PC)**

The starting point of the curve where the first tangent (back tangent) meets the curve. Also called point of commencement.

B. **Point of Tangency (PT)**

The end point of the curve where the second tangent (forward tangent) meets the curve.

C. **Point of Intersection (PI)**

The point where the two tangents intersect.

D. **Radius (R)**

The radius of the circular arc that forms the curve. It determines the sharpness of the curve; a smaller radius indicates a sharper curve.

E. **Central Angle (Δ or I)**

The angle subtended at the center of the circle by the arc of the curve. It's also known as the intersecting angle (I) between the two tangents.

F. **Length of Curve (L_x)**

The length of the curve measured along the arc from PC to PT.

Length of curve=$(\pi R \Delta)/180$

G. **Tangent Length (T)**

The distance from the PI to either the PC or PT along the tangent.

- tangent length = R Tan $(\Delta/2)$

H. **Long Chord (LC)**

The straight-line distance from PC to PT.

Length of chord = 2R sin $(\Delta/2)$

I. **External Distance (E)**

The distance from the PI to the midpoint of the curve. It represents how far the curve lies from the line connecting the tangents. Also called apex distance.

- $E = R[\sec((\frac{\Delta}{2}) - 1]$

J. **Middle Ordinate (M)**

The perpendicular distance from the midpoint of the curve to the midpoint of the long chord.

K. **Angle of deflection**

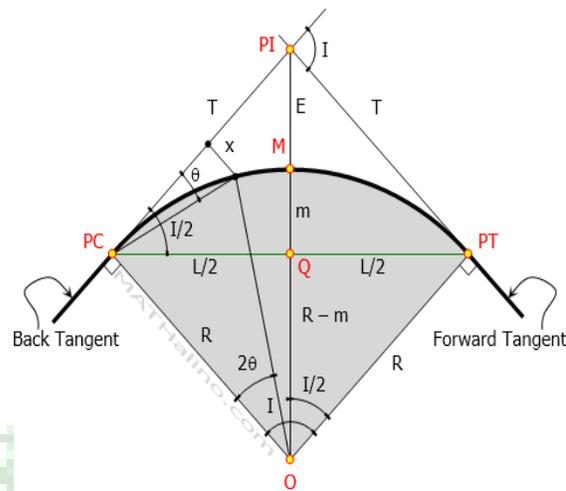the angle through which the forward tangent deflects is called angle of deflection of curve.

Figure 001. Circular Curve

*Setting out of simple circular curve

A. Linear methods:

The Linear Method involves measuring straight-line distances to determine points along the curve. This method is particularly useful for small-radius curves, such as those found in kerbs or boundary walls. Key techniques include:

   a. **Offsets from the Long Chord**: This involves measuring perpendicular distances (offsets) from the long chord at regular intervals to locate points along the curve.
   b. **Offsets from Chords Produced**: This method extends the chords beyond the curve and measures offsets to determine curve points.
   c. **Offsets from Tangent Lengths**: Offsets are measured from the tangent lines at regular intervals to establish points on the curve.
   d. **Successive Bisection of Arcs or Chords**: This technique divides the curve into smaller segments, bisecting each arc or chord to find intermediate points.

These methods are straightforward and suitable for smaller projects where high precision is not critical.

   B. Angular method

   By tangential method or deflection angle method or rankin's method.

   *All numerical and remaining part discuss in physical and online class.

1. **In plane surveying, which of the following assumptions is made?**
   A) Earth's curvature is accounted for
   B) Earth is treated as a curved surface
   C) Earth's surface is assumed flat (Plane)
   D) Plumb lines converge at Earth's center

2. **Geodetic surveying differs from plane surveying primarily because:**
   A) It has lower accuracy
   B) It ignores spherical geometry
   C) It considers Earth's curvature
   D) It uses simple instruments only

3. **For areas less than approximately _____, plane surveying can be used without significant error.**
   A) 260 km²
   B) 500 km²
   C) 1000 km²
   D) 2000 km²

4. **Which type of trigonometry is needed in geodetic surveying?**
   A) Plane trigonometry only
   B) Neither plane nor spherical trigonometry
   C) Both plane and spherical trigonometry
   D) Spherical trigonometry

5. **Which instruments are typical in geodetic surveying that are *not* commonly used in plane surveying?**
   A) Tape and chain
   B) Theodolite only
   C) GPS and GNSS receivers
   D) Compass and tape

6. **Which of the following is not true about plane surveying?**
   A) Curvature of the Earth is ignored
   B) Suitable for areas less than ~260 km²
   C) Degree of accuracy is high
   D) It uses plane triangles

7. **What is the typical area limit for applying plane surveying without significant error?**
   A) Greater than 500 km²
   B) 1000 km²
   C) Less than ~260 km²
   D) Any size; curvature is always negligible

8. **Which survey is made in connection with the construction of streets, water supply systems, and sewers?**
   a) Traverse surveying
   b) Hydrographic surveying
   c) Cadastral surveying
   d) City surveying

9. **Which of the following is a classification based on the instrument used?**
   a) Topographic surveying
   b) Hydrographic surveying
   c) Cadastral surveying
   d) Traverse surveying

10. **Determining points of strategic importance are called _____ surveying.**
    a) Topographic
    b) City
    c) Military
    d) Traverse

11. **For exploring mineral wealth which type of surveying is used?**
    a) Topographic
    b) Engineering
    c) Military
    d) Mine surveying

12. **Determining quantities or providing sufficient data for the design of roads and reservoirs is the role of _____ surveying.**
    a) Topographic
    b) Engineering
    c) City
    d) Cadastral

13. **Mapping natural features such as rivers and streams through horizontal and vertical measurements is characteristic of _____ surveying.**
    a) Topographic
    b) Engineering
    c) City
    d) Cadastral

14. **Which of the following is based on the nature of the field survey?**
    a) Topographic surveying
    b) Mine surveying
    c) Military surveying
    d) Chain surveying

15. **Which of the following is NOT classified by instrument or method?**
    a) Chain surveying
    b) Topographic surveying
    c) Traverse surveying
    d) Aerial surveying

16. **A survey used for water navigation, harbor works, or mean sea level determination is called _____ surveying.**
    a) Topographic
    b) Hydrographic
    c) Cadastral
    d) City

17. **A reconnaissance survey in engineering primarily aims to**
    a) Establish control points
    b) Collect detailed measurements
    c) Identify suitable project locations
    d) Boundary demarcation

18. **Which survey determines the relative positions of points using angular and linear measurements on a global scale?**
    a) Topographic
    b) Geodetic
    c) Hydrographic
    d) Route

19. **The primary goal of a control survey is to**
    a) Measure for detailed mapping
    b) Establish reference points for other surveys
    c) Determine elevations and terrain contour
    d) Profile existing structures

20. **Which survey type is used to define precise property boundary locations?**
    a) Topographic
    b) Cadastral
    c) Route
    d) Construction

21. **What purpose does a stakeout survey serve in construction?**
    a) Map site topography
    b) Establish control points
    c) Mark exact structure placement
    d) Create terrain elevation profiles

22. **Which survey focuses on waterbody depths and features?**
    a) Topographic
    b) Cadastral
    c) Hydrographic
    d) Geodetic

23. **Route surveying is primarily conducted to**
    a) Define property ownership
    b) Set control points
    c) Design transport corridors
    d) Measure earthwork volumes

24. **Which type of survey captures physical surface features and elevations?**
    a) Hydrographic
    b) Geodetic
    c) Topographic
    d) Cadastral

25. **Monitoring surveys are used to**
    a) Set reference points
    b) Measure structural changes over time
    c) Map waterbodies
    d) Profile terrain elevations

26. **A survey conducted to establish legal property boundaries falls under which category?**
    a) Hydrographic survey
    b) Cadastral survey
    c) City survey
    d) Engineering survey

27. **Which field-based survey type is used to support the design of projects like roads, bridges, or reservoirs?**
    a) Cadastral
    b) Hydrographic
    c) Engineering surveying
    d) Astronomical surveying

28. **A survey undertaken to gather information about geological strata (layers of soil/rock) would be classified as**
    a) Topographic survey
    b) Cadastral survey
    c) Geological survey
    d) Mining survey

29. **Observation and establishment of global positional coordinates using celestial bodies is characteristic of:**
    a) Hydrographic survey
    b) Astronomical survey
    c) Engineering survey
    d) Military survey

30. **Surveys aimed at discovering ancient artifacts and mapping heritage sites are classified as:**
    a) Archaeological survey
    b) Hydrographic survey
    c) Military survey
    d) Geological survey

31. **Which survey method uses only linear measurements and no angular measurements?**
    a) Chain surveying
    b) Compass surveying
    c) Theodolite surveying
    d) Plane table surveying

32. **Compass surveying primarily uses which instrument to determine directions?**
    a) Theodolite
    b) Total station
    c) Prismatic compass
    d) Abney level

33. **Plane table surveying typically uses which instrument to sight and draw lines on-site?**
    a) Prism square
    b) Plumb bob
    c) Alidade
    d) Graphometer

34. **Which instrument is commonly used for performing trigonometric leveling and vertical angle measurements?**
    a) Dumpy level
    b) Theodolite
    c) Open cross-staff
    d) Clinometer

35. **For rapid surveying with distance and elevation determined indirectly, which instrument is essential?**
    a) Abney level
    b) Tachaeometer
    c) GPS receiver
    d) Optical square

36. **Which of the following surveys is classified by the use of photogrammetric instruments?**
    a) Theodolite surveying
    b) Photogrammetric surveying
    c) Cylinder surveying
    d) Compass surveying

37. **Which instrument is used to measure slope or angle of ground and is often part of minor survey tools?**

    a) Optical square
    b) Clinometer or Abney level
    c) French cross-staff
    d) Ranging rod

38. **Which set of instruments below is typically used in chain surveying to set out right angles?**
    a) Dumpy level and chain
    b) Cross staff, optical square, prism square
    c) Theodolite and compass
    d) GPS and total station

39. **What is the classification for surveying that uses total stations combining angular and distance measurements?**
    a) Chain surveying
    b) Compass surveying
    c) Theodolite surveying
    d) Total station surveying

40. **Which instrument is used to orient plane tables by aligning to magnetic north?**
    a) Spirit level
    b) Plumbing fork
    c) Compass
    d) Alidade

41. **Which method divides the area into a network of triangles to establish control points?**
    a) Traverse surveying
    b) Triangulation surveying
    c) Trilateration surveying
    d) Plane table surveying

42. **Which method involves connecting a series of straight survey lines, forming either an open or closed polygon?**
    a) Triangulation surveying
    b) Traverse surveying
    c) Tachaeometric surveying
    d) Photogrammetric surveying

43. **Which approach involves measuring only lengths between points and computing angles afterwards?**
    a) Traverse surveying
    b) Triangulation surveying
    c) Trilateration surveying
    d) Tacheometric surveying

44. **Which surveying method improves angular accuracy by repeating measurements multiple times?**
    a) Repetition method

b) Trilateration

c) Traverse surveying

d) Plane-table surveying

45. **Which method integrates angle measurements and electronic distance measurements into one instrument?**

a) Tacheometry

b) Theodolite surveying

c) Total station surveying

d) Compass surveying

46. **Which method determines distances and elevations indirectly using stadia measurements?**

a) Trilateration

b) Tachaeometric surveying

c) Traverse surveying

d) Triangulation surveying

47. **Which method belongs to modern aerial or satellite-based surveying techniques?**

a) Plane-table surveying

b) EDM surveying

c) Photogrammetric or remote-sensing surveying

d) Traverse surveying

48. **Choosing between triangulation or traverse as the primary method depends largely on**

a) Terrain type and equipment availability

b) Surveyor's preference

c) Weather conditions

d) Legal boundaries

49. Which of the following is *the* first principle of surveying?

A) Part to part

B) Part to whole

C) Whole to part

D) Whole to whole

50. **Why is the "whole to part" principle followed in surveying?**

A) It speeds up the survey

B) It reduces manpower

C) It prevents accumulation of errors

D) It enhances mapping aesthetics

51. **The "whole to part" principle also helps to**

A) Improve plotting accuracy

B) Eliminate localized errors

C) Both A and B

D) None of the above

52. **The main *principle* of surveying—"work from whole to part"—also known as**

A) Control framework method

B) Error accumulation principle

C) Subdivision approach

D) Independent check principle

53. **In practical implementation, surveying typically proceeds as**

A) Detail points $\longrightarrow$ control points

B) Control network $\longrightarrow$ detail mapping

C) Random points $\longrightarrow$ fixed stations

D) Whole $\longrightarrow$ nothing

54. **A new survey station is established by measuring from two known control points. This principle is best described as**

A) Location of a point by one reference point

B) Location of a point by measurements from two points of reference

C) Location of a point by three reference points

D) Working from part to whole

55. **The principle of "consistency in work" in surveying emphasizes that**

A) Different methods and instruments should be used to cross-check quality

B) The same procedures and instruments should be used throughout a project

C) Observations should rely on the most advanced instruments for all tasks

D) Measurements should always be independent and duplicated across entries

56. **The principle of** independent check **in surveying emphasizes that**

A) The same surveyor should perform all measurements to maintain consistency

B) Each measurement must be verified using at least two different observers or methods

C) Only high-accuracy instruments should be used throughout the project

D) Field checks are unnecessary if the control network is accurate

57. **In surveying, the** principle of accuracy and economy **states that**

A) Surveys should use the most precise instruments available, regardless of cost

B) A survey should be as accurate as necessary, but not more so than required

C) Surveys must always aim for maximum accuracy, even if it increases cost

D) Accuracy and economy are competing goals and should be balanced equally

58. **When selecting the most appropriate surveying method for a particular project, which principle should govern the choice?**
    A) Principle of maximum accuracy
    B) Principle of cost minimization
    C) Principle of suitability
    D) Principle of observer preference

59. **When drawings are drawn smaller than the actual size of the objects, the scale used is called**
    A) Enlarging scale
    B) Reducing scale
    C) Representative scale
    D) Graphical scale

60. **If the scale of a map is represented by a representative fraction (R.F.) of 1:4000, and the distance between two points A and B on the map is 10 cm, what is the actual distance between A and B on the ground?**
    A) 0.4 km
    B) 4 km
    C) 40 km
    D) 400 km

61. **An engineer's scale is a type of scale used in engineering drawings. Which of the following is a characteristic of an engineer's scale?**
    A) It uses a representative fraction (RF) to denote scale
    B) It is primarily used for small-scale maps
    C) It is designed for measuring distances on drawings directly
    D) It is not suitable for architectural plans

62. **Which term below is another name for graphical scale?**
    A) Verbal scale
    B) Representative fraction
    C) Linear scale
    D) Statement scale

63. **What is the major advantage of using a graphical scale on maps?**
    A) Easier to understand verbally
    B) More precise than RF
    C) Remains accurate even if map is resized
    D) Written in local languages

64. **Which of the following best describes a graphical scale?**

A) A written statement like "1 cm to 1 km"
B) A fraction such as 1:25,000
C) A line bar marked with ground distances
D) A notation of units used on the map

65. **What does the Vernier scale on a caliper enable you to do?**
    A) Measure weight
    B) Increase measurement precision beyond main scale
    C) Avoid parallax error completely
    D) Automatically zero the instrument

66. **How many Vernier divisions typically align with 9 main scale divisions?**
    A) 5
    B) 9
    C) 10
    D) 15

67. **The scale of chords is used to measure:**
    A) Length
    B) Radius
    C) Angle
    D) Diameter

68. **How is a scale of chords constructed?**
    A) Dividing a straight line into equal parts
    B) Laying out radial lines
    C) Drawing an arc, marking equal angle divisions, and projecting chords onto a line
    D) Using graduated concentric circles

69. **What is a key advantage of the scale of chords?**
    A) Works even if map is resized
    B) Better length precision than vernier
    C) Enables angle measurement when no protractor is available
    D) Measures depth and elevation

70. **The ratio of shrunk length to original length is called:**
    A) Shrinkage factor
    B) Shrinkage ratio
    C) Correction factor
    D) Both (A) and (B)

71. **Shrunk scale is related to original scale by:**
    A) Original scale × shrinkage factor
    B) Shrunk scale × shrinkage factor
    C) Vernier scale × shrinkage factor
    D) Diagonal scale × shrinkage factor

72. **What is the *least count* of a measuring instrument?**
    A) Largest value it can measure
    B) Smallest value it can resolve
    C) Maximum error of the instrument
    D) Total number of divisions on the scale

73. **What is the primary objective of creating a survey plan?**
    A) To determine the relative positions of points on the earth's surface
    B) To calculate the area of land
    C) To estimate construction costs
    D) To design building structures

74. **Which of the following is a key purpose of maps in civil engineering?**
    A) To provide detailed topographical information for design and construction
    B) To calculate material quantities
    C) To schedule construction activities
    D) To estimate project costs

75. **Which of the following is NOT a typical use of survey plans and maps?**
    A) Planning construction projects
    B) Determining property boundaries
    C) Estimating construction costs
    D) Designing building structures

76. **Which of the following is a common surveying method used to create plans and maps?**
    A) Remote sensing
    B) Plan surveying
    C) Geotechnical testing
    D) Structural analysis

77. **In plan surveying, what is the primary focus?**
    A) Measuring vertical distances
    B) Measuring horizontal distances and angles
    C) Analyzing soil properties
    D) Assessing structural integrity

78. **What does a small-scale map typically represent?**
    A) Detailed features of a small area
    B) Generalized features of a large area
    C) Precise measurements of a specific site
    D) Architectural designs of a building

79. **What is the primary characteristic of a large-scale map?**
    A) It covers a large geographic area with minimal detail.
    B) It covers a small geographic area with detailed features.
    C) It is used for global navigation.
    D) It shows only political boundaries.

80. **What is the primary purpose of a map?**
    A) To provide detailed topographical information
    B) To represent geographical areas on a flat surface
    C) To calculate distances between locations
    D) To display political boundaries

81. **What does a theodolite primarily measure?**
    A. Horizontal angles only
    B. Vertical angles only
    C. Both horizontal and vertical angles
    D. Distances using laser

82. **A total station combines which two main surveying techniques?**
    A. Compass and chain
    B. Leveling and tape measurement
    C. Electronic theodolite and EDM
    D. Topographic mapping and photogrammetry

83. **How is an Abney level typically used in surveying?**
    A. Measuring chain length
    B. Reading vertical and slope angles
    C. Recording angles between stations
    D. Determining magnetic bearings

84. **In a prismatic compass, where is the zero mark on the graduated ring?**
    A. North
    B. East
    C. South
    D. West

85. **Which instrument is used for measuring the area on a contour or plotted map?**
    A. Clinometer
    B. Planimeter
    C. Graphometer
    D. Alidade

86. **What is the primary principle behind the pacing method in surveying?**
    A) Measuring distance by counting revolutions of a wheel
    B) Walking and counting paces, then multiplying by pace length
    C) Using a handheld electronic device to record steps
    D) Calibrated to give speed directly

87. **Which of the following best describes a passometer?**
    A) A device that measures distance by wheel revolutions
    B) An instrument carried by hand that counts steps
    C) A device attached to a vehicle for speed and distance
    D) A watch-like instrument carried vertically that counts paces automatically

88. **What does a pedometer record compared to a passometer?**
    A) Paces only
    B) Distance directly rather than just steps
    C) Wheel revolutions
    D) Speed directly

89. **An odometer in surveying is which of the following?**
    A) Records number of paces the surveyor takes
    B) Calculates distance based on wheel revolutions
    C) Displays distance automatically as you walk
    D) Used only indoors

90. **In the context of surveying approximate linear measurement, a speedometer is:**
    A) A handheld instrument for counting steps
    B) A device similar to a passometer
    C) An odometer calibrated to give distance directly
    D) A precision tape measure

91. **Which tape type is light, flexible, and prone to shrinkage in wet conditions?**
    A. Steel tape
    B. Invar tape
    C. Cloth/linen tape
    D. Synthetic tape

92. **Which tape is reinforced with metal wires (e.g., brass or copper) woven into cloth for improved durability?**
    A. Synthetic tape
    B. Woven metallic tape
    C. Invar tape
    D. Steel tape

93. **Which tape is made of a steel strip and is commonly used for relatively accurate horizontal measurements on flat terrain?**
    A. Invar tape
    B. Synthetic tape
    C. Steel tape
    D. Cloth tape

94. **Which tape is light, flexible, and particularly safe to use around electric or railway installations?**
    A. Steel tape
    B. Synthetic/Fiberglass tape
    C. Invar tape
    D. Cloth tape

95. **Which type of tape is made from a nickel–steel alloy offering extremely low thermal expansion, ideal for high-precision baseline measurements?**
    A. Steel tape
    B. Synthetic tape
    C. Invar tape
    D. Cloth tape

96. **How many types of chains are commonly used in chain surveying?**
    A. 4   B. 5   C. 6   D. 8

97. **Which chain is 66 ft long and consists of 100 links?**
    A. Metric chain   B. Gunter's chain   C. Engineer's chain   D. Revenue chain

98. **Which type of chain is 100 ft long with 100 links (each link 1 ft)?**
    A. Metric chain   B. Gunter's chain   C. Engineer's chain   D. Steel band chain

99. **What is the length and number of links of a metric chain (in India)?**
    A. 20 m, 100 links   B. 30 m, 150 links   C. Both A & B   D. None

100. **Which chain is typically 33 ft long and used in cadastral/revenue surveys?**
    A. Metric chain   B. Gunter's chain   C. Engineer's chain   D. Revenue chain

101. **Chain Surveying is suitable for _____.**
    A. All types of ground
    B. Fairly level ground
    C. Uneven ground
    D. Highly detailed, crowded terrain

102. **Chain Surveying uses which principle?**
    A. Quadrangulation
    B. Triangulation
    C. Orientation
    D. None of these

103. **A well-conditioned triangle in chain surveying ideally has angles:**
    A. Nearly 60°
    B. Greater than 120°

C. Less than 30° or greater than 120°

D. None of these

104. **How many types of chains are commonly used?**

A. 4

B. 5

C. 6

D. 8

105. **Gunter's chain consists of how many links?**

A. 500

B. 50

C. 1000

D. 100

106. **The process of locating intermediate points on a survey line is called:**

A. Aligning

B. Extending

C. Ranging

D. Offsetting

107. **An** offset **in chain surveying is the _____ distance from the survey line.**

A. Lateral

B. Horizontal

C. Normal

D. Inclined

108. **Which is the** simplest instrument **for setting right angles?**

A. Cross staff

B. Optical square

C. Prism square

D. Site square

109. **Which of the following is** not required **equipment for chain surveying?**

A. Dumpy level

B. Pegs

C. Arrows

D. 20 m chain

110. **Errors that occur consistently in the same direction and accumulate over the survey line are called:**

A. Compensating errors

B. Cumulative errors

C. Gross errors

D. Random errors

111. **Which of the following is an example of a** positive cumulative error**?**

A. Chain used was longer than standard

B. Temperature higher than calibration temperature

C. Chain held non-horizontally on slope

D. Arrow misplacement during chaining

112. **Errors that may occur in either direction and tend to cancel out on long measurements are known as:**

A. Random errors

B. Compensating errors

C. Gross errors

D. Systematic errors

113. **Which type of error is due to carelessness, misreading, or booking mistakes and can be eliminated?**

A. Cumulative error

B. Compensating error

C. Gross error (blunder)

D. Systematic error

114. **Which type of error is** least serious, **being likely to partially cancel out over long surveys?**

A. Cumulative error

B. Random error

C. Compensating error

D. Gross error

115. **A chain found to be 0.10 m longer than standard during calibration leads to:**

A. Positive cumulative error

B. Negative cumulative error

C. Compensating error

D. Random error

116. **One primary objective of error correction in chain surveying is to:**

A. Increase survey speed

B. Ensure measurement accuracy

C. Avoid using instruments

D. Simplify field work

117. **Chain standardization correction is needed because:**

A. Chain alignment may be off

B. Tape length varies with temperature

C. Actual tape/chain length may differ from its nominal length

D. The survey line is sloped

118. **What is a Benchmark (BM)?**

A. A line of sight to the rod

B. A reading taken at an unknown point

C. A fixed point with known elevation used as a

reference

D. A staff held vertical at each station

119. **What does BS (Back Sight) refer to in levelling?**

A. Final staff reading

B. First staff reading taken on a known point after setting up the instrument

C. An intermediate reading

D. The arithmetic check of readings

120. **What does FS (Fore Sight) refer to in levelling?**

A. Intermediate reading

B. Final reading on a new point whose elevation is to be determined

C. Reading on benchmark

D. Arithmetic check value

121. **What is the Reduced Level (RL)?**

A. Elevation of instrument eye above ground

B. Vertical distance between a point and an assumed datum

C. Horizontal distance from instrument to staff

D. Reading between two stamps on the levelling rod

122. **Which term describes the procedure of setting up the level at a new location and taking a backsight on the last turning point?**

A. Cross levelling

B. Check levelling

C. Turning the level

D. Fly levelling

123. **Which of the following is NOT a recognized levelling instrument?**

A. Dumpy Level

B. Automatic Level

C. Laser Level

D. Barometer

124. **What is the primary objective of levelling in surveying?**

A. To measure horizontal distances

B. To determine the elevation of points relative to a datum

C. To calculate area and volume

D. To establish boundary lines

125. **Which instrument is commonly used in levelling to measure height differences?**

A. Theodolite

B. Total Station

C. Levelling Staff (Rod)

D. Compass

126. **In levelling, what does the term 'Reduced Level (RL)' refer to?**

A. The height of the instrument above the ground

B. The vertical distance of a point from a reference datum

C. The horizontal distance between two points

D. The angle of elevation from the instrument to the point.

127. **In levelling, what does the term 'Back Sight (BS)' refer to?**

A. The final reading taken at a station

B. The first reading taken at a station on a known point

C. The difference in height between two points

D. The instrument's height above the ground\

128. **Which of the following lists the two principal methods used to reduce level-book (backsight/intermediate/foresight) data to reduced levels (R.L.) in spirit leveling?**

A) Trigonometric & Barometric methods

B) Height of Instrument (Collimation) & Trigonometric method

C) Reciprocal & Trigonometric methods

D) Height of Instrument (HI) method & Rise and Fall method

129. **When using the rise-and-fall method, which of the following arithmetic checks ensures internal consistency of the leveling computations:**

A) ΣB.S. – ΣF.S. = Last R.L. – First R.L.

B) ΣB.S. – ΣF.S. = ΣRise – ΣFall = Last R.L. – First R.L.

C) H.I. = R.L. + B.S.

D) R.L. = H.I. – (I.S. / F.S.)

130. **In the HI (Height of Instrument) method, the reduced level (R.L.) for a point is obtained as:**

A) R.L. = H.I. + F.S.

B) R.L. = H.I. – I.S./F.S.

C) R.L. = Previous R.L. + Rise

D) R.L. = ΣB.S. – ΣF.S.

131. **What is the correct formula to determine the Height of Instrument (H.I.) at a given instrument setup?**

A) H.I. = Elevation of change point + Foresight (F.S.)

B) H.I. = Elevation of Bench Mark + Backsight (B.S.)

C) H.I. = Foresight + Backsight

D) H.I. = Intermediate Sight (I.S.) + Backsight

132. **Once the H.I. is established, how do you compute the Reduced Level (R.L.) of a point from its staff reading (whether it's I.S. or F.S.)?**

A) R.L. = H.I. + Staff reading

B) R.L. = Staff reading − H.I.

C) R.L. = H.I. − Staff reading

D) R.L. = Previous R.L. ± (Rise & Fall)

133. **Which arithmetic check is commonly applied when using the H.I. method to verify the computations?**

A) $\Sigma BS - \Sigma FS = \Sigma Rise - \Sigma Fall$

B) $\Sigma FS - \Sigma BS = $ First R.L. − Last R.L.

C) $\Sigma BS - \Sigma FS = $ Last R.L. − First R.L.

D) Σ(Intermediate sights) = 0

134. **Which of the following best describes a limitation of the Height of Instrument method compared to the Rise & Fall method?**

A) It requires double the number of instrument setups

B) It is slower and involves more arithmetic

C) It does not detect errors in intermediate sight readings

D) It needs a trigonometrical correction

135. **In the** Rise-and-Fall method**, how is the rise or fall between two consecutive staff readings defined?**

A) Rise or fall = Backsight − Foresight

B) Rise or fall = Foresight − Backsight

C) Rise or fall = Previous staff reading − Next staff reading

D) Rise or fall = Next staff reading − Previous staff reading

136. **How is the Reduced Level (R.L.) of a station computed using Rise-and-Fall data?**

A) $R.L._n = R.L._{n-1} + $ (Next staff reading − Previous)

B) $R.L._n = R.L._{n-1} + $ Rise (if B.S. − F.S. > 0), or − Fall

C) $R.L._n = $ Height of Instrument − Staff reading

D) $R.L._n = R.L._0 + (\Sigma Rise - \Sigma Fall)$

137. **What is the standard arithmetic check used to validate computations in the Rise-and-Fall method?**

A) $\Sigma B.S. - \Sigma F.S. = $ Last R.L. − First R.L.

B) $\Sigma Rise - \Sigma Fall = \Sigma B.S. - \Sigma F.S. = $ Last R.L. − First R.L.

C) ΣIntermediate Sights = $\sum$Backsights + $\sum$Foresights

D) H.I. = R.L. + B.S.

138. **Which of the following best describes a major advantage of the Rise-and-Fall method over the Height of Instrument method?**

A) Faster computation when many intermediate sights are used

B) Simpler bookkeeping with fewer arithmetic steps

C) Internal error detection for every station, including intermediate sights

D) Ability to compute H.I. without benchmarks

139. **Which type of levelling uses the difference in atmospheric pressure to determine elevation difference?**

A) Trigonometric levelling

B) Spirit (direct) levelling

C) Barometric levelling

D) Profile levelling

140. **Which of these is** not **a recognized method of levelling?**

A) Barometric levelling

B) Trigonometric levelling

C) Spirit levelling

D) Traverse levelling

141. **Which method calculates elevation differences using vertical angles and horizontal distances?**

A) Barometric levelling

B) Trigonometric levelling

C) Spirit levelling

D) Traverse levelling

142. **Which is the most commonly used type of levelling, using a spirit level and staff directly?**

A) Barometric levelling

B) Trigonometric levelling

C) Direct (spirit) levelling

D) Traverse levelling

143. **Which of the following are sub-types of direct levelling?**

A) Simple levelling

B) Differential levelling

C) Fly levelling

D) all of above

144. **Which type of levelling is used when measuring elevation across obstacles like rivers with reciprocal observations?**
     A) Differential levelling
     B) Profile levelling
     C) Cross-section levelling
     D) Reciprocal levelling

145. **A horizontal line departs from a level surface because of**
     A) Refraction
     B) Radius of earth
     C) Curvature of earth
     D) Parallelism

146. **On long sights, the horizontal line of sight bends downward (concave toward Earth) due to**
     A) Refraction
     B) Radius of earth
     C) Curvature
     D) Parallelism

147. **The formula for curvature correction (in meters) over a distance ddd in km is:**
     A) $0.0785 \times d2$
     B) $-0.0785 \times d2$
     C) $+0.0673 \times d2$
     D) $-0.0673 \times d2$

148. **The combined correction due to curvature and refraction (in meters, with d in km) is** approximately:
     A) $-0.0785d2 + 0.0112d2$
     B) $+0.0673d2$
     C) $-0.0673d2$
     D) $0.095d2$

149. **In levelling, the type of surveying where curvature of the Earth must be considered is called:**
     A) Geodetic surveying
     B) Plane surveying
     C) Differential levelling
     D) Trigonometric levelling

150. Horizontal line departs from a level surface because of
     A) Refraction
     B) Radius of Earth
     C) Curvature of Earth
     D) Parallelism

151. In long sights, the horizontal line of sight slightly bends downward (concave) due to
     A) Refraction
     B) Radius of Earth
     C) Curvature of Earth
     D) Parallelism

152. Find the correction for refraction over a distance of 1,200 m:
     A) 0.0106 m
     B) 0.0160 m
     C) 0.0016 m
     D) 0.0116 m

153. The correction for refraction is approximately what fraction of the curvature correction?
     A) 1/5
     B) 1/6
     C) 1/7
     D) 1/8

154. **In levelling instruments,** temporary adjustments **include:**
     A) Axis of bubble tube perpendicular to vertical axis
     B) Line of collimation parallel to bubble axis
     C) Setting up, levelling up, and elimination of parallax
     D) Two-peg test

155. **Which of the following is a** permanent adjustment **of a dumpy level?**
     A) Setting up the level
     B) Levelling up
     C) Axis of level tube perpendicular to vertical axis
     D) Focusing (Elimination of parallax)

156. **Which of the following statements is** true **regarding adjustments in levelling instruments?**
     A) Temporary adjustments are done only once when the instrument is manufactured.
     B) Permanent adjustments include centering and levelling up.
     C) Temporary adjustments are performed before each setup and include focusing.
     D) Permanent adjustments are done at every setup.

157. **Plane tabling is a _____ method of surveying.**
     A) Analytical

B) Graphical

C) Mathematical

D) None of the above

158. **Which instrument is used to sight an object during plane-table surveying?**

A) Compass

B) U-frame

C) Plumbing fork

D) Alidade

159. **Which instrument is used for levelling a plane table?**

A) Plumb bob

B) Spirit level

C) Compass

D) U-frame

160. **Which of the following is *not* an accessory of plane table surveying?**

A) Spirit level

B) Plumb bob

C) Compass

D) Theodolite

161. **A plumbing fork with a plumb bob is used for which purpose?**

A) Levelling

B) Sight to object

C) Centering the table

D) Orientation

162. **Which type of alidade increases accuracy and allows inclined sightings?**

A) Plain alidade

B) Telescopic alidade

C) Both A and B

D) None of the above

163. Contour interval is
    a.   The vertical distance between two consecutive contours
    b.   The horizontal distance between two consecutive contours
    c.   The vertical distance between two points on same contour
    d.   The horizontal distance between two points on same contour
164. Check lines (or proof lines) in Chain Surveying, are essentially required
    a.   To plot the chain lines
    b.   To plot the offsets
    c.   To indicate the accuracy of the survey work
    d.   To increase the out-turn
165. There are two stations A and B. Which of the following statements is correct?
    a.   The fore bearing of AB is AB
    b.   The back bearing of AB is BA
    c.   The fore and back bearings of AB differ by 180°
    d.   All the above
166. *In direct method of contouring, the process of locating or identifying points lying on a contour
     is called
    a.   Ranging
    b.   Centring
    c.   Horizontal control
    d.   Vertical control
167. The Random errors tend to accumulate proportionally to
    a.   Numbers of operations involved
    b.   Reciprocal of operations involved
    c.   Square root of the number of operation involved
    d.   Cube root of the number of operation involved
168. Detailed plotting is generally done by
    a.   Radiation
    b.   Traversing
    c.   Resection
    d.   All of the above
169. Which of the following methods is more suitable in case of small distances?
    a.   Traversing
    b.   Radiation
    c.   Resection
    d.   Intersection
170. Which of the following methods is having a wider scope with the use of tacheometer?
    a.   Resection
    b.   Trisection
    c.   Intersection
    d.   Radiation
171. Which of the following can give the best output?

    a.   Traversing
    b.   Intersection
    c.   Resection
    d.   Radiation

172. Which of the following is used for locating details of the station points?
    a.   Radiation
    b.   Intersection
    c.   Trisection
    d.   Traversing

173. Which of the following methods is a widely used method of plane tabling?
    a.   Radiation
    b.   Intersection
    c.   Traversing
    d.   Resection

174. Which of the following methods can be useful in having an enlarged output?
    a.   Intersection
    b.   Resection
    c.   Traversing
    d.   Radiation

175. In levelling operation
    a.   When the instrument is being shifted, the staff must not be moved
    b.   When the staff is being carried forward, the instrument must remain stationary
    c.   Both (a) and (b)
    d.   Neither (a) nor (b)

176. Volume of the earth work may be calculated by
    a.   Mean areas
    b.   End areas
    c.   Trapezoidal
    d.   All the above

177. Which among the following set share the same working principle?
    a.   Traversing and Radiation
    b.   Traversing and trisection
    c.   Traversing and Resection
    d.   Traversing and intersection

178. Bowditch rule is applied to
    a.   An open traverse for graphical adjustment
    b.   A closed traverse for adjustment of closing error
    c.   Determine the effect of local attraction
    d.   None of the above

179. Straight, parallel and widely spaced contours represent
    a.   A steep surface
    b.   A flat surface
    c.   An inclined plane surface
    d.   Curved surface

180. Imaginary line passing through points having equal magnetic declination is termed as
    a. Isogon
    b. Agonic line
    c. Isoclinic line
    d. None of these
181. Which of the following methods of plane table surveying is used to locate the position of an inaccessible point?
    a. Radiation
    b. Intersection
    c. Traversing
    d. Resection
        (Note: **Radiation** and **Intersection** are the method to locate the point and **Resection** is the method to locate the table and **Traversing** is used in both.)
182. Refraction correction
    a. Completely eliminates curvature correction
    b. Partially eliminates curvature correction
    c. Adds to the curvature correction
    d. Has no effect on curvature correction
183. If the whole circle bearing of a line is 270°, its reduced bearing is
    a. N 90° W
    b. S 90° W
    c. W 90°
    d. 90° W
184. The process of determining the locations of the instrument station by drawing re sectors from the locations of the known stations is
    a. Radiation
    b. Intersection
    c. Resection
    d. Traversing
185. Total latitude of a point is positive if it lies
    a. North of the reference parallel
    b. South of the reference parallel
    c. East of the reference parallel
    d. West of the reference parallel
186. Under ordinary conditions, the precision of a theodolite traverse is affected by
    a. Systematic angular errors
    b. Accidental linear errors
    c. Systematic linear errors
    d. Accidental angular errors
187. An angle of deflection right, may be directly obtained by setting the instrument to read
    a. Zero on back station
    b. 180° on back station
    c. 90°
    d. 270° on back station

188. . Location of contour gradient for a high way is best set out from
    a. Ridge down the hill
    b. Saddle down the hill
    c. Bottom to the ridge
    d. Bottom to the saddle

189. Setting out a curve by two theodolite method, involves
    (A) Linear measurements only
    (B) Angular measurements only
    (C) Both linear and angular measurements
    (D) None of these

190. The methods used for locating the plane table stations are
    (A) Radiation
    (B) Traversing
    (C) Intersection
    (D) Resection
    (E) B and D

191. The ratio of the angles subtended at the eye, by the virtual image and the object, is known as telescopes
    (A) Resolving power
    (B) Brightness
    (C) Field of view
    (D) Magnification

192. Back bearing of a line is equal to
    (A) Fore bearing ± 90°
    (B) Fore bearing ± 180°
    (C) Fore bearing ± 360°
    (D) Fore bearing ± 270°

193. The type of surveying which requires least office work is
    (A) Tachometry
    (B) Trigonometrical leveling
    (C) Plane table surveying
    (D) Theodolite surveying

194. For a closed traverse the omitted measurements may be calculated
    (A) Length of one side only
    (B) Bearing of one side only
    (C) Both length and bearing of one side
    (D) All the above

195. Horizontal distances obtained by thermometric observations
    a. Require slope correction
    b. Require tension correction
    c. Require slope and tension corrections
    d. Do not require slope and tension corrections

196. A clinometer is used for
    (A) Measuring angle of slope
    (B) Correcting line of collimation
    (C) Setting out right angles
    (D) Defining natural features

197. Pick up the correct statement from the following:
    a. Box sextant is used for the measurement of horizontal angles
    b. Cross staff is used for setting out right angles
    c. Gradiometer is used for setting out any required gradient
    d. All the above

198. Intersection method of detailed plotting is most suitable for
    (A) Forests
    (B) Urban areas
    (C) Hilly areas
    (D) Plains

199. Benchmark is established by
    (A) Hypsometry
    (B) Barometric levelling
    (C) Spirit leveling
    (D) Trigonometrical levellin

200. Probable systematic error in precise levelling as recommended by International Geodetic Association should not exceed (where 'k' is in kilometers.)
    (A) ± 0.1 √k mm
    (B) ± 0.2 √k mm
    (C) ± 0.1 √k
    (D) 0.2 √k mm

201. Probable accidental error in precise levelling as recommended by International Geodetic Association should not exceed (where k is in kilometers.)

(A) ± 0.1 √k mm   (B) ± 0.5 √k mm   (C) ± 1 √k mm   (D) ± 5 √k mm

202. Orientation of a plane table by solving two point problems is only adopted when
    a. Saving of time is a main factor
    b. Better accuracy is a main factor
    c. Given points are inaccessible
    d. None of these

203. The distance between steps for measuring downhill to obtain better accuracy
    a. Decreases with decrease of slope
    b. Increases with increase of slope
    c. Decreases with increase of slope
    d. Decreases with decrease of weight of the chain

204. In chain surveying, perpendiculars to the chain line are set out by

(A) A theodolite   (B) A prismatic compass
(C) A level   (D) An optical square

205. The additional lines which are measured to show the correctness of the chain surveying are called:

(A) Check clines   (B) Proof lines   (C) Tie lines   (D) All of these

206. Greater accuracy in linear measurements, is obtained by

(A) Tacheometry   (B) Direct chaining
(C) Direct taping   (D) All the above

207. If the whole circle bearing of a line is 180°, its reduced bearing is

(A) S 0° E   (B) S 0° W   (C) S   (D) N

208. The difference in the lengths of an arc and its subtended chord on the earth surface for a distance of 18.2 km, is only

(A) 1 cm   (B) 5 cm   (C) 10 cm   (D) 100 cm

209. Profile levelling is usually done for determining

(A) Contours of an area   (B) Capacity of a reservoir
(C) Elevations along a straight line   (D) Boundaries of property

210. Subtense tacheometry is generally preferred to if ground is

(A) Flat   (B) Undulating   (C) Mountainous   (D) Deserts

211. In reciprocal levelling, the error which is not completely eliminated, is due to

(A) Earth's curvature   (B) Non-adjustment of line of collimation
(C) Refraction   (D) Non-adjustment of the bubble tube

212. The staff intercept will be
    a. Greater farther off the staff is held
    b. Smaller, farther off the staff is held
    c. Smaller, nearer the staff is held
    d. Same, wherever the staff is held

213. Horizontal distances obtained tacheometerically are corrected for

(A) Slope correction   (B) Temperature correction
(C) Refraction and curvature correction   (D) All the above

214. Designation of a curve is made by:
    a. Angle subtended by a chord of any length

      b.   Angle subtended by an arc of specified length

      c.   Radius of the curve

      d.   Curvature of the curve

215. A simple circular cruve is designated by the

      a.   radius of the curve

      b.   curvature of the curve

      c.   angle subtended at the centre by a chord of any length

      d.   angle subtended at the centre by a chord of particular length

216. While measuring with a metallic tape of 30 m length pull should be applied

      (A) 1 kg   (B) 2 kg   (C) 3 kg   (D) 4 kg

217. A series of straight parallel and equally spaced contours represent _____

      a.   Hills   B) Ponds   C) Plane surface   D) Desert

218. What is the shape of contour lines in case of a watershed?

      a.   U shape   B) V shape   C) W shape   D) O shape

219. What is the shape of contour lines in case of a valley?

      a) U shape   b) V shape   c) W shape   d) O shape

220. Which of the following instruments can be used without a tripod?

      a) Prismatic compass   b) Surveyor's compass

      c) Theodolite   d) Sextant

221. In which of the following compass sighting and reading taking can be done simultaneously from one position of the observer?

      a) Prismatic compass   b) Surveyor's compass

      c) Theodolite   d) Sextant

222. The optical square is used to measure angles by

  A) double reflection   B) refraction

  C) reflection   D) double refraction

223. The instrument used for setting out an offset at a right angle, is called

  A) optical square   B) open cross - staff

  C) french cross - staff   D) adjustable cross-staff

224. Bench marks are fixed by

  A) Profile leveling   B) trigonometric leveling

  C) barometric leveling   D) spirit leveling

225. The sensitivity of the double tube can be increased by:

  A) increasing the viscosity of fluid   B) decreasing the radius of fluid

  C) decreasing the length of double   D) increasing the diameter of the tube

226. The method most suitable for plotting in hilly areas is:

  A) traversing   B) intersection

  C) radiation   D) resection

227. The types of level normally used in hilly area is :

  A) hand level   B) dumpy level

  C) abney level   D) none of the above

228. Chainage is a distance measured :

  A) perpendicular to a tie line   B) along a chain line

  D) perpendicular to a chain   C) line none of the above

229. Cadastral map is a map having:

A) large scale
C) medium scale

B) small scale
D) all of the above

Answers

1	C	21	C	41	B	61	C	81	C	101	B	121	B	141	B	161	C
2	C	22	C	42	B	62	C	82	C	102	B	122	C	142	C	162	C
3	A	23	C	43	C	63	C	83	B	103	A	123	D	143	D	163	C
4	D	24	C	44	A	64	C	84	C	104	B	124	B	144	D	164	A
5	C	25	B	45	C	65	B	85	B	105	D	125	C	145	C	165	C
6	C	26	B	46	B	66	C	86	B	106	C	126	B	146	A	166	D
7	C	27	C	47	C	67	C	87	D	107	A	127	B	147	B	167	C
8	D	28	C	48	A	68	C	88	B	108	A	128	D	148	C	168	A
9	D	29	B	49	C	69	C	89	B	109	A	129	B	149	A	169	B
10	C	30	A	50	C	70	D	90	C	110	B	130	B	150	C	170	D
11	D	31	A	51	C	71	A	91	C	111	C	131	B	151	A	171	A
12	B	32	C	52	A	72	B	92	B	112	B	132	C	152	B	172	D
13	A	33	C	53	B	73	A	93	C	113	C	133	C	153	C	173	C
14	A	34	B	54	B	74	A	94	B	114	C	134	C	154	C	174	D
15	B	35	B	55	B	75	C	95	C	115	B	135	C	155	C	175	C
16	B	36	B	56	B	76	B	96	B	116	B	136	B	156	C	176	D
17	C	37	B	57	B	77	B	97	B	117	C	137	B	157	B	177	A
18	B	38	B	58	C	78	B	98	C	118	C	138	C	158	D	178	B
19	B	39	D	59	B	79	B	99	C	119	B	139	C	159	B	179	C
20	B	40	C	60	B	80	B	100	D	120	B	140	D	160	D	180	A

181	B	201	C	221	A
182	B	202	C	222	C
183	C	203	C	223	B
184	C	204	D	224	D
185	A	205	D	225	D
186	C	206	C	226	B
187	A	207	C	227	C
188	B	208	C	228	B
189	B	209	C	229	A
190	E	210	B		
191	D	211	C		
192	B	212	B		
193	C	213	C		
194	D	214	C		
195	D	215	D		
196	A	216	C		
197	D	217	C		
198	C	218	A		
199	C	219	B		
200	D	220	A		

Construction Materials

1.Rocks/Stones

*Introduction

- Stone are naturally occurring materials derived from the earth crust. They have irregular shape and size. chemical composition are mixture of two or more minerals.
- Stone are used in the construction of any types of structure like Building, Bridge, Retaining Wall, Railway, Damp, Gabions, Base coarse etc.
- Petrology: is that branch of geology which deals with the study of rocks, with particular stress on their mode of formation, composition and uses for all types of engineering works.

*Rock Cycle

Cycle: Ongoing transformation among rock types. Integrates all formation processes in a loop
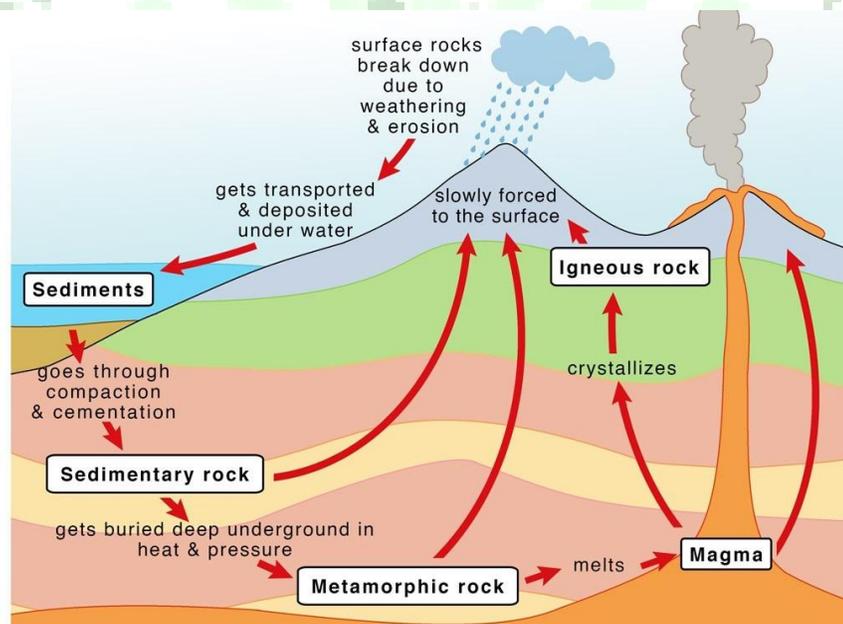
Fig 1.1 Rock cycle

Stage	Process	Resulting Rock Type
Magma cooling	Crystallization	Igneous rock
Weathering & erosion	Fragmentation	Sediment
Lithification	Compaction & cementation	Sedimentary rock
Heat & pressure	Metamorphism	Metamorphic rock
Melting	Heat under deep crust	Magma

*Quarrying of stone

- ➢ **Quarrying of stone:** It is the process of extracting natural rock materials (dimension stones, aggregates) from the Earth's surface.
- ➢ **Quarry:** A Quarry is an open pit mine where rocks, stone, sand, slate, gravel are extracted directly from the earth surface.
- ➢ **Seasoning of stones:** The freshly cut stone carries some natural moisture known as quarry sap. When stones are exposed to atmosphere after quarrying, the stones are harder and compact. The process takes about 6 -12 months for complete remove quarry sap is called seasoning of stone. Using unseasoned stones may cause cracking, splitting, or weakness over time.

*Process of Quarrying

- A. **Community and regulatory compliance**- Legal safety, permits, stake holder engagement
- B. **Site selection and preparation**- Conduct geological surveys and core drilling to access rock quality thickness and bedding planes.
- - Clear vegetation and Overburden
- C. **Splitting technique**- **Digging:** Used for small patches of soft rock
        -**Heating:** Rock layers are thermally expanded to create fractures, allowing separation.
        -**Wedging:** Steel Wedges inserted into drilled holes to split the rock along natural or induced cracks.
        -Drilling and blasting: Hole drilled and filled with controlled explosive to fracture large rock masses for easier handling.
- d. **Extraction and Hauling:** -Use excavators, loaders, cranes and trucks to lift and
        transport stone blocks to in site processing area.
- e. **Primary Cutting**: - Produce usable blocks for building.
- f. **Stockpiling:** -Store a final products.
- g. **Waste handling and recalamation:** -manage leftover materials and restore site.

1.1 Methods of Quarrying
a. Hand Tools
- ➢ **Digging/Excavating**: Used for small, soft stones—laborers use pick-axes, chisels, crowbars to manually remove material.
- ➢ **Wedging (Plug-and-Feather)**:
    - o Drill holes (~10–15 cm deep, 10–15 cm apart), insert feathers and a central plug, then hammer to split stone along natural grain
    - o Especially suited for valuable stratified stones (e.g., marble, limestone, slate). Minimal waste and good block control.
- ➢ **Heating**:
    - o Build a fire on the rock surface; differential expansion causes cracking. Remove blocks with tools
    - o Works best for thin, horizontal beds (e.g., granite, gneiss).
b. **Machine Quarrying (Channeling)**
- ➢ Use channeling machines (powered by steam, air, or electric) to cut deep grooves around target blocks.
- ➢ Drill horizontal holes beneath blocks, then use wedges or hydraulic jacks to detach
- ➢ Ideal for extracting large dimension-stone blocks cleanly (e.g., marble or limestone).
c. **Blasting**
- ➢ Suitable for hard, massive stones with no natural fissures.
- ➢ **Process**:
    - o **Drill** blast-holes in patterns
    - o **Charge** with explosives (ANFO, dynamite, gunpowder)

- o **Tamp** with clay or stone dust
- o **Fire** the charges to break rock into manageable pieces

- *Define quarrying of stones and (outline the key criteria for selecting a suitable quarry site. / Discuss the environmental, logistical, and technical factors influencing quarry operation planning and layout.)*
- *Explain in detail four common methods used in quarrying stones.*
- *Describe the blasting process in stone quarrying and explain the significance of the "Line of Least Resistance" (LLR).*
- *Elaborate on the concepts of natural bed and planes of cleavage in rocks and their relevance during the quarrying process.*

2. Classification of Rocks
- Explain the geological, physical, and chemical classifications of stones with examples.
- Differentiate between intrusive and extrusive igneous rocks with examples and engineering significance.
- Explain the physical classification of stones and describe how this affects their workability in construction.
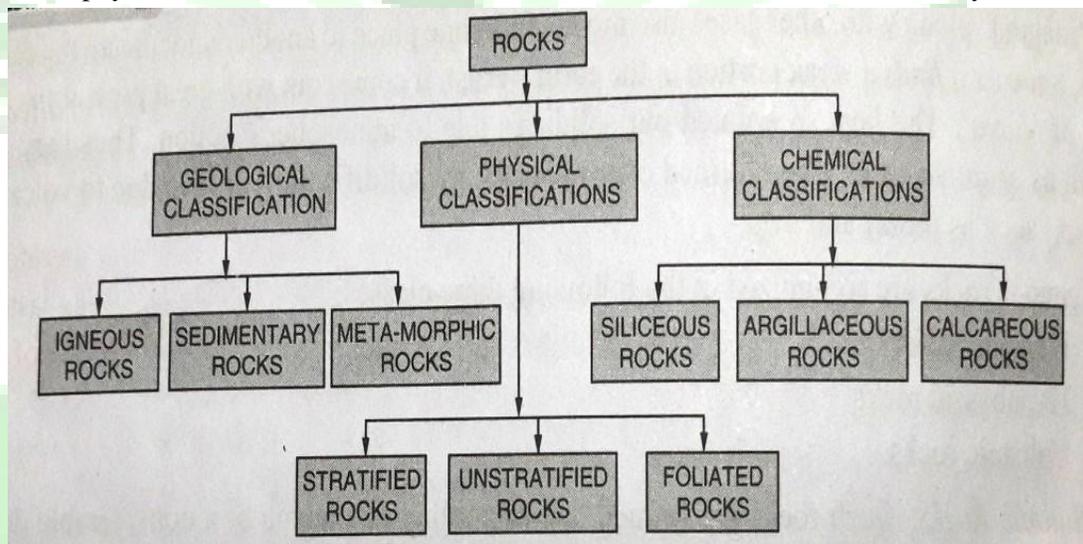
Fig 1.2 Classification of Rocks.

2.1 Geological Classification

a. Igneous Rock: Igneous Rocks are formed due to solidification of molten magma on the surface of the earth and below the surface of the earth.
- Main Constituents is silica.
- Strong and durable.
- Example: Granite, Pegmatite, Diorite, Gabbro, Peridotite, Basalt, Andesite, Rhyolite etc. *(GPDGP BAR)*
- Igneous rocks are classified as extrusive or intrusive based on where their molten material (magma) solidifies:

i. Intrusive Rock:-(plutonic rock) They solidify underground**,** cooling slowly and developing coarse-grained (phaneritic) textures. For Eg. Granite, Pegmatite etc. *(GPDGP)*

ii. Extrusive Rock:(Volcanic) They solidify very near the earth's surface and cools rapidly, producing unique textures and rock types. For eg. Basalt, Trap etc. *(BAR बार)*

b. Sedimentary Rock: Sedimentary rocks are formed due to the gradual decomposition of materials like sand, sand, silt, gravel, debris etc.

- Also called aqueous (argillaceous) Rock.
- Main constituents are sand, silt.
- Example: Dolomite, lime stone, Sandstone, magnesite, lignite, gypsum, chalk etc. *(DSMLGC)*

c. Metamorphic Rock: Metamorphic Rocks are formed due to exposure to high heat, high pressure, and chemically active fluids in igneous and sedimentary rock.
- High temperature, high pressure and chemicals process knowns as metamorphism.

Original Rock	Rock after Metamorphism
Dolomite/Lime stone	Marble
Granite	Gneiss
Sand stone	Quartzite
shale	slate
(LM GG SQ SS)	

2.2 Physical classification

a. Stratified Rock: It can be distinct layer which can be separate.
-Example: All sedimentary Rock, Marble and Quartzite. *(st-MSQ)*

b. Unstratified Rock: It can't be any stratification and easily split into thin layers.
- Example: All igneous rock. *(UN- I)*

c. **Foliated Rock:** It can be split in a certain direction.
- Example: All metamorphic rock except Quartzite and marble. *(F-MQ)*

2.3 Chemical classification

a. Argillaceous Rock: Main content of these rock/Principle constituents is clay, alumina.
- Example: slate, kaolin, laterites and stone.

b. Siliceous Rock: Main content of these rock/Principle constituents is silica.
- Example: Granite, trap, basalt, quartzite, gneiss, syenite, sand stone.

c. Calcareous Rock: Main content of these rock/ Principle constituents is calcium.
- Example: Marble, limestone, dolomite etc.

3. Availability of stone in Nepal

3.1 National Mining - Geographical Location:

a. Stone, Sand, Gravel (Construction Aggregate): Terrai and Chure have large - vast reserves of clay soil, many stone quarries provide materials used in house construction and construction.

b. Fosa Dhunga (dimension/decorative stones): Granite, marble, quartzite, and slate mines are well-known in districts like Makwanpur, Sindhuli, Udayapur, and Darchula.

c. Limestone: Abundant throughout Nepal: Proven to be 540 million tons and potentially up to 420 million tons. Such as Udayapur, Dhading, Dang, Surkhet, Salyan, Bandi etc.

d. Dolamite: Dang, Darchula, Khotang, Doti, rolpa, kavre, makawanpur.

e. Marble: Godawari, lalitpur.

f. Granite: sindhuli, udayapur, dodeldhura.

g. Quartzite: dhankuta, taplejung, ramechhap, ilam.

h. Slate and phyllite: dhankuta, taplejung, baglung, tanahun, sindhupalchock.

3.2 Major Mining and Manufacturing:

➢ More than 150 mining and crushing industries, mainly operating in the Terai-Hill region and involved in the production of construction materials.
➢ Research has revealed that mines of granite, marble, quartzite, etc. have been discovered in the Makwanpur district.

3.3 Utility and Market

- ➢ Slate stones from the Chure and hilly regions are now being used as an alternative to tiles and tablets and are being exported to cities like Kathmandu, Pokhara, and Dang.
- ➢ The stone crusher industry has become a source of economic income as it is creating jobs.

3.4 Challenges and management
- ➢ Many mines are unauthorized or illegal, causing environmental problems (e.g. landslides, river, exploitation).
- ➢ The government and local levels have begun to emphasize the need for tax management, but implementation is still weak and, despite some industries being registered, there is a lack of serious monitoring.

4. Characteristics of good building stone (फटाह DSP आइसक्यो)
a. Fire and chemical resistance:
- ➢ rich in CaCO3 or iron oxide.
- ➢ high heat or acids are resist.
b. Toughness and impact resistance:
- ➢ Ability to resist shake and vibration.
- ➢ used for heavy load or machinery exposure should have a toughness index >19 or at least 13-19 for moderate.
- ➢ Measure by AIV (aggregate impact value).
c. Hardness and wear resistance:
- ➢ determine by moh's scale.
- ➢ moh's scale ≥ 14 for general and ≥ 17 for roads and pavements.
d. Durability and weather resistance:
- ➢ Should resist cycles of wet-dry, freeze-thaw, acid rain, wind and heat.
- ➢ most maintains edges and textures over time fine-grained, homogeneous and free from cracks or cavities.
e. Strength: -
- ➢ A minimum crushing strength of 100kg/cm2 but crushing strength of good building stone should be more than 1000kg.cm2.
- ➢ Example: Basalt = 150-185 N/mm2,granite = 75-127 N/mm2.
- ➢ Strength of stone in wet condition is 30-40% less as compared to dry condition.
f. Porosity and water absorption :
- ➢ low porosity essential to prevent moisture damage and freezing.
- ➢ water absorption should be <5% by weight after 24 hours.
g. Appearance and texture:
- ➢ Uniform, pleasing color.
- ➢ Fine compacted crystalline structure with clean fracture surfaces.
h. Economical consideration:
- ➢ Cost effectiveness, accessible quarry stone, cheapest cutting/dressing cost transport feasibility.
- ➢ Cost effectiveness, accessible quarry stone, cutting/dressing cost transport feasibility.
i. Specific gravity and weight:
- ➢ heavier stone are dense and less porous.
- ➢ suitable stone have specific gravity 2.4-2.8.
j. Workability and seasoning:
- ➢ Must be workable, easily cut/dressed without excessive cost.
- ➢ Should be properly seasoned (exposed 6-12 month) to remove quarry moisture (sap) and improve strength.
5. Testing of stone (SAWCHCIA) CIA WAS CH
a. Smith's Test:
- ➢ To find dirty materials in stone.
- ➢ keep it for half an hours.

➢ If slightly cloudness is present that means stone is good and durable.
➢ If water is too dirty then stone is weak means it contain soluble earthy and minerals.

b. Acid test:
➢ To check weather resistance.
➢ Resistance poor weathering property.
➢ This test is not used for lime stone and sand stone.
➢ Powder represents the presence of CaCo3.
➢ Take 100gm of stone chips.
➢ Immersed it in 5% solution of dilute sulphuric acid or hydrochloric acid for three days.(HCL/H2SO4) and 95% of water.
➢ After three days take it out from solution and check it's edge.
➢ If corner and edges remains sharp as before then stone is able to resist weathering action.

c. Water absorption test:
➢ To determine the amount of water absorbed in 24 hrs.
➢ Water absorption capacity should not be greater than 5% .
➢ If any stone absorb more than 10% water of its drt weight will be rejected for masonry.
➢ Take 50gm stone chips, keep it in oven at 105°C for 3 days.
➢ Take out and cool it in desicator and take weight W1.
➢ Immersed sample to water for 3 days.
➢ take out stone chips from water and take wt. W2.
➢ water absorption $=((W2-W1)/W1.)*100$

d. Crushing Test:
➢ to determine strength of stone.
➢ take a 3 cube block of stone size 40*40*40mm.
➢ place this block in water for 72 hrs.
➢ cover the surface of specimen with plaster of paris.
➢ Apply axial load on cube by crushing testing machine.
➢ the rate of loading should be 13.72 N//mm2 per minute.
➢ Therefore, crushing strength=load at which sample crushed/area of bearing face of specimen.
➢ crushing strength should be greater than 1000 Kg/cm2 (100Mpa or 100N/mm2)

e. Hardness test:
➢ to determine hardness of stone.
➢ scratching/cutting resisting capacity of stone sample is checked for hardness coefficient,
➢ used machine :dorry's testing machine.

Mohs Value/ Hardness number	Reference Mineral	Everyday Equivalent
1	Talc	-----
2	Gypsum	Fingernail (~2–2.5)
3	Calcite	Copper penny (~3.2–3.5)
4	Fluorite	Steel nail (~4)
5	Apatite	Knife blade/glass (~5.5)
6	Orthoclase feldspar	Steel needle (~6.5)
7	Quartz	Glass plate (~7)
8	Topaz	------
9	Corundum (ruby/sapphire)	------
10	diamond	----

f. Crystallization / Freezing–Thawing Test:
➢ Alternately soak stones in sulfate solution or freeze/thaw cycles. Measures deterioration under salt crystallization or frost.

g. Abrasion / Attrition Test:
➢ To determine wearing resistance of stone.
➢ used machine: dowel testing machine.
➢ In this test machine have 2 cylinder of 34cm and 20cm situated at 30° with horizontal.

➢ 60mm size stone are put into cylinder and rotated at 30rpm for 5hrs and then sieve from 1.5mm sieve.
➢ %wear = (loss in wt.)*100/ intial wt.
➢ For good building stone wear should not be more than 3%.
➢ Results are having good correlation with the performance of the pavement.

h. Impact test/toughness test:
➢ Determine toughness of stones.
➢ Used machine: Cast iron anvil machine.
➢ Toughness of stone is tested by breaking the stone under a hammer.
➢ 2 kg weight hammer freely fall from a height of 1cm,2cm.
➢ <13 toughness smooth/soft stone.
➢ 13-19 moderate tough stone
➢ >19 very tough stone

6. Key Points for Laying of Stone Masonary work
➢ Clean each stone and saturated if with water before setting. it clean and moisten the bed that will receive it.
➢ Lay the masonry is roughly levelled courses. Ensure that the bottom of the foundation is large with selected stones. (generally 0.4-0.6 H).
➢ Lay the courses with leaning beds parallel to the natural bed of the material.(90°).
➢ Keep a surplus of stones at the site to selected from.
➢ beds have an average thickness of not more than 1 inch (25mm).
➢ stone should not be place during rains sufficiently heavy or prolonged to wash the mortar from the masonry.
➢ Loads are not allowed on the stone before it is fully set.
➢ height of stone masonry wall in one day should not be more than 80 cm.
➢ continuous vertical joints are avoided.
➢ flag stones are used for under the beam, tiles, trusses, sill etc.

7. Method of laying stone in construction
  7.1 Rubble stone masonry work
  a. Uncoursed random rubble stone masonry work:
➢ uses irregular, undressed stones stacked without aligning them in layers.
➢ Joints are filled with mortar or small spalls.
➢ Used for construction of walls of low height in case of ordinary building.
➢ The roughest and cheapest.
  b. Coursed random rubble stone masonry work:
➢ uses hammer dressed stones stacked with aligning them in layers.
➢ Joints are filled with mortar or small spalls.
➢ The cheapest.
  c. Squared rubble masonry
➢ the face stones are squared on all joints and beds by hammer dressing or chisel dressing before their actual laying is called squared rubble masonry.
  d. Dry rubble masonry
➢ Stones are laid without using any mortar.
➢ height not more than 3m.
  7.2 Ashlar masonry
➢ Finely dressed stones are laid in cement or lime mortar is known as ashlars masonry.
➢ The courses are of uniform height, all the joints are regular, thin and have uniform thickness.
➢ Ashlars masonry is much costly as it requires dressing of stones.

> Suitability: this masonry is used for heavy structures, architectural building, high piers and abutments of bridge.
> Ashlars masonry is further sub divided into the following types:

A) Ashlar fine or coursed ashlar masonry:
> Stone blocks of same height in each course are used.
> Every stone is fine tooled on all sides.

B) Rough Tooled ashlar masonry:
> Stones blocks of same height in each course are used.
> Stones are rough tooled and dressed with chisel.
> thickness of joints is uniform, which does not exceed 6mm.

C) Rock or quarry faced ashlar masonry:
> This type of masonry is similar to rough tooled type except that there is chisel-drafted margin left rough on the face which is known as quarry faced.

D) Block-in course masonry:
> Stones are all squared and properly dressed.
> different height of stones are used in each course.

E) Chamfered ashlar masonry:
> It's similar to quarry faced except that the edges are beveled or chamfered to 45° for depth of 2.5cm or more.

2.2 Cement

*Introduction
> Cement is a finely ground powder that acts as a binding agent in construction.
> Cements in a general sense are adhesive and cohesive materials which are capable of bonding together
> particles of solid matter into a compact durable mass.
> Joseph aspedin of was the first to introduce portland cement in 1824 AD.

1. **Ingredients of cements** (ingredients =कच्चा सामाग्रीहरु,जसले उत्पादन सुरु गर्छ, Constituents=निर्माण पछिका रासायनिक भागहरु, जुन सिमेन्टको गुण निर्धारण गर्छ) (LS Aim SA)

a. Lime (Calcium oxide) CaO
> **-**composition 60%-65%.
> -chemical formula CaO.
> -control soundness and strength (soundness = volume changes after setting and hardening)**.**
> **-**If it excess quantity in cement makes the cement unsounds.

b. Silica (silicon dioxide) SiO2
> **-**composition 17%-25%.
> -chemical formula SiO2.
> -provide to the strength of cement due to the formation of dicalcium and tricalcium silicates.
> -excess it causes lowers strength and increases setting time of cement.

c. Alumina (Aluminum oxide) Al2O3
> **-**composition 3-8%.
> -chemical formula Al2O3
> -provide quick setting.
> -Excess is causes slow setting.
> Reduces clinkering temperature, if it is in excess weakens the cement.

d. Iron Oxide (ferrous oxide) Fe2O3
> **-**composition 0.5-6% .
> -chemical formula Fe2O3.
> -provide color, strength and hardness to the cement.

➢ It induces reddish brown tint to the cement.
➢ -excess it caused discolor of cement (brown, green, white).

e. Magnesium oxide (MgO)
➢ **-**composition 0.5-4%.
➢ -chemical formula MgO.
➢ -Gives hardness and color.
➢ -excess it causes crack in mortar and concrete.

f. Sulphur Trioxide (SiO3)
➢ -composition 1-2%.
➢ -chemical formula SiO3.
➢ -makes cement soundness.
➢ -excess of it's caused unsound.

g. Alkalis
➢ -composition 0.5-1%.
➢ -chemical formula
➢ -controls efflorescence. एफ्लोरे सन्स
➢ Accelerate setting of cement paste
➢ -excess of it's causes efflorescence.

2. Composition of cement clinker/Bogue's Compound. बोगस कम्पाउन्ड
-It consists of following major compounds:-

$$C_3S = 4.071\% \ CaO - 7.602\% \ SiO_2 - 6.7187\% \ Al_2O_3 - 1.4297\% \ Fe_2O_3$$
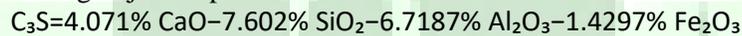
a. Tricalcium silicate (3CaO SiO2) (C3S) (Alite)
➢ -composition 25-50% (fixed 40%).
➢ **-**It generate more heat of hydration.
➢ -To developed early strength and hardness.
➢ -Best cementing materials.

b. Dicalcium silicate (2CaO SiO2) (C2S) (Belite)
➢ -composition 25-40% (32%).
➢ -it generate less heat of hydration.
➢ -to develop ultimate strength.
➢ Resistance to chemical attack.

c. Tricalcium aluminate (3CaO Al2O3) (C3A) (celite)
➢ **-**composition 5-11% (10.5%).
➢ -it generate more heat of hydration.
➢ It's responsible for initial set and greater tendency to volume changes.
➢ -It reacts rapidly with water.
➢ -It also helps to setting of cement.

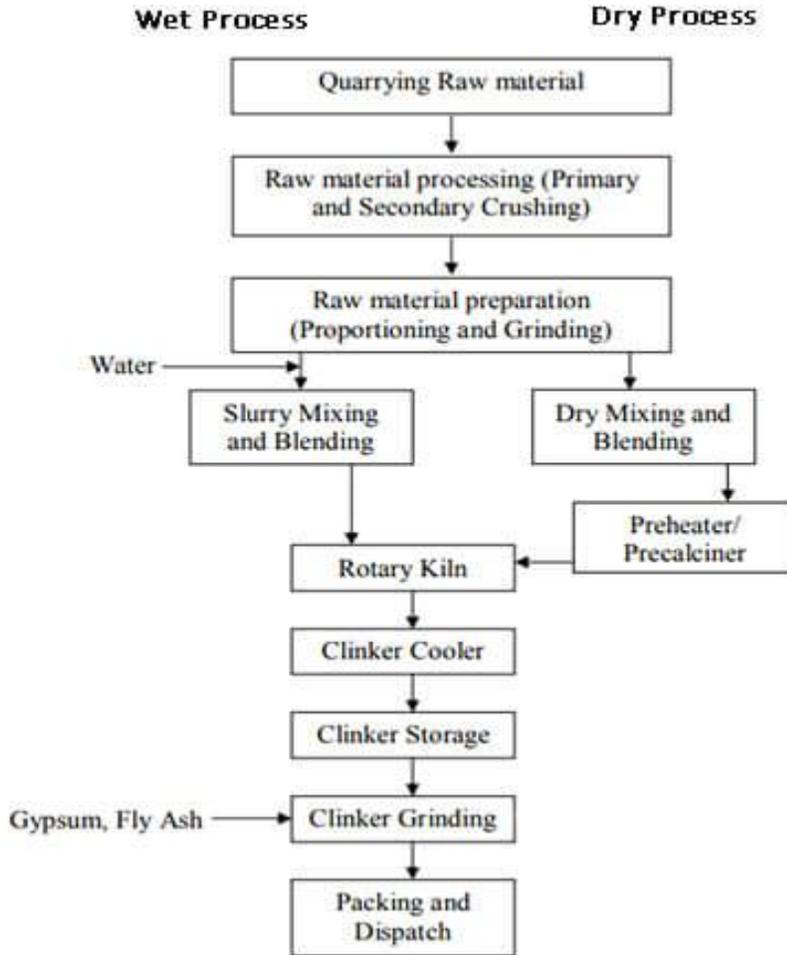### d. Tetra-calcium aluminum ferrite (4CaO Al2O3 Fe2O3) (C4AF) (felite)
➢ -composition 8-14% (9%).
➢ **-**it reacts very slow and responsible for increasing volume of cement.
➢ -It has less cementing value.
➢ -it also reduce cost.

(C3A>C3S>C4AF>C2S)=Heat of hydration कति दिन्छ भनेर

C4AF>C3A>C3S>C2S)=rate of hydration कति चाडो प्रतिक्रिया हुन्छ भनेर

a. **Manufacture of cement**
   Flow chart of manufacturing OPC.

Blending:: Slurry लाई mechanical stirring वा compressed air मार्फत homogeneous बनाउने।

Temperature range in cement manufacture clinker is 1400-1500 C

Density of cement is taken as 1440 kg/m3

b. **Different Between Dry and Wet Process of Cement manufacturing.**

Objectives	Dry Process	Wet Process
Mixing	-Raw materials are mixed in dry state in blenders.	-Raw materials are mixed in wash mill 35-50% water.
Product out from mill	-The dry materials existing the mill are called kiln feed.	-Materials existing the mill are called slurry and it can be flow.
Fuel consumption production cost	-Low i.e. 100 kg coal per tonne of cement produced. -cost of production is less.	-High i.e 350 kg of coal per tonne of cement produced. -cost of production is high.

Capital cost	High due to blenders.	(cost of establishment) is comparative by less.
Size of kiln	Size of kiln needed for manufacturing of cement is smaller.	Size of the kiln needed for manufacturing of cement is bigger.
Quality of mixing	Difficult to control mixing of raw materials, so it's difficult to obtain a better homogenous materials.	Raw materials can be mixed easily, so a better homogenous materials can be obtained.

c. **Types of cement** *(ROWEP QO SLC HA BPH)*
  a. Rapid hardening cement RHC
  - ➢ **-**more C3S and less C2S as compared to OPC.
  - ➢ -adding CaCl2 <2% increase. For extra rapid hardening in RHC.
  - ➢ -higher strength at fast.
  - ➢ -produce large shrinkage in mass concrete.
  - ➢ -suitable for repair of roads, bridges etc.
  - ➢ -some strength in 1 days which an OPC attains in 3 days.
  b. Ordinary Portland cement OPC
  - ➢ **-**Most common cement.
  - ➢ -suitable for all types of structure.
  - ➢ -available grade 33,43,53 .
  c. White cement
  - ➢ **-**manufacture from pure white chalk and clay free from iron oxide.
  - ➢ -clear decorative choices and high temperature process use.
  d. Expansive cement
  - ➢ **-**Expands after setting.
  - ➢ -suitable for prestressed structure, grouting, shielding.
  e. Portland pozzolana cement
  - ➢ **-**initial strength is law and final strength is high.
  - ➢ -pozzolana-20-30%.
  - ➢ -curing time is also higher.
  - ➢ -increase workability.
  - ➢ -Reduce shrinkage.
  - ➢ -used in marine and mass concreting (hydraulic structure).
  f. Quick cement
  - ➢ **-**obtain by adding Al2So4 and CaCl2 with OPC power form.
  - ➢ -used for underground purpose.
  - ➢ -amount of gypsum is reduce.
  g. Oil well cement
  - ➢ **-**high pressure and temperature tolerance due to special TPU and retarder blend for oil or gas wells.
  h. Sulphate resisting cement
  - ➢ **-**low C3A protection against sulphate corrosion.
  - ➢ -suitable for canal. culverts, syphon, sea coast area construction.
  - ➢ -expansion not more than 5mm.
  i. Low heat Portland cement
  - ➢ **-**low C3S(5%) and C3A and more contents of C2S(46%).
  - ➢ -Expansion not more than 10mm.
  - ➢ -prevents thermal cracking, useful for large structures (eg: dams).
  j. Colored cement

➤ -colored cements are made by adding pigment 5-10%.

k. High alumina cement
➤ -the alumina content should not be less than 35%.
➤ -fast hardening, flexibility and durability in high temperature and chemical environment.

l. Air-entraining cement
➤ -Large baffles improve workability and fall settlement in compact bulk construction in frost-free condition.

m. Blast furnace slay cement
➤ -25-80% slag mixed, low heat generation.
➤ -useful in solid structures.

n. Portland limestone cement
➤ -5-15% limestone admixture.
➤ -used as part of company toll and carbon emission reduction efforts.

o. Hydrophobic (Hydrographic) cement
➤ -water resistance.
➤ useful in dams, water tank, railing structure.

d. **Test of cement** *(CHeSS FACTS)*

a. Consistency test
-measures the water required to form a paste of standard consistency.
-It's done Vicat apparatus.
-it ensures proper workability and hydration in cement.
-Process
-mix 25-30% water with 400g cement.
-fill the vicat mold and use the plunger.(10mm dia, 50mm length)
-If the penetration is 5-7mm, that water percentage is the normal/standard consistency.
-repeated and adjust if necessary.
-from this, the water-cement ratio can be calculated and forms the basis for other quality tests.

b. Heat of Hydration
-evaluates the amount of heat generated as cement reacts with water.
-it's done by isothermal conduction calorimetry(Modern Method), solution (chemical) Calorimetry (older method), manual solution calorimetry (simple bal setup).

c. Soundness test
-to determine the presence of uncombine lime and magnesia in cement.
-done bylechatelies apparatus.
-to ensure cement does not expand excessively after setting.
-prevents cracking and disintegration due to expansion of the cement.
-the expansion should not exceed 10mm for any type of cement.

d. Setting time test
-ensures that the cement/concrete remains workable for the correct amount of time.
-vicat apparatus is used(performed at 0.85p water).
-Initial setting time:- time from mixing until the paste begins to stiffen and loses plasticity. The vicat needle cannot penetrate to within about 5mm of the mould bottom.
-Final setting time:- Time from mixing until the paste has hardened sufficiently that the Vicat needle only makes a surface mark, no deeper penetration.
-It's tested by the angular needle.

S.N.	Types of cement	Initial setting time	Final setting time
1	OPC	30 Minute(1/2 hrs)	600 minute(10 hrs)

2	RHC	30 Minute(1/2 hrs)	600 minute(10 hrs)
3	PPC	30 Minute(1/2 hrs)	600 minute(10 hrs)
4	HAC	30 Minute(1/2 hrs)	600 minute(10 hrs)
5	WPC	30 Minute(1/2 hrs)	600 minute(10 hrs)
6	BFC	30 Minute(1/2 hrs)	600 minute(10 hrs)
7	SRPC	30 Minute(1/2 hrs)	600 minute(10 hrs)
8	LHC	60 Minute(1 hrs)	600 minute(10 hrs)
9	QSC	5 Minute	30 minute(1/2 hrs)
10	SSC	240 Minute(4 hrs)	270 minute(4 hrs 30 minute)

e. Fineness test

-to measure the fineness of cement particles.

-fine cement offers a larger surface area for hydration , leading to faster strength development.

-In IS sieve:- measure grain size:90 micron (9 no) sieved used.

-Air permeability method:- specific area for OPC =2250cm2/gram.

specific area for RHPC =3000cm2/gram.

specific area for LHC =3250cm2/gram.

specific area for OPC =2250cm2/gram.

specific area for PPC =3000cm2/gram.

f. Air content test

-to measure the air content in cement.

-excessive air can reduce strength and durability.

-important for quality control

g. Compressive strength test

-to determine the compressive strength of cement after hardening.

-ensures cement meets the required load bearing capacity for structural safety and durability.

-cement sand ratio 1:3

-cube size 7.06*7.06*7.06cm.

-minimum strength shall be 115kg/cm2 for 3 days.(11.5N/mm2)

-minimum strength shall be 175kg/cm2 for 7 days.(17.5N/mm2)

-standard temperature 27+- 2°.

h. Tensile strength test

-to measure the tensile strength of cement ,its resistance to tension or cracking.

-ensures cement has adequate tensile strength to resist cracking under tension in structural applications.
-carried out on standard briquetes machine.
-tensile strength of cement after 3 and 7 days of curing should not be less than 20 and 25 kg/cm2 respectively.
i. Specific gravity test
-to measure specific gravity of cement.
-indicates the density of cement , influencing the mix design and strength characteristics.
-measured by Le-chateller's flask
-specific gravity of OPC is 3.15.
* Admixture
-the admixture are the materials other than basis ingredients of cement concrete added to the concrete mix to improve certain properties of cement concrete. In the fresh or hardened concrete.
-addition of admixture is done immediately before or drying mixing.
This admixture affects the following properties/Function of admixture/advantage by admixture
-increase resistance against freezing and thawing.
-Increases workability
-reduces strength
-reduces the tendency of segregation and bleeding
-decreases permeability
-increases resistance to chemical attack
-reduces unit weight and alkalis aggregate reaction

8.2 Mineral admixture(Pozzolanic admixture)
-pozzolanic materials are essentially siliceous and aluminous compound which in itself does not posses any binding property, but when finely ground reacts with lime released during the hydration of cement in the presence of water to produce the compound which possess binding property. Use of pozzolanic admixture in general gives the following properties:
-lower heat of hydration
-lower thermal shrinkage
-lower alkali-aggregate reaction
-improve workability
-reduce cost
-improve extensibility
-lower susceptibility to teaching
-improves resistance against Sulphur attack pozzolanas are further classified into:
a. Natural pozzolana
b. artificial pozzolana
-Fly ash
-Ground blast furnace
-silica fumes
-surkhi
-rice husk ash
8.3 Chemical admixture *(PARAS BB CC GG)*
a. Plasticizers (water reducers) or water reducing admixture
-Decreases water requirement.
-Enhances concrete workability.
-lowers water content, improves strength.
-improved durability, increased strength.
-enhances concrete pumpability.

-facilitates easier placement, compaction

-polycarboxylate ethers commonly used.

b. Accelerator or accelerating admixture

-increase heat of hydration of cement.

-quickens concrete setting time.

-useful in cold weather to prevent delays.

-boosts early concrete strength.

-quicker formwork removal after pouring.

-often includes calcium chloride <2%, aluminium chloride, sodium carbonate.

c. Retarders or retarding admixture

-slows down concrete setting time.

-helpful in high temperatures.

-extends concrete workable time.

-allows for intricate job demands.

-commonly uses sugar or lignosulfonates.

-improves finishing in hot weather.

-reduce the rate of hydration.

-example: calcium sulphate, sugar, starch, gypsum (2-3%) add.

d. Air entraining admixture

-introduction micro bubbles for durability.

-enhance freeze-thaw resistance in concrete.

-improves workability, durability and cohesion.

-used in extreme cold places.

-boosts resistance to sulfate attack.

-fatty acid salts are widely used.

-Example: vinsol resin, darex, reepal, cheecol etc.

e. Super plasticizer Or Super plasticizing admixture

-minimizes water demands up to 30%.

-low workability, extremely high strength.

-avoids things like bleeding, segregation etc.

-no compaction or little compaction required.

-used in highly reinforced members.

-prevents honeycombing, cracking etc.

f. Other special admixtures

-Bleeding agent: To control/check bleeding, paraffin wax etc.

- blast furnace slag and fly ash: enhancing long-term strength and durability, mitigating sulfate/alkali-silica reactions, and lowering CO_2 emissions from cement production.

-corrosion inhibiting agents: to delay corrosion initiation and reduce its progression in reinforced concrete.

-coloring agents: used in concrete work are mainly raw umber (brown), ferrous oxide (black), red oxide (red), and chromium oxide (green).

-grouting: improving flowability, reducing shrinkage, and increasing strength by introducing plasticizing, expansion, or setting-modifying agents.

-Gas forming agent: reducing settling and bleeding while improving bond strength and void filling.

Specification, Storage and transport of cement

(1. how to storage and transportation of cement is done?)

9.1 Specification

-Dimension of cement bag 75cm*40cm*18cm.

-area of cement bag 40*75=3000cm2

-height of cement bag=18cm

-packing of bag =50kg per bag

- Labeling on bag= Brand name, types of cement, net weight, batch number, manufacturing date, manufacturing details.

9.2 Storage

-Height from ground surface=20cm(minimum)(15-20)cm

-space from wall=30cm(minimum)

-space between pile =1.6m

-width should not be greater than 3m

-height should not be greater than 2.7m

-No. of Bag should not be more than 15 in horizontally and 10 in vertically.

- upto 3 months stored, strength reduced 0%.

- after 3 months stored, strength reduced 20%.

- after 6 months stored, strength reduced 30%.

- after 12 months stored, strength reduced 40%.

- after 24 months stored, strength reduced 50%.

9.3 Transport

S.N.	Challenge	Solution
1	Moisture and contamination	Sealed bulk packing, precleaned trucks.
2	Dust and spillage	Bulk tankers dust control systems
3	Delivery delays	Route optimization, off-peak scheduling real time GPS.
4	Temperature	Pre-load cooling, surveys, to check ≤100°C.
5	Maintenance and safety	Regular inspections ,driver training.

*Fineness of cement

➢ Colour of cement is uniformly greenish grey.
➢ A handful of cement, thrown into a bucket of water, floats.
➢ Hand is thrusted into a bag of cement, it feels cool.
➢ Rubbed in between figure, it feel smooth.

MCQ

1. What are the main constituents of cement ? Explain. (5)
2. Explain the chemical composition of (cement clinker) cement.(5)

3. List out the different types of cement with explain. (10)
4. Why OPC cement is widely used in construction industry. Justify this statement.(5)
5. Difference between dry and wet process. (5)
6. Defined initial and final setting time of cement, what are the ingredients of cement, explain its functions in cement. (3+7=10)

The compressive strength of OPC 53 grade cement after 28 days should be at least:
A. 33 MPa
   B. 43 MPa
   C. 53 MPa
   D. 63 MPa

The main compound responsible for early strength in cement is:

A. C_2S (Dicalcium Silicate)
   B. C_3S (Tricalcium Silicate)
   C. C_3A (Tricalcium Aluminate)
   D. C_4AF (Tetracalcium Aluminoferrite)

The fineness of cement is measured in:

A. kg/m^3
   B. m^2/kg
   C. mm^2
   D. m^3/kg

Which of the following cement types is best suited for marine construction?

A. Ordinary Portland Cement
   B. Rapid Hardening Cement
   C. Sulphate Resisting Cement
   D. Low Heat Cement

The major component in cement responsible for strength is:

A. Lime
   B. Silica
   C. Alumina
   D. Iron oxide

Clay and Clay Products

1. **Bricks**
   -Bricks are small structural materials in rectangular shape.
   1.1 Basic information of brick
   -NS (modular) size=230mm*115mm*57mm
   -No. of bricks using 1 m3 brick work=500(IS), 530(NS machine made), 560 (NS hand made)
   -IS standard size=19cm*9cm*9cm
   -nominal size=20cm*10cm*10cm.

-weight of one brick =3 kg

-weight of 1 m3 of brick=1600 to 1920 kg

-the minimum thickness of brick wall is 4'(four inch) or 10cm or Half brick.

-20 tones coals are required for burning of 100000 bricks.

-Height of chimney 30m or 98.42 feet.

-**Brick Clay:-** The mixture of clay and sand.

1.2 Composition of Good brick earth/Ingredient of good brick earth/constituents of good bricks *(SALIMA)*

(1. what are the essential constituents of good brick earth? Write their percentage composition.

a. Silica (SiO2)

-composition (50-60)%.

-chemical formula SiO3.

-It enable to retain shape.

-Imparts durability.

-Excess of silica present in brick earth makes brick brittle and weak.

b. Alumina (Al2O3)

-Composition (20-30)%.

-chemical formula Al2O3.

-It provides plasticity to the earth and makes hard on drying.

-Excess makes the brick crack and warping and becomes hard when the burnt.

c. Lime (CaO)

-composition (<10)%.

-chemical formula CaO.

-Reduce shrinkage of brick.

-causes to melt and loose it shape.

-Jhama bricks is the results of high percentage of lime.

d. Iron oxide (Fe2O3)

-composition <7%.

-chemical formula Fe2O3.

-Gives red color.

-excess of its makes the color dark blue or blackish.

-Improve impermeability and durability.

e. Magnesia (MgO)

-composition <1%.

-chemical formula MgO.

-small quantity of magnesia in brick earth provided yellow tinge to brick and decreasing shrinkage.

-excess of it's causes brick to decay.

f. Alkalis

-Composition <10%.

-Excess of It's causes efflorescence.

-Quick setting.

-to melt, warp.

1.1 Harmful Substance in brick earth *(SOCIAL PW)*

a. Sulphur: It causes the formation of a spongy, swollen structure in the brick and the bricks are discolored by white blotches.

b. Organic matter: it creates porous on the brick.

c. carbonaceous matter: it causes black color to the brick.

d. Iron pyrites: it causes to split the brick into smaller pieces during burning.

e. Alkalies: Mainly in form of soda and potash and Excess of alkalis causes efflorescence.

f. Lime: change the color yellow excess of it causes melting of brick and looses it's shape.

g. pebbles: Non-Homogenous mixture is formed. Pebbles or grit or any kimd is undesirable in brick because it will not allow the clay to be mixed properly which will result in week and porous.

h. Water: excess water causes shrinkage during burning.

1.2 Manufactures of bricks

a. Preparation of brick earth(Un soling, Digging, Weathering, Blending, Tempering).

b. Moulding

c. Drying

d. Burning

a. Preparation of brick earth

i. Unsoling: Top part of the soil surface(20cm) is removed.

-It's done to remove the impurities leaves, roots etc.

ii. Digging: it is the process to excavation of soil by adding fly ash, sandy loam, rice husk etc.

iii. Weathering: The excavated soil is left out in the atmosphere adding small amount of water.

-It helps to enhance the plasticity and strength of soil.-at least 1 month.

iv. Blending: The required sand earth or calcareous earth of brick is added to the weathered soil and mixed.

-this process is called blending.(चाहिएको ingredients मिसाउने र अलि चलाउने प्रकृया)

v. Tampering: It's a kneading process.

-It can be done by the feet or pug mill.

-the process of mixing clay, water and other ingredients to make bricks is known as kneading.

b. Moulding

-The process of giving a definite shape and size to the brick using mould.

-Moulds are made from shishum.

-Types of moulding:- **Hand moulding** (Ground moulding, Table moulding)

                      Machine moulding (Plastic process, Dry process - Strong

                                                - campact

c. Drying: Dried in air for (3-8) days but not in sun.

-Natural process (slow, cheep).

-Artificial process (fast,costly).

d. Burning: Three main stages -(DOV)

-Dehydration (400-650°C).

-Oxidation (650-900°C).

Vitrification (900-1100°C).

-Burning can be done in following ways:-

i. clamp or open or pozawah. (60% bricks are get)

ii. Intemittent kiln

iii. Continuous kiln

-Haffman's kiln (circular-continuous-over ground)

-Bull's trench kiln (elliptical-semi continuous-semi/over ground)

-Tannel kiln

1.2 Types of bricks/classification of bricks

2.1 Based on Field practices/Quality

a. First class brick

-crushing strength should not be less than 10.5 N/mm2 or 105 Kg/Cm2.

-Water absorption should not be more than 15% (<15%).

-well burnt, regular edge.

-hard and sound.

-specific gravity 1.8.

-Struck two bricks metallic ringing sound comes.

-color deep rod, cherry or copper color.

-uses:- Facing wall (Pointing, flooring and reinforced brick work).

b. Second class bricks

-Crushing strength should not be less than 7 N/mm2 or 70 Kg/Cm2.

-Water absorption should not be more than 20% (<20%).

-ground mould, burnt in kiln.

-surface is not smooth.

-Not uniform color.

-uses:- internal wall, unimportant masonry work, centering of reinforced brick and RCC structures etc.

c. Third class bricks

--strength should not be less than 3.5 N/mm2 or 35 Kg/Cm2.

-Water absorption should not be more than 25% (<25%).

-under burnt brick.

-ground mould but burnt in clamp.

-irregular shape and size.

-dull sound is produced while struck.

-cracks and flows are available.

-Roughness surface

-uses:- interior wall and temporary building.

d. Fourth class/Jhama/ overburnt bricks

-over burnt

-irregular, distovted.

-black in color.

-brittle in nature.

-it can uses as an aggregate in concreting works of foundation flooring, ballast in foundation.

2.2 Based on finish

a. sand faced bricks

b. rustic faced bricks

2.3 Based on burning

a. Pale Burning- Under burnt brick

b. Body brick- well burnt brick

c. Arch - Over burnt brick

2.4 Based on manufacturing

a. Machine made brick-

b. Hand made brick-

2.5 Based on uses

a. Common bricks

b. Engineering bricks-strong, regular, compact.

c. facing brick.

1.3 Properties of good brick

-strength should not be less than 10.5 N/mm2 or 105 Kg/Cm2.

-Water absorption should not be more than 15% (<15%).

-well burnt, regular edge.

-hard and sound.

-specific gravity 1.8.

-Struck two bricks metallic ringing sound comes.

-color deep rod, cherry or copper color.

-thermal conductivity of bricks should be low.

1.4 Testing of bricks *(CHESS Winner)*

-5-10 bricks for lots between 2001-10000 bricks

-10-20 bricks for lots between 10001-35000 bricks

-15-30 bricks for lots between 35001-50000 bricks

-bricks lots over 50000 are split into sub-lots of 50000 each.

a. Compressive strength (Crushing) strength test

-determine loads-bearing capacity.

-C:S (1:3) mortar is filled over the frag of brick.

-24hrs. (that bricks is covered with wet jute bag for 24hrs.)

-then its immersed in water for 3 days.

-then constant load of 14N/mm2 is applied constantly and noted the load at which brick fail.

-generally 5 no. of sample are prepared for testing.

-typical minimum strength is around 3.5 N/mm2.

b. Water absorption test

-indicates porosity and potential dampness issues.

-bricks drying at first 105°c to 107°C. weight (W1).

-brick should be immersed in water for 24 hrs. at 27+-2°C temperature. weigh(W2)

-water absorption= {(W2*W1)/W1}*100.

-good bricks absorb ≤15%.

c. Efflorescence test

-defects soluble salts harmful to aesthetics and structure.

- Take 5 bricks at random from the given sample.

- place each brick on end in a dish containing distilled water ensuring depth immersion at least 2.5cm.

- keep the dish in a ventilated room (Temp. 20°C to 30°C) till the whole of distilled water in the dish evaporates.

-white patches over the brick surface is measured.

-when area of white patches 0% nill.

- when area of white patches <10% slight.

-when area of white patches without any powdering or flaking surface 50% moderate..

-when area of white patches accompanied by flaking of surface 50% heavy.

-when area of white patches all over the brick is serious.

e. Dimension test

- Ensures bricks are uniform in size and shape for proper alignment.

- Randomly select 20 bricks, measure dimensions, and compare to standard (e.g., 230× 115 × 57 mm according to NS And 190*90*90 mm according to IS).

1.5   Defects of bricks *(BBC SLC BE)*

a. Bloating

-Appearance of spongy, swollen surfaces due to carbon or sulfur in clay.

-weakened load bearing capacity and poor durability.

b. Blisters

- Small pits or bubbles formed from trapped air during molding or drying.

c. Black core

-black areas remain inside the brick due to incomplete oxidation, this is also a sign of poor firing.

d. Efflorescence

- White or grey salt deposits on surface as a result of soluble salts and moisture.

e. Cracks and checks

-Straight (rapid drying) or random (differential shrinkage or lime lumps).

f. Chuffs

- Surface deformities caused by rainwater hitting hot bricks during drying.

g. Laminations

- Thin flaky layers due to entrapped air in clay.

h. Spots

- Dark spots from iron sulfide in clay; aesthetic defect suited only for non-exposed work.

1.6   Common brick pieces

a. Full brick - A standard, uncut rectangular brick used in regular masonry.

b. Queen closer -when a brick is cut into two portion along with it's length it forms queen closer.

c. Queen closer quarter -when queen closer is broken into two part.

d. king closer -when a triangular piece of brick laying between center of one end and center of adjacent side is removed then it form king closer.

-without triangular portion.

e. Bevelled Closer -when structure face of the bricks is bevelled in such a way that half width is maintain at one end and full width at another end.

f. Mitred Closer -when header of brick is cut splayed/mitred at an angle of 45 degree to 60 degree its full width then it forms mitred closer.

g. half bat -bat is a portion of brick cut along width (half length of original brick)

h. Three-quarter Bat -when length of bat is equal to three quarter of the length of full brick it forms three quarter bat.

i. Bevelled bat -any bat whose width is beveled.
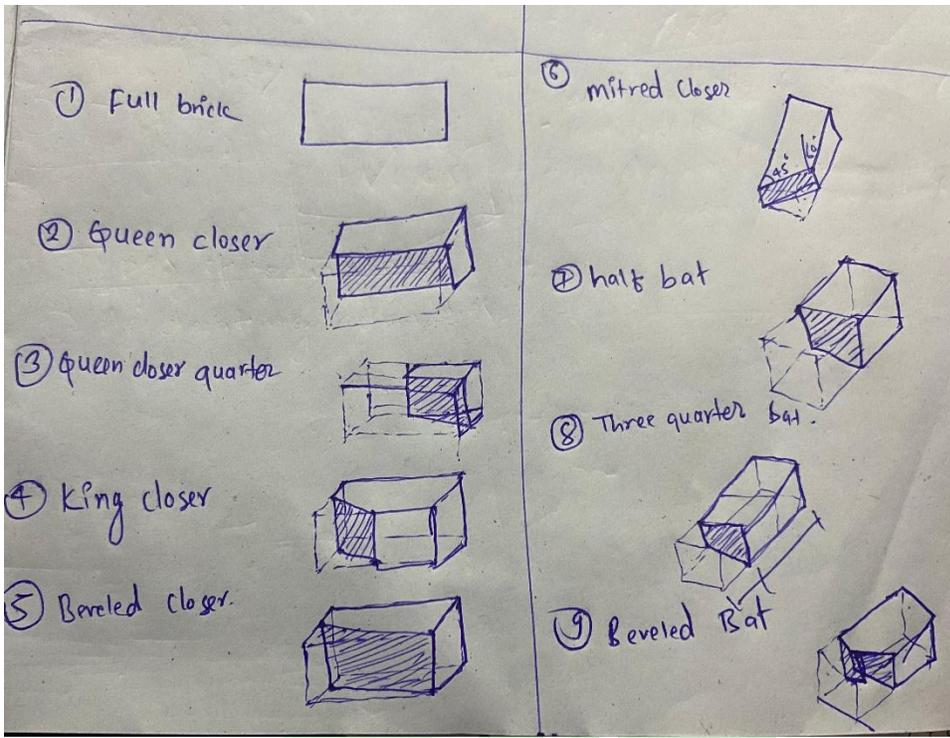
1.7   Laying of bricks
A. Preparation of the Base
- Clean the surface where bricks are to be laid.
- Ensure the foundation or bed is level and dampen it before starting.
B. Mixing and Applying Mortar
- Prepare fresh mortar (commonly 1:4 and 1:6 cement:sand for brickwork).
- Spread a layer of mortar (about 10–12 mm thick) evenly over the base.
C. Laying the First Course
- Start from the corners of the wall.
- Place corner bricks first and check alignment using a spirit level and plumb bob.
- Stretch a string line between corners to guide straightness.
D. Positioning Bricks
- Butter the end of each brick with mortar (for the vertical joint).
- Place the brick on the bed and press or tap it lightly with the trowel handle to adjust level.
E. Maintaining Bond
- Follow the choosen bond pattern (Stretcher, English, Flemish, etc.) for strength and appearance.
- Stagger vertical joints between courses.
F. Checking Alignment and Level
- Use spirit level horizontally and vertically to ensure proper alignment.
G. Curing
- After completion, cure the brickwork by sprinkling water for at least 7 days to gain strength.

1.8   Bond of Bricks
   a. Header Bond -all bricks are laid with header overlapping midway with courses of brick above and below on the face of wall.
   b. Stretcher Bond -when bricks are laid with stretcher overlapping midway with courses of brick above and below on the face of wall.

c. English Bond

 -consist of alternate course of header and stretcher.

-each header is centrally above the stretch.

-to break continuity of vertical joint queen closer of bricks is used at beginning and end of wall.

- queen closer are used in header course, after a header in both side.

- use: exterior wall where plaster is done.

d. Flemish bond

-alternate bricks are placed (header and stretcher) in every course.

-also called dutch bond.

-construction is slightly difficult than English bond required good skill.

-this has good appearance than English bond.

-this bond is weaker than English bond.

-if outer surface is to plastering then this bond isn't preferred.

- use: exterior wall where plastering is no needed.

i. single Flemish bond -it's the combination of English and Flemish bond, minimum thickness required is 1 and half brick thickness.

-main purpose of this bond is to provide good aesthetic appearance on front surface and also maintaining it's strength by providing English bond.

ii. Double Flemish bond -this having same appearance on both side but it's weaker.

e. Raking bond

-Diagonal pattern

-Herring-type bond

f. Rat-trap bond

-this provides caving internally which helps to improve thermal insulation.

2.4 Paints and Varnishes

Paint and varnishes are used to protect metals, timber or plastered surface from the corrosive effect of weather, heat moisture or gases. They are also used to improve their appearance.

Paints

The fluid paste prepared by dissolving a base into a vehicle (carrier) along with a colouring pigments is known as paint lead paint are more poisonous.

*Basic Composition of Paints/ ingredients of paints

   a. Base-

- it's Main component of paint.

- It also possesses the binding properties.

- It forms an opaque(अपारदर्शिण) coating.

- Example- Red lead, White lead, zinc oxide, aluminium powser and lithophone.

   b. vehicle/carrier

- medium which supports base and allow it to spread uniformly.

   - example- But oil, puppy oil, tung oil, linseed oil etc.

   -also known as carrier or binder.

   c. Thinner/solvent-

- Volatile substance which moves paint thin and applicable.

   - it makes the paint of workable consistency.

-mostly used thinner is turpentine.

- after paint applied, thinner evaporates and paint dries.
  - Example-penetration, naptha, turpentine.
    d. Drier-
- helps to mix together element dry rapidly to more paint hard.
-also known as plasticizers.
  -example-litharge, red lead, lead acetate, magnesia dioxide.
    e. Filler/adulterants/Extender-
- Increase volume make durable.
  - Reduce cost.
  - Example-asbestos power.
    f. pigment-
- it gives required color of paint.
  -maximum percentage of pigments in the paints should not be more than 10 percentage.

S.N.	Color	Pigments
1	white	White zinc,
2	blue	Cobalt blue, Prussian blue, indigo, ultra marine
3	Green	Chrome green, copper sulphate
4	yellow	Chrome yellow, yellow ochre
5	brown	Umber, burned sienna, burned timber
6	red	Red lead, venedion red, Indian red
7	black	Charcoal black, suit, lamp black

*Basic Properties of Paints
  -apply easy and freely.
  -dry quickly in reasonable time.
  -good spreading power.
  -hard and durable.
  -attractive and pleasing appearance.
  -it should be cheap.
  -form a thin film परत of uniform nature i.e. should not crack.

*Function of paints
  a. decoration/aesthetics
Paint enhances the visual appearance of surfaces by providing color, gloss, चमक and texture बनावट
  b. protection against weathering and corrosion.
Paint acts as a protective barrier, shielding ढाल from environmental factors such as moisture, oxygen, and
  pollutants.
  c. ease of cleaning/hygiene
Painted surfaces often possess smooth, non-porous finishes that resist dirt accumulation and facilitate
  cleaning.
d. Communication and Identification
Color coding and surface markings in paint convey information or designate तोकिएको specific areas.
  e. preservation of material integrity

Paints contribute to the longevity दिर्घायु of materials by providing a protective layer that mitigates कम गर्छ the effects of environmental degradation. ह्रास

f. UV (ultraviolet) and environmental resistance

Advanced coatings incorporate UV-absorbing pigments and stabilizers that protect from the damaging effects of ultraviolet radiation.

*Defects of paints

a. Blistering and peeling

-formation of bubbles due to presence of moisture.

-it can be removed by using emulsion paints.

b. Crawling क्रलिगं

-ton thick paint becomes uneven.

-if occurs in vertical direction called sagging ढल्किरहेको and in horizontal in call wrinkling.चाउरी परेको

c. chalking चाकिगं

-formation of powder in surface of paint.

d. Fading

-loss of color.

e. Flashing

-formation of shining surface

f. Grinning

-exposed of background due to low quality.

h. Running

-expose due to more thin, if thinner is large quantity.

i. saponification

-patch due to alkali.

j. Flacking

-flacks are formed due to thick layer.

k. Checking

- surface cracks if small called crazing.

-if large area in crocodile.

l. Alligatoring

-one layer slider over another

m. Cracking

-deep crack.

Fading Defect of Paint

Sagging Defect of Paint

Running Defect of Paint

Flaking Defect of Paint

Fleshing Defect of Paint

Saponification Defect of Paint

Blooming Defect of Paint

Wrinkling Defect of Paint

Blistering Defect of Paint

2.4.1 Types of paints

a. Oil paint

-applied in three coats (primer, undercoat and finishing coat).

-cheap and easy to apply.

-linseed oil as vehicle

-turpentine is thinner

-pigment

-uses: Automobiles.

b. Aluminum /branze paint

-made by dissolving aluminum powder in sprit/varnish.

-resistance to wear and fire.

-uses: pipe, radiator.

c. Asbestos एस्बेस्टोस पेन्ट paint

-the main constituent is fibrous asbestos.

-also known as fire proof paint.

-made by adding asbestos.

-uses: DPC, Combusting, chamber.

d. Cellulose paint

-made by dissolve cellulose in soil.

-uses: airplane, car, ships, automobiles, aircrafts.

e. cement paint

-made by adding suitable pigment to white cement.

-it's applied in two coats.(first coat is applied in wet surface but free from excess water and allowed to dry for 24 hrs, the second coat is then applied which gives good appearance.)

f. Emulsion paint

-it contains binding materials such as polyvinyl acetate, synthetic resins etc.

-pigment in emulsion.

-uses: Protective surface.

g. enamel paint

-made by adding white lead, zinc white in oil/spirit.

-acid resistance less affected by cold water.

-uses: both external and internal walls, timber metal and concrete.

h. Graphite paint

-by dissolving graphite in oil to used in sea structure.

i. Distemper

-Powdered chalk + pigment.

- base -chalk.

- solvent-water.

- it's also called water paint.

- white lead can be used in place of chalk.

- it can be removed by washing with water.

- it's less durable.

j. Bituminous paint

-made by asphalt bitumen dissolved in mineral spirit or naphtha.

-black in color and suitable pigments are added for required color.

-Uses: iron works under water, exterior brick work, concrete and plaster surface.

-to reduce the moisture permeability.

k. Synthetic rubber paint

-prepared from resin.

-dries quickly

-it's little affected by weather and sunlight.

-it resist chemical attack well.

2.4.2 Paint Preparation Techniques

a. Surface assessment and cleaning

-assess surface: check for rust, grease, existing coating, cracks and contaminants.

-**clean and degree:** remove dirt, oils, salts using soap and water, solvents, degreasers, or pressure/steam cleaning.

b. Old coating removing

-Scrape or sand: remove peeling paint or soil with scrapers, hand sanding, or power tools.

-abrasive methods: use sand blasting, shot blasting, or bristle blasting to strip coatings and profile rigid surfaces.

c. Repair and leveling

-fill defects: Use spackling compound, filler or patch kits to repair cracks, holes, dents

-**Sand smooth:** Even out filled areas and feather edges for seamless blending

d. surface profiling

-Roughen surface: Create micro-roughness for better adhesion using sanding, abrasive blasting, grinding, or acid etching

e. Dust removal

-Tack cloth or wipe: Final dust pickup using tack cloths or microfiber after sanding/cleaning to avoid finish defects

f. Priming

-apply primer: Seal porous or bare surfaces, improve topcoat adhesion, and block stains.

- choose compatible primers (stain-blocking, bonding, metal-specific)

g. Masking and protection

- mask areas not to be painted with painter's tape,

-cover floors and furniture with drop cloths or plastics sheeting.

2.4.3 Used common paints

- it provides colourful, pleasant, and decorative appearance to surface.

- It prevention from corrosion.

- it prevent decay of wooden member by wet rot.

Varnishes

*Ingredients of varnishes

A. Resin:

- principle constituents of varnish.

- Example: copal, amber, gum, mastic etc.

B. solvent: linseed oil, turpentine oil, sprit etc.

C. **Drier: litharge lead acetate (very little amount)**

*types of varnish:

*Used of varnish:

- it protect the painted surface.
- it shines the painted surface.
- it gives brilliant effect to the wooden surface, map, photograph etc.
-Liquid made by dissolving resin in spirit/oil for giving good finish.
    -Main constituents is resin.
    a. Natural varnish - shallow, copal, resin.
    b. Artificial varnish - phenyl resin, buty resin.
    c. Oil varnish - Resin + oil+ turpentine (interior and exterior)
                      -Most protective.
                        -most durable(suitable for both interior and exterior)
d. Spirit varnish- resin + spirit (furniture and interior work)
-Most attractive surface
    e. Turpentine varnish
- suitable for interior works on painted surface.

Bitumen

Bitumen is a versatile and essential material in construction, used primarily as a binder and waterproofing
   agent.
***Types of bitumen**
A. cutback bitumen:
It's the made by adding kerosene with the bitumen.
- no heat is needed before using it.
- cold area, mountainous area, high altitude area.
- it's used for soil establization and road construction.
B. Bitumen emulsion:
Bitumen water emulsifier (1%)
- it's an aqueous solution.
- it's divided into fine globules.
- no heating is needed.
- bitumen emulsion are liquid product in which tiny droplets of bitumen or bituminous binder are depressed
    in an aqueous medium.
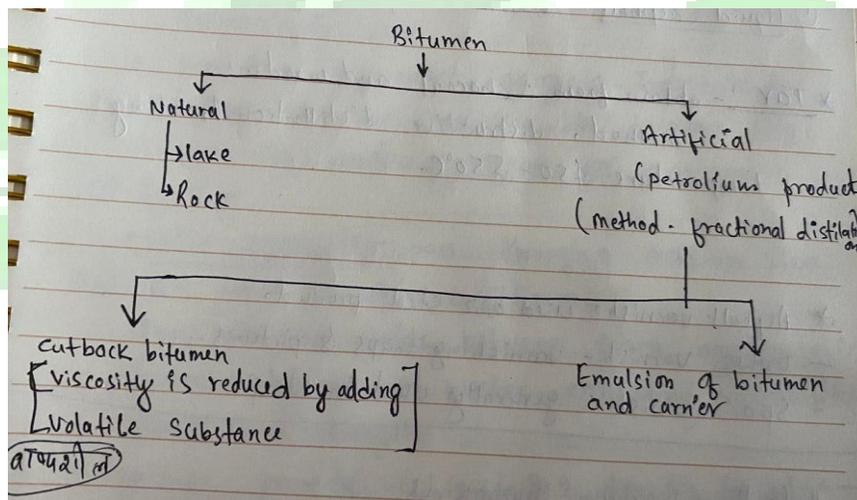
*Used of bitumen:

a. batteries: fixing of roofing tiles.
b. damp proofing, joint filler: water proofing package paper.
c. heat insulation materials for building
d. refrigeration and cold storage equipment.
e. road making material.

Asphalt

-bitumen + inert material.

1. Types of asphalt
   a. Natural of asphalt- found in rock or lack.
   b. Refined asphalt- obtain by heating.
   c. Mastic asphalt- moisture of bitumen fine aggregate and filler.
   -form void less mass.
   -used in road /bridges.
   d. Cutback asphalt- made by adding volatile substance to form cutback.
   e. Liquid asphalt- Distilled asphalt of 425°C.

Tar

-Obtain from:-chacoal and wood.
   -Method:-distructive distillation heating temperature 450-550°C.

   *asphalt varnish:- used over steel prodect.
   *water varnish:- varnishing maps and picture.
   *spar varnish:- generally used in ships.

*Remaining Part Discuss in physical and online class

1. **Which type of rock forms from molten magma?**
   a. Sedimentary b. Metamorphic
   c. Igneous d. Artificial

2. **Metamorphic rocks are formed due to:**
   a. Erosion
   b. Weathering
   c. High temp. & heavy pressure
   d. Water

3. **Which is a metamorphic rock?**
   a. Granite b. Limestone
   c. Sandstone d. Marble

4. **Granite is a:**
   a. Sedimentary b. Metamorphic
   c. Igneous d. Artificial

5. **A sedimentary rock:**
   a. Limestone b. Granite
   c. Marble d. Basalt

6. **Rock formed by volcanic activity:**
   a. Limestone b. Basalt
   c. Marble d. Slate

7. **Sandstone is:**
   a. Igneous b. Metamorphic
   c. Sedimentary d. Artificial

8. **Not a natural stone:**
   a. Basalt b. Marble
   c. Granite d. Terrazzo

9. **Stratification is in:**
   a. Igneous b. Metamorphic
   c. Sedimentary d. Artificial

10. **Layered structure:**
    a. Slate b. Granite
    c. Marble d. Quartzite

11. **Limestone under heat & pressure becomes:**
    a. Quartzite b. Granite
    c. Marble d. Sandstone

12. **"Quarry sap" refers to:**
    a. Polish
    b. Crushed stone
    c. Cemented sand
    d. Moisture in new stone

13. **What is the major distinction between intrusive and extrusive igneous rocks?**
    a) Chemical composition
    b) Mineral content
    c) Place where they solidify
    d) Color

14. **Nepal has the largest known deposits of which construction material?**
    a) Granite
    b) Marble
    c) Cement-grade Limestone
    d) Sandstone

15. **In which districts are Nepal's granite deposits primarily found?**
    a) Kathmandu and Lalitpur
    b) Makwanpur, Sindhuli, Udayapur, Dadeldhura
    c) Ilam and Taplejung
    d) Dang and Rolpa

16. **Where is marble mined in Nepal?**
    a) Mustang, Manang
    b) Godavari (Lalitpur), Chhatre Deurali (Dhading), Anekot (Kavre)
    c) Sankhuwasabha and Ilam
    d) Dadeldhura and Doti

Answersheet

1c 2c 3d 4c 5a 6b 7c 8d 9b 10c 11c 12d 13c 14c 15b 16d

17. **Which of the following is *not* one of the eight major constituents (on an oxide basis) in ordinary Portland cement?**
    A) Calcium oxide (CaO)
    B) Silicon dioxide (SiO_2)
    C) Zinc oxide (ZnO)
    D) Aluminum oxide (Al_2O_3)

18. **What is the *typical percentage range* of silicon dioxide (SiO_2) in ordinary Portland cement (by mass)?**
    A) 5–10%
    B) 19–23%
    C) 40–50%
    D) 60–70%

19. **Why is *gypsum ($CaSO_4 \cdot 2H_2O$)* added to the clinker during milling of cement?**
    A) To increase early strength
    B) To accelerate hydration
    C) To control/slows the initial setting
    D) To improve color uniformity

20. **At what approximate temperature does the calcination of limestone occur in the rotary kiln during the dry-process manufacture of cement?**

A. 500–700 °C

B. 900–1,000 °C

C. 1,200–1,300 °C

D. 1,350–1,450 °C

21. **Which choice best describes the primary rationale for adding** gypsum **to cement during the final grinding stage?**

    A. To increase early compressive strength

    B. To delay the initial setting (prevent flash set)

    C. To speed up hydration (early curing)

    D. To reduce wear on the mill

22. **What is the main benefit of rapid cooling of clinker (using a grate cooler) immediately after it exits the kiln?**

    A. Inhibits alite (C_3S) reverting to belite (C_2S)

    B. Removes gypsum moisture content

    C. Melts the clinker nodules for better size

    D. Burns out remaining sulphates

23. **Which type of cement is blended with pozzolanic materials (like fly ash or calcined clay), offers enhanced durability and sulphate resistance, and is widely used in hydraulic or marine construction?**

    A) Ordinary Portland Cement (OPC)

    B) Portland Pozzolana Cement (PPC)

    C) Portland Slag Cement (PSC)

    D) Sulphate Resisting Cement (SRC)

24. **Which type of cement achieves approximately the 7-day compressive strength of Ordinary Portland Cement within just 3 days (under similar curing conditions)?**

    A) Low-Heat Cement

    B) Sulphate Resisting Cement

    C) Rapid Hardening Cement

    D) High Alumina Cement

25. **Which type of cement is specifically manufactured with reduced tricalcium aluminate ($C_3A \leq 5\%$) to improve resistance to sulphate attack in soils or groundwater?**

    A) White Cement

    B) Ordinary Portland Cement (OPC)

    C) Sulphate Resisting Portland Cement (SRC)

    D) Air-Entraining Cement

26. **In large-scale concrete pours like dam construction, which cement type is preferred due to its low heat of hydration, minimizing thermal cracking?**

    A) Rapid Hardening Cement

    B) Low Heat Portland Cement

    C) White Portland Cement

    D) Portland Slag Cement

27. **Which type of cement is manufactured using raw materials with extremely low iron and manganese oxides, fired at higher kiln temperatures ($\approx$ 1600–1700 °C), and is used primarily for decorative, architectural concrete?**

    A) High Alumina Cement

    B) Coloured Cement

    C) White Portland Cement

    D) Portland Pozzolana Cement

28. **According to Abram's law, the strength of well-compacted concrete depends solely on the…**

    A) Water–cement ratio

    B) Cement content

    C) Water–sand ratio

    D) Water content

29. **What two actions occur as a result of the chemical reaction between water and cement?**

    A) Swelling, shrinkage

    B) Expansion, contraction

    C) Setting, hardening

    D) Strong, weak

30. **The ratio of the weight of water to the weight of cement is called the…**

    A) Aggregate–sand ratio

    B) Water–cement ratio

    C) Cement–water ratio

    D) Sand–aggregate ratio

31. **How many times is each layer of concrete rodded in a slump cone test?**

    A) 75 times

    B) 25 times

    C) 12 to 15 times

    D) 35 to 65 times

32. **The sieve size used for the fineness test of cement (as per IS) is _____ μm.**

    A) 90 μm

    B) 45 μm

    C) 22.5 μm

    D) 14 μm

33. **What is the approximate amount of water required (by weight of cement) to achieve standard consistency in the consistency test?**
    A) 0.78 times
    B) 0.79 times
    C) 0.77 times
    D) 0.76 times

34. **What are admixtures in concrete?**
    A) Ingredients which are added to in cement before or after concrete mix
    B) Ingredients added in cement to make it shinier
    C) Ingredients added to aggregates to improve strength
    D) Ingredients that replace cement

35. **Which statement is incorrect regarding the functions of admixtures?**
    A) They enhance workability
    B) They reduce segregation in concrete
    C) They retard the initial set to keep concrete workable for a shorter time
    D) They accelerate early strength development

36. **Which option does** not **fall under chemical admixtures?**
    A) Plasticizers
    B) Superplasticizers
    C) Accelerators
    D) Pozzolanic materials

37. **Admixtures that speed up the setting and hardening of concrete are called…**
    A) Plasticizers
    B) Retarders
    C) Superplasticizers
    D) Accelerators

38. **ow much water reduction can superplasticizers achieve?**
    A) 12–30%
    B) 5–10%
    C) 30–45%
    D) Only 5%

39. **What is the main purpose of retarders?**
    A) Increase curing rate
    B) Provide water-proofing
    C) Slow the curing rate
    D) Speed up finishing operations

40. **Why are air-entraining admixtures used in concrete?**

A) To relieve bursting pressure during wetting and drying
B) To introduce discontinuous air bubbles
C) To aid workability
D) All of the above

41. **What is the particle size of silica fume relative to cement?**
    A) Same size as cement
    B) Half the size of cement
    C) One hundredth the size of cement
    D) One tenth the size of cement

42. **Where should cement bags be placed in a storage shed to prevent dampness?**
    A) Directly on the floor
    B) On wooden planks or plastic sheets
    C) Stacked against walls
    D) On wet platform

43. **What is the minimum distance cement bags must be stored from the wall of the shed?**
    A) 0.1 m
    B) 0.3 m
    C) 1 m
    D) 2 m

44. **What is the maximum recommended stacking height for cement bags in storage?**
    A) 5 bags high
    B) 8 bags high
    C) 12 bags high
    D) 20 bags high

45. **Cement bags in a storage shed should be unloaded:**
    A) Randomly
    B) From the top one by one
    C) In stepwise removal from multiple levels
    D) By pulling the entire stack

46. **Cement sheds must have:**
    A) Leaky walls to allow moisture to escape
    B) A completely watertight structure
    C) Loose roofing
    D) Open walls for ventilation

47. **Once cement is mixed into concrete, how long should the entire process of mixing, transporting,** placing, and compacting take ideally?
    A) Within 30 minutes
    B) Within 90 minutes

C) Within 120 minutes

D) Within 60 minutes

48. **Which method is used for continuous transportation of concrete?**

A) Pans

B) Wheelbarrows

C) Belt conveyors

D) Buckets

49. **In concrete pumping, which statement is correct?**

A) Slump must be between 50–80 mm

B) Water–cement ratio should be between 0.5–0.65

C) Bend count in pipeline should be minimized

D) All of the above

50. **Which constituent of good brick earth, added in small quantities, imparts a yellow tint and reduces shrinkage?**

A. Alumina

B. Silica

C. Iron Oxide

D. Magnesia

51. **Brick Color Change Due to Excess Component**

A. Yellow

B. Red

C. Dark blue or blackish

D. Grey

52. **Which constituent in good brick earth prevents cracking, shrinking, and warping, thus enhancing durability?**

A. Lime

B. Alumina

C. Silica

D. Magnesia

53. **Which component imparts plasticity to the brick earth, enabling easy molding?**

A. Silica

B. Alumina

C. Iron Oxide

D. Alkalis

54. **Which of the following acts as a flux during burning and helps reduce shrinkage in brick earth?**

A. Iron Oxide

B. Lime

C. Magnesia

D. Alkalis

55. **What ingredient gives bricks their red color and adds hardness and durability?**

A. Magnesia

B. Alumina

C. Iron Oxide

D. Silica

56. **Which constituent, in small amounts, reduces shrinkage and gives a yellow tint to the bricks?**

A. Lime

B. Iron Oxide

C. Magnesia

D. Alkalis

Important question of construction materials

57. During production of cement raw material are mixed in

a.   Ball mill

b.   Pug mill

c.   Rice mill

d.   Cement mill

58. The loss of ignition in cement should not exceed

a. 1%

b. 4%

c. 8%

d. 12%

59. Gypsum is added to cement for reducing the fast reacting property of

a. dicalcium silicate

b. tricalcium silicate

c. tricalcium aluminate

d. tetra calcium alumino ferrite

60. The commonly used raw material in the manufacture of cement is

a. slate

b. sand stone

c. limestone

d. basalt

61. The undesirable properties of cement is due to formation of

a. dicalcium silicate

b. tricalcium silicate

c. tricalcium aluminate

d. tetracalcium aluinate

62. The types of cement is considered good if
    a. it contains C3S in large amount
    b. it contains C2S in large amount
    c. It contains C3A in large amount
    d. all of the above

63. A slow setting cement has higher percentage of
    a. tricalcium aluminate
    b. tricalcium silicate
    c. dicalcium silicate
    d. gypsum

64. Flash setting of cement means
    a. hydration of cement
    b. hardening of cement
    c. stiffening of cement without strength development
    d. all of the above

65. The most commonly used accelerator for concreting is
    a. gypsum
    b. calcium chloride
    c. calcium oxide
    d. calcium sulphate

66. The percentage of alumina and silica in good fire clay vary respectively is
    (A) 25, 75   (B) 30, 70
    (C) 35, 65   (D) All of these

67. With increase in moisture content, the bulking of sand
    (A) Increases
    (B) Decreases
    (C) First increases to a certain maximum value and then decreases
    (D) First decreases to a certain minimum value and then increases

68. The vehicle used in case of enamel paints is usually
    (A) Linseed oil   (B) Water
    (C) Varnish   (D) None

69. The vehicle used in case of oil paints is usually
    (A) Linseed oil   (B) Water
    (C) Varnish   (D) None

70. Resins are
    (A) Not soluble in water
    (B) Soluble in spirit
    (C) Used in varnishes
    (D) Left behind on evaporation of oil

71. According to IS specifications, the compressive strength of ordinary Portland cement after three days should not be less than
    (A) 7 MPa   (B) 11.5 MPa
    (C) 16 MPa   (D) 21 MPa

72. The weight of a good quality brick when immersed in water for a period of 16 hours should not exceed the weight of dry brick
    (A) 20 %   (B) 15 %
    (C) 10 %   (D) None

73. Addition of pozzolana to ordinary Portland cement increases
    (A) Bleeding
    (B) Shrinkage
    (C) Permeability
    (D) Heat of hydration

74. Percentage of carbon content in mild steel is
    (A) Less than 0.25
    (B) Between 0.25 and 0.7
    (C) Between 0.7 and 1.5
    (D) Greater than 1.5

75. Durability of building stone is affected by its
    (A) Chemical composition
    (B) Texture
    (C) Resistance to atmosphere
    (D) All the above

76. In brick masonry the bond produced by laying alternate headers and stretchers in each course is known as
    (A) English bond
    (B) Double Flemish bond
    (C) Zigzag bond
    (D) Single Flemish bond

77. Stainless steel contains
    a.   18% of chromium and 8% nickel
    b.   8% of chromium and 18% of nickel
    c.   12% of chromium and 36% of nickel
    d.   36% of chromium and 12% of nickel

78. Excess of silica in brick earth results in

    a.   Cracking and warping of bricks

    b.   Loss of cohesion

    c.   Enhancing the impermeability of bricks

    d.   None of the above

79. The slump recommended for mass concrete is about

    (A) 25 mm to 50 mm

    (B) 50 mm to 100 mm

    (C) 100 mm to 125 mm

    (D) 125 mm to 150 mm

80. Wrought iron is used for

    (A) Structural works in beams

    (B) Small sized water pipes

    (C) Columns and struts

    s (D) None to these

81. The type of steel used for precision levelling staff, is

(A) Titanium steel

(B) Carbon steel

(C) Invar

(D) Stainless steel

82. The maximum quantity of calcium chloride used as an accelerator in cement in percentage by weight of cement is

(A) 1

(B) 2

(C) 3

(D) 4

83. The cement becomes unsound by the presence of excess

(A) Sulphur   (B) Magnesia

(C) Lime   (D) All of these

Topics wise MCQ Discuss in physical and online class.

Answers

1	C	21	B	41	C	61	C	81	C
2	C	22	A	42	B	62	A	82	B
3	D	23	B	43	B	63	C	83	D
4	C	24	C	44	B	64	C		
5	A	25	C	45	C	65	B		
6	B	26	B	46	B	66	A		
7	C	27	C	47	A	67	C		
8	D	28	A	48	C	68	C		
9	B	29	C	49	D	69	A		
10	C	30	B	50	D	70	C		
11	C	31	B	51	C	71	C		
12	D	32	A	52	C	72	A		
13	C	33		53	B	73	B		
14	C	34	A	54	B	74	A		
15	B	35	C	55	C	75	D		
16	B	36	D	56	C	76	B		
17	C	37	D	57	A	77	A		
18	B	38	A	58	B	78	B		
19	C	39	C	59	C	79	A		
20	B	40	D	60	C	80	B		

Mechanics of materials and structure

3.1 Mechanics of materials

Mechanics of Materials, also known as Strength of Materials, is a fundamental branch of engineering that focuses on understanding how materials deform and fail under various types of loading.

➢ This field is essential for designing and analyzing structures such as buildings, bridges, and mechanical components to ensure they can withstand applied forces without failure.

3.1.1 Internal effect of loading

In a structural system, the internal effects of loading are:
a. Deformation and internal stresses.
b. Deformation of system
c. Emergence of internal stresses.
d. Rigid body movement of the system

*Stress

The internal resistance of a material to deformation, quantified as force per unit area (e.g., Pascals, Pa).

i.e. stress=internal resisting force /Area=N/m²

Types of stress are:

A. Direct stress
   a. Normal/axial stress
      ➢ It acts perpendicular to the cross-sectional are on which load is subjected.
      ➢ Normal stress= axial force/area=A.F./A
   i. **Tensile Stress**:
      ➢ Occurs when a material is subjected to pulling forces, causing it to elongate.
   ii. **Compressive Stress**:
      ➢ Occurs when a material is subjected to pushing forces, causing it to shorten.
   b. Shearing stress
      ➢ It develops due to shear force.
      ➢ It acts tangential to the surface.
   c. Bearing stress
      ➢ It develops at the state of load transfer.
      ➢ It defines the load bearing capacity of a body.
   d. Thermal stress
      ➢ It develops due to change in temperature of a body.

B. Indirect stress
   a. Bending stress
      ➢ It develops due to bending of a body.
   b. Torsional stress
      ➢ It develops torsion action on a body.

*Strain

The deformation or displacement of material particles relative to each other, expressed as a dimensionless ratio of change in length to original length.

Strain=change in length of the body/original length of body
➢ It has no unit.

Types of strain are:

A. **Normal strain**
   a. **Tensile Strain**:
      ➢ Occurs when a material is stretched or elongated.
   b. **Compressive Strain**:
      ➢ Happens when a material is compressed or shortened.

B. **Shear strain**
   ➢ It develops due to shear stress.
   ➢ It is measured by the angular deformation accompanying the share stress.

C. **Volumetric strain**
   ➢ It's defined by change in volume per unit original volume.
      Volumetric strain=change in volume / original volume.

Some related topics

A. **Hook's Law**

According to hook's law "stress is directly proportional to strain with in limit of proportionality".

   i.e. stress∝strain

or, stress= modulus of elasticity*strain

where,

   the value of modulus of elasticity = $2*10^5$N/mm^2=200KN/mm^2

   the value of modulus of elasticity = $5000\sqrt{fck}(IS\ 456:2000)$

   $=5700\sqrt{fck}(IS\ 456:1978)$

The value of modulus of elasticity = $2.1*10^5$N/mm^2 for mild steel

- The modulus of elasticity is inversely proportional to temperature.

B. **Modulus of elasticity/young's modulus (E)**

The ratio of linear stress to linear strain is called modulus of elasticity.

C. **Modulus of rigidity (N)**

It's the defined as the ratio of shear stress to shear strain is called modulus of rigidity.

D. **Bulk modulus (K)**

When three mutually perpendicular stress is acting on body, then the ratio of direct stress to volumetric strain is called bulk modulus.

   i.e. bulk=direct stress/volumetric strain

E. **Poison's ratio(μ)**

It's defined as the ratio of lateral strain to longitudinal strain is called poison's ratio.

   ➢ The value of poison's ratio for concrete= 0.1-0.2
   ➢ The value of poison's ratio for steel= 0.25-0.33
   ➢ The value of poison's ratio for cast irn= 0.21-0.27

*Relation between E,N,K,M

E=2N(1+ μ)-----------(i)

E=3K(1-2 μ)----------(ii)

E=$\frac{9KN}{3K+N}$

3.1.2 Ultimate strength and working stress of materials

*Ultimate strength:

The stress, which attains it's maximum value is known as ultimate stress. It's defined as the largest stress obtained by dividing the largest value of the load reached in a test to the original cross-sectional area of the test piece.

*Working Stress:
When designing, it's desirable to keep the stress lower than the maximum or ultimate stress at which failure of the material takes place. This stress is known as the working stress or design stress. It's also known as safe or allowable stress.

*Stress- Strain Curve
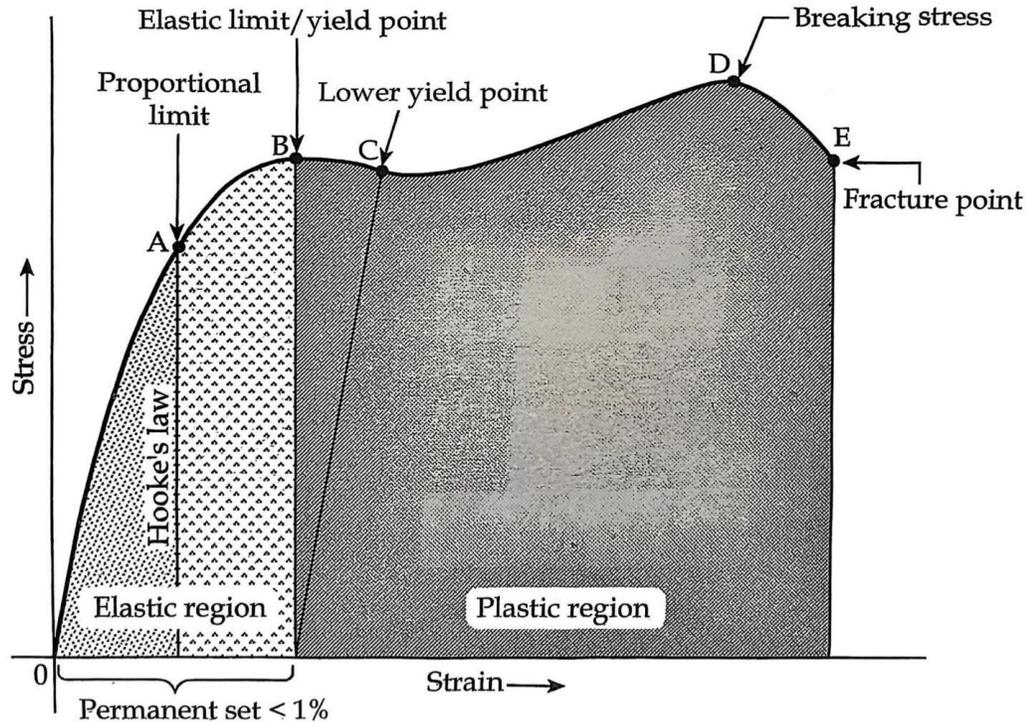
Explaining stress-strain graph

The different regions in the stress-strain diagram are:

A. **Proportional limit**
It's the region in the stress-strain curve that obey's hooke's law. In this limit, the stress-strain ratio gives us a proportionality constant known as young's modulus. The point OA in the graph represents the proportional limit.

B. **Elastic limit**
It's the point in the graph up to which the material returns to its original position when the load acting on it is completely removed. Beyond this limit, the material doesnot return to it's original position, and a plastic deformation starts to appear in it.

C. **Yield point**
The yield point is defined as the point at which the material starts to deform plasticity. After the yield point is passed, permanent plastic deformation occurs. There are two yield points (i) upper yield point (ii) lower yield point.

D. **Ultimate stress point**

It's a point that represents the maximum stress that a material can endure before failure. Beyond this point, failure occurs.

E. Fracture or breaking point

It's the point in the stress-strain curve at which the failure of the material takes place.

3.2 Mechanics of Beams

The beam is a structural member which is used to bear different loads. It resists the vertical loads, shear forces and bending moments.

*__Types of beam__

A. **Simply Supported Beam**:
➢ Supported at both ends (commonly with one pinned support and one roller), allowing rotation at the ends. Widely used and statically determinate.
B. **Cantilever Beam**:
➢ Fixed at one end and free at the other. Common in balconies, awnings, and certain bridge segments.
C. **Continuous Beam**:
➢ Extends over more than two supports. Offers better load distribution but is statically indeterminate.
D. **Fixed (Built-in) Beam**:
➢ Both ends are fully restrained (no rotation or translation), increasing resistance to bending but requiring indeterminate analysis.
E. **Overhanging Beam**:
➢ Supported at two points, but one or both ends extend beyond the supports.
F. **Double Overhanging Beam**:
➢ Both ends extend beyond supports, with support typically located in the center.
G. **Trussed Beam**:
➢ A beam reinforced with a truss-like frame to accommodate longer spans (commonly used in warehouses)

*__Loads on Beams__

A. Dead load
➢ The load of constant magnitude that remains in one position is called dead load.
➢ It consists of structure's own weight and other loads.
B. **Live Load**
➢ Variable or movable loads such as people, equipment, or furniture.
C. Impact load
➢ The load caused by the vibration of moving vehicles or movable loads is called impact load.
D. Lateral Load
➢ Load caused by wind and earthquake is called lateral load.
E. Longitudinal load
➢ The load caused either by stopping a train on a railway bridge or truck on a highway bridge is called longitudinal load.

*__Common Types of load on Beam__

A. Point (Concentrated) Load
➢ **Definition**: A force applied at a specific, singular point along the beam.

      ➢ **Examples**: A column or heavy equipment resting on the beam.
B. Uniformly Distributed Load (UDL)
      ➢ **Definition**: A load that is evenly spread across a length of the beam, with constant intensity (e.g., kN/m).
      ➢ **Examples**: The weight of a floor slab transferred onto the beam.
C. Uniformly Varying Load (UVL)
      ➢ **Definition**: Load intensity increases linearly across the span—zero at one end, maximum at the other (triangular).
      ➢ **Examples**: Hydrostatic pressure on a retaining wall or sloped snow load.
D. Trapezoidal (Non-Uniform) Load
      ➢ **Definition**: A load whose intensity varies in a non-uniform but typically linear manner—combination of UDL and UVL.
      ➢ **Examples**: Earth pressure on retaining structures.
E. Moment (Couple)
      ➢ **Definition**: A pure bending moment applied to the beam, causing rotation. No net force, just a torque.
      ➢ **Examples**: Moments at fixed supports or applied by connected structural elements.
F. Inclined Point Load
      ➢ **Definition**: A point load applied at an angle, comprising vertical and horizontal components.
      ➢ **Effects**:
      ➢ Vertical component → Shear forces & bending moments.
      ➢ Horizontal (axial) component → Tension or compression within the beam.
G. Arbitrary/General Variable Loads
      ➢ **Definition**: Complex or irregular load distributions that do not conform to standard shapes. These require integration or numerical methods to analyze.
      ➢ **Use**: Often represent real-world, uneven loading scenarios.

*Supports

A. Pinned (Hinged) Support
      ➢ **What it does**: Restricts horizontal and vertical displacement, but allows rotation.
      ➢ **Reactions provided**: Horizontal and vertical forces only (no moment).
      ➢ **Where used**: Typical in simply supported beams, truss systems. Also simplifies analysis by avoiding moment transfer.
B. Roller Support
      ➢ **What it does**: Prevents vertical displacement but allows horizontal movement and rotation.
      ➢ **Reactions provided**: Vertical force only.
      ➢ **Where used**: Bridges and structures that undergo thermal expansion or contraction.
C. Fixed Support
      ➢ **What it does**: Prevents all movement—horizontal, vertical—and rotation.
      ➢ **Reactions provided**: Horizontal force, vertical force, and a moment.
      ➢ **Where used**: Cantilever beams, retaining walls, or structural frame connections needing high rigidity.

      ➢ **Details**: In structural terms, it resists translation in both axes and restrains rotation, making it a statically indeterminate connection.

3.2.1 Shear force and bending moment
    A. Axial force
- ➢ It act along the longitudinal direction.
- ➢ It's defined as the algebraic sum of all longitudinal force acting along either direction of assumed section.
- ➢ The variation of axial force is called axial force diagram.

    B. Shear force
- ➢ It actual along the transverse direction .
- ➢ It's defined as the algebraic sum of all tranverse force acting along either direction of assumed section.

    C. Bending moment
- ➢ The algebraic sum of all moment due to force acting on either side of assume section is called bending moment.
- ➢ Saging moment is taken as positive bending moment.
- ➢ Hagging moment is taken as negative bending moment.

*Shearing force diagram

    This is a graphical representation of the variation of the shearing force on a portion or the entire length of a beam or frame. As a convention, the shearing force diagram can be drawn above or below the x-centroidal axis of the structure, but it must be indicated if it is a positive or negative shear force.

*Bending moment diagram

    This is a graphical representation of the variation of the bending moment on a segment or the entire length of a beam or frame. As a convention, the positive bending moments are drawn above the x-centroidal axis of the structure, while the negative bending moments are drawn below the axis.

***Shear force and bending moment diagram**

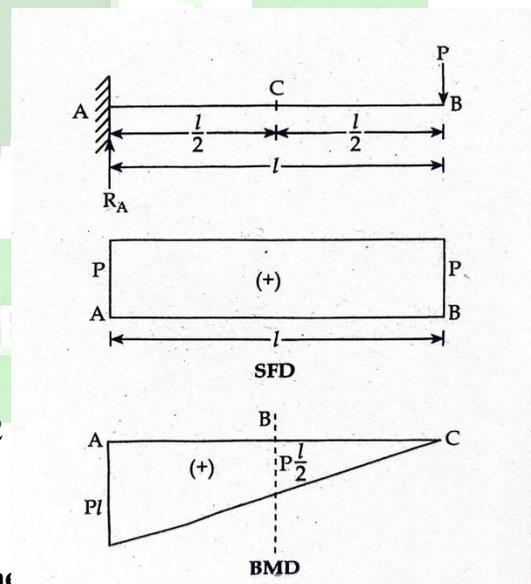**For a cantilever beam carrying point load on free end**

        Let R_A be the support at A

          $R_A = P$

      To draw SFD

          SF at A= R_A=p

          SF at B=P

      To draw BMD

          BM at A=P*l =Pl

          BM at mid span=P*(l/2)=Pl/2

          BM at B=0

For a cantilever beam carrying udl w/length throught the .

    Let R_A be the support reaction at A and C be the centre of beam.

$R_A = wl$

To draw SFD

SF at A $= R_A = wl$

SF at C $= w*l/2 = wl/2$

SF at B $= 0$

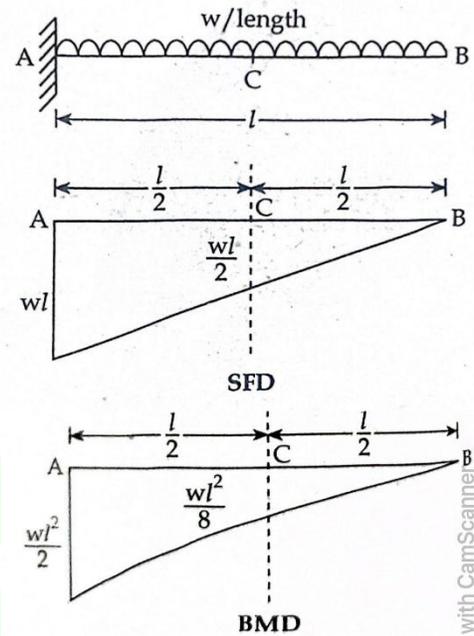**To draw BMD**

BM at B $= 0$

BM at C $= w*l/2 *l/4 = wl^2/8$

BM at A $= w*l*l/2 = wl^2/2$

For a simply supported beam of span l carrying point load p at the center

Or, $R_A*l - P*l/2 = 0$

Or, $R_A = p/2$

Also,

$R_A + R_B = P$

$R_B = P - P/2 = P/2$

To draw SF

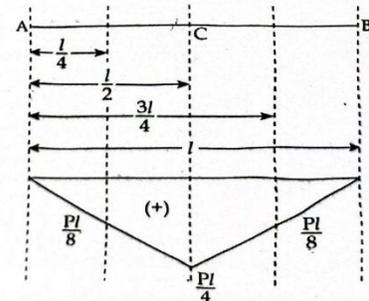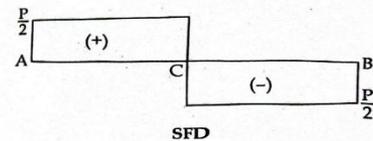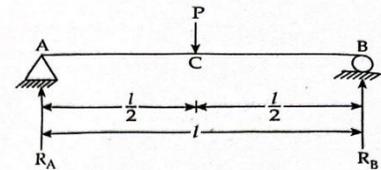SF at A, $SF_A = R_A = P/2$

SF at just left of C $= R_A = p/2$

SF at just right of C $= R_A - P = p/2 - p = -p/2$

SF at B $= R_A - P = p/2 - P = -P/2$

To draw BM

BM at A $= 0$

BM at l/4 from A $= R_A*l/4 = P/2*l/4 = Pl/8$

BM at center C = $R_A*l/2=P/2*l/2=Pl/4$

BM at 3l/4 from A = $R_A*3l-P*(3l/4-l/2)$

$=P/2*3l/4-P*(3l-2l)/4=3Pl/8-Pl/4$

$= (3Pl-2Pl)/8$

$=Pl/8$

BM at B=0

3.3 Simple strut Theory
*Strust

A strut is a structural member (a beam, rod, or bar) designed primarily to resist longitudinal (axial) compression**.** It may be oriented vertically, inclined, or horizontally depending on the design requirements.

*Euler's theory
The struts which fail by buckling can be analyzed by euler's theory. In the following sections, different cases of the struts have been analysed.

Critical load (P) = $(P^2El)/Cl^2$

Where,

C is a constant representing the end conditions of the column.

a) C=1 for column both ends hinged
b) C=4 for one end fixed and other end free
c) C=1/4 or a both ends fixed
d) C=1/2 for one end fixed and other end hinged.

S.N.	End condition	Effective length	Crippling load
1	Both ends are hinged	Left=l	$\dfrac{\pi 2El}{l2}$
2	Both ends fixed	Left=l/2	$4\dfrac{\pi 2El}{l2}$
3	One end fixed and other free	Left=2l	$\dfrac{\pi 2El}{4l2}$
4	One end fixed and other hinged	Left=l/$\sqrt{2}$	$\dfrac{2\pi 2El}{l2}$

*All Numerical and remaining part discuss in physical and online class.

1. Which type of stress occurs when a material is subjected to forces that tend to elongate it?

   A) Compressive stress
   B) Tensile stress
   C) Shear stress
   D) Torsional stress

2. What type of stress is produced when forces act to shorten a material?
   A) Tensile stress
   B) Compressive stress
   C) Shear stress
   D) Torsional stress

3. Which stress is caused by forces that act parallel to the surface of a material?

   A) Tensile stress
   B) Compressive stress
   C) Shear stress
   D) Bending stress

4. What type of stress results from twisting forces applied to a material?

   A) Tensile stress
   B) Compressive stress
   C) Shear stress
   D) Torsional stress

5. Which of the following is a type of normal stress?

   A) Shear stress
   B) Tensile stress
   C) Torsional stress
   D) All of the above

6. Which stress is associated with the twisting of a shaft?

   A) Bending stress
   B) Torsional stress
   C) Shear stress
   D) Axial stress

7. What type of stress occurs when a material is subjected to a uniform pressure in all directions?

   A) Bending stress
   B) Hydrostatic stress
   C) Shear stress
   D) Axial stress

8. Which stress is experienced by a material when it is subjected to a bending moment?

   A) Shear stress
   B) Bending stress
   C) Torsional stress
   D) Tensile stress

9. What type of stress is caused by temperature changes in a material?

   A) Thermal stress
   B) Bending stress
   C) Shear stress
   D) Torsional stress

10. Which stress is associated with the internal resistance of a material to deformation?

    A) Internal stress
    B) External stress
    C) Residual stress
    D) Applied stress

11. What type of stress is generated when a material is subjected to cyclic loading?

    A) Fatigue stress
    B) Thermal stress
    C) Shear stress
    D) Bending stress

12. Which stress is caused by the application of an external force over a specific area?

    A) Shear stress
    B) Normal stress
    C) Axial stress
    D) All of the above

13. Which stress is associated with the deformation of a material due to an applied force?

    A) Strain
    B) Stress
    C) Shear stress
    D) Bending stress

14. What type of stress is generated when a material is subjected to a force that causes it to elongate or compress?

    A) Normal stress
    B) Shear stress
    C) Torsional stress
    D) Bending stress

15. Which stress is caused by the application of a force that acts parallel to the surface of a material?

    A) Shear stress
    B) Normal stress
    C) Torsional stress
    D) Axial stress

16. Which stress is associated with the internal resistance of a material to deformation under an applied force?

    A) Internal stress
    B) External stress
    C) Residual stress
    D) Applied stress

17. Strain is defined as the ratio of:

    A) Force to area
    B) Change in length to original length
    C) Stress to strain
    D) Mass to volume

18. Which of the following is a unit of strain?

    A) N/m²
    B) m/m
    C) kg/m³
    D) N·m

19. Strain is a:

    A) Scalar quantity
    B) Vector quantity
    C) Neither scalar nor vector
    D) Both scalar and vector

20. Which type of strain occurs due to a change in volume?

    A) Linear strain
    B) Volumetric strain
    C) Shear strain
    D) Angular strain

21. Shear strain is measured in:

    A) Radians
    B) Meters
    C) Pascals
    D) None of the above

22. The strain produced in a material is inversely proportional to:

    A) Young's Modulus
    B) Stress
    C) Area
    D) Force

23. Which of the following is true about strain?

    A) It is dimensionless
    B) It has units of force
    C) It is always positive
    D) It depends on the material's density

24. In the elastic region of a stress-strain curve, strain is:

    A) Proportional to stress
    B) Independent of stress
    C) Zero
    D) Inversely proportional to stress

25. The point on the stress-strain curve where the material starts to yield is known as the:

A) Ultimate tensile strength
B) Yield point
C) Fracture point
D) Proportional limit

26. Which of the following materials exhibits a large amount of strain before fracture?

A) Brittle materials
B) Ductile materials
C) Both A and B
D) Neither A nor B

27. The slope of the stress-strain curve in the elastic region represents:

A) Poisson's ratio
B) Young's Modulus
C) Bulk Modulus
D) Shear Modulus

28. Which of the following is a dimensionless quantity?

A) Stress
B) Strain
C) Force
D) Energy

29. The strain energy stored in a material is directly proportional to:

A) Stress
B) Strain
C) Both A and B
D) Neither A nor B

30. In a tensile test, the elongation of a specimen is an example of:

A) Stress
B) Strain
C) Force
D) Energy

31. Which of the following is not a type of strain?

A) Linear strain
B) Volumetric strain

C) Shear strain
D) Thermal strain

32. Which of the following is true about shear strain?

A) It is a measure of angular distortion
B) It is measured in radians
C) It occurs due to forces acting parallel to the surface
D) All of the above

33. Which of the following statements is correct?

A) Strain is always positive
B) Strain can be negative
C) Strain is independent of stress
D) Strain is a vector quantity

34. The total strain in a material is the sum of:

A) Elastic strain
B) Plastic strain
C) Both A and B
D) Neither A nor B

35. What does Hooke's Law state within the elastic limit of a material?
A) Stress is inversely proportional to strain
B) Stress is independent of strain
C) Stress is directly proportional to strain
D) Stress is exponentially related to strain

36. The modulus of elasticity (Young's modulus) is defined as:
A) The product of stress and strain
B) The ratio of stress to strain
C) The difference between stress and strain
D) The sum of stress and strain

37. The unit of Young's modulus is:
A) Newton (N)
B) Pascal (N/m²)
C) Newton-second (N·s)
D) Meter per second squared (m/s²)

38. Which material typically obeys Hooke's Law?
    A) Rubber
    B) Steel
    C) Glass
    D) Clay

39. Modulus of Rigidity (Shear modulus) is defined as the ratio of:
    A) Tensile stress to tensile strain
    B) Shear stress to shear strain
    C) Tensile stress to shear strain
    D) Shear stress to tensile strain

40. The Bulk Modulus is given by the ratio of:
    A) Tensile stress to tensile strain
    B) Volumetric stress to volumetric strain
    C) Shear stress to shear strain
    D) Force to area

41. Poisson's ratio (μ) is defined as:
    A) Lateral strain divided by longitudinal strain
    B) The negative of lateral strain divided by longitudinal strain
    C) Longitudinal strain divided by lateral strain
    D) The ratio of stress to strain

42. Which equation correctly relates E, Bulk Modulus (K), and Poisson's ratio (μ)?
    A) $E = 2K (1 + \mu)$
    B) $E = 3K (1 - 2\mu)$
    C) $E = 2K (1 - \mu)$
    D) $E = K / (1 - 2\mu)$

43. The combined relation between E, G, and K is:
    A) $E = 9KG / (3K + G)$
    B) $E = 9KG / (K + 3G)$
    C) $E = 3KG / (K + G)$
    D) $E = 9KG / (K + G)$

44. Under elastic behavior, the constant of proportionality between shear stress and shear strain is called:
    A) Young's modulus
    B) Bulk modulus
    C) Modulus of rigidity
    D) Poisson's ratio

45. The ultimate tensile strength of a material is:

    A) The maximum stress a material can withstand without permanent deformation
    B) The maximum stress a material can withstand before fracture
    C) The stress at which a material begins to yield
    D) The stress at which a material breaks

46. The working stress is:

    A) The maximum stress a material can withstand before fracture
    B) The stress at which a material begins to yield
    C) The stress considered safe for design purposes
    D) The stress at which a material breaks

47. The ratio of ultimate stress to working stress is called:

    A) Factor of safety
    B) Modular ratio
    C) Poisson's ratio
    D) Elastic modulus

48. The factor of safety is used to:

    A) Ensure that the material does not fail under maximum load
    B) Calculate the ultimate tensile strength
    C) Determine the yield point of a material
    D) Measure the ductility of a material

49. In the working stress method of design:

    A) The material is assumed to behave elastically up to the point of failure
    B) The permissible stress is determined by dividing the ultimate stress by a factor of safety
    C) The material is assumed to behave plastically
    D) The factor of safety is not considered

50. The modular ratio is the ratio of:

    A) Young's modulus of steel to Young's modulus of concrete
    B) Ultimate stress of steel to ultimate stress of concrete
    C) Working stress of steel to working stress of concrete
    D) None of the above

51. A beam that is supported at both ends and is free to rotate is known as:

    A) Cantilever beam
    B) Simply supported beam
    C) Fixed beam
    D) Continuous beam

52. A beam that is fixed at one end and free at the other end is called:

    A) Cantilever beam
    B) Simply supported beam
    C) Fixed beam
    D) Continuous beam

53. A beam that is supported at more than two points is known as:

    A) Cantilever beam
    B) Simply supported beam
    C) Fixed beam
    D) Continuous beam

54. A beam that has one end fixed and the other end simply supported is called:

    A) Propped cantilever beam
    B) Simply supported beam
    C) Fixed beam
    D) Continuous beam

55. A beam that extends beyond its support at one or both ends is known as:

    A) Cantilever beam
    B) Simply supported beam
    C) Overhanging beam
    D) Fixed beam

56. A beam that is fixed at both ends is called:

    A) Cantilever beam
    B) Simply supported beam
    C) Fixed beam
    D) Continuous beam

57. A beam that is subjected to a uniformly distributed load is known as:

    A) Cantilever beam
    B) Simply supported beam
    C) Overhanging beam
    D) Uniformly loaded beam

58. A beam that is subjected to a point load at its center is called:

    A) Simply supported beam
    B) Cantilever beam
    C) Point loaded beam
    D) Overhanging beam

59. A beam that is subjected to a varying load along its length is known as:

    A) Uniformly loaded beam
    B) Point loaded beam
    C) Variable loaded beam
    D) Overhanging beam

60. A beam that is subjected to torsion is known as:

    A) Torsion beam
    B) Twisted beam
    C) Shear beam
    D) Fixed beam

61. A beam that is used to support a floor or roof is known as:

    A) Floor beam
    B) Roof beam
    C) Slab beam
    D) Structural beam

62. A beam that is used to support a bridge deck is called:

    A) Bridge beam
    B) Deck beam
    C) Girder
    D) Truss beam

63. A beam that is used to support a roof truss is known as:

    A) Truss beam
    B) Roof beam
    C) Purlin
    D) Rafter

64. A beam that is used to support a floor slab is known as:

    A) Slab beam
    B) Floor beam
    C) Girder
    D) Rafter

65. The variation of bending moment along the length in a cantilever beam with uniformly distributed load is _____.
    A) constant
    B) parabolic
    C) linear
    D) cubic

66. What is the bending moment at the end supports of a simply supported beam?
    A) Maximum
    B) Minimum
    C) Zero
    D) Uniform

67. In a beam, the effect of bending stress compared to shear stress is:
    A) greater than
    B) less than
    C) equal to
    D) negligible

68. Which of the following describes axial loading?
    A) Forces perpendicular to the beam's axis

B) Forces along the longitudinal axis
C) Twisting moments
D) Bending loads

69. The internal couple due to external forces is called _____, and the resultant internal force perpendicular to the member is _____.
    A) shear force; axial force
    B) bending moment; shear force
    C) axial force; bending moment
    D) bending moment; axial force

70. The variation of the bending moment along the length in a cantilever beam with a uniformly distributed load is _____.
    A) constant
    B) parabolic
    C) linear
    D) cubic

71. What is the bending moment at the end supports of a simply supported beam?
    A) Maximum
    B) Minimum
    C) Zero
    D) Uniform

72. What is the maximum shear force when a cantilever beam is loaded with UDL throughout?
    A) $w \times l$
    B) w
    C) w/l
    D) $w+l$

73. Sagging (positive bending moment) in a simply supported beam under uniform load occurs at _____.
    A) Supports
    B) Mid-span
    C) Point of contraflexure
    D) Point of emergence

74. What is the maximum bending moment for a simply supported beam carrying a point load WWW at its center?
    A) W
    B) W/m

C) W·l

D) (W·l)/4

75. Which is the correct relationship between bending moment M and shear force V?
A) V=dM/dx
B) V=M·x
C) M=dV/dx
D) M=Vx

76. The slope of the shear force diagram is equal to _____.
A) Bending moment
B) Load intensity
C) Moment of inertia
D) Deflection

77. At a point in a beam where shear force is zero, the bending moment is _____.
A) Maximum
B) Zero
C) Increasing
D) Infinite

78. The buckling (critical) strength of a strut is proportional to which parameter?
A) EI/L^2
B) EA/λ^2
C) EI/L^2
D) All of the above

79. The buckling strength of a strut depends on:
A) Young's modulus E
B) Moment of inertia I
C) Effective length Le
D) All of the above

80. The factor KKK in the Euler formula accounts for:
A) Material properties
B) Cross-sectional shape
C) End support (boundary) conditions
D) Temperature effects

81. Euler's formula for critical load is not applicable when the slenderness ratio is:
A) Very high
B) Moderate

C) Very low

D) Irrelevant

82. A compression member always tends to buckle in the direction of:
A) The axis of load
B) Perpendicular to the axis of load
C) Maximum cross-sectional area
D) Minimum radius of gyration

83. What is the primary focus of Strength of Materials?
A) Thermal properties
B) Stress and strain analysis
C) Material composition
D) Fluid dynamics

84. What is tensile strain?
A) Ratio of original length to change in length
B) Ratio of change in length to tensile force applied
C) Ratio of tensile force to change in length
D) Ratio of change in length to original length

85. Which law is also known as the elasticity law?
A) Poisson's law
B) Bernoulli's law
C) Stress law
D) Hooke's law

86. What is the factor of safety?
A) Ratio of stress to strain
B) Ratio of ultimate stress to permissible stress
C) Ratio of permissible stress to ultimate stress
D) Ratio of longitudinal strain to stress

87. What is creep?
A) Gradual increase of plastic strain with time and varying load
B) Gradual increase of elastic strain with time and varying load
C) Gradual increase of plastic strain with time under constant load
D) Gradual increase of elastic strain with time under constant load

88. Which of these loads is not commonly applied to a building?
   A) Environmental load
   B) Live load
   C) Dead load
   D) Rain load

89. Which is a statically determinate structure?
   A) Two-hinged arch
   B) Fixed beam
   C) Double overhanging beam
   D) Continuous beam

90. In a truss, if a member is not subject to any external force or load, the force in that member is?
   A) Zero

B) √2 KN (Tensile)
C) 1 KN (Tensile)
D) 1 KN (Compressive)

91. What type of load do truss members primarily carry?
   A) Bending load
   B) Flexural load
   C) Axial load
   D) Shear load

92. In a beam with a moment M applied at one end and the other hinged, the carry-over moment at the hinged support is?
   A) –M
   B) +M/2
   C) +M
   D) 0

Topics Wise MCQ Discussion in physical and online class.

Answers

1	B	21	A	41	B	61	A	81	C
2	B	22	A	42	B	62	D	82	D
3	C	23	A	43	B	63	C	83	B
4	D	24	A	44	A	64	A	84	D
5	B	25	B	45	C	65	B	85	D
6	B	26	B	46	B	66	C	86	B
7	B	27	B	47	C	67	A	87	C
8	B	28	B	48	A	68	B	88	D
9	A	29	C	49	A	69	B	89	C
10	C	30	B	50	B	70	B	90	A
11	A	31	D	51	A	71	C	91	C
12	B	32	D	52	B	72	A	92	D
13	B	33	B	53	A	73	B		
14	A	34	C	54	D	74	D		
15	A	35	C	55	A	75	A		
16	A	36	B	56	C	76	B		
17	B	37	B	57	C	77	A		
18	B	38	B	58	D	78	D		
19	A	39	B	59	C	79	D		
20	B	40	B	60	C	80	C		

1. Hydraulics
Hydraulics is a branch of science and engineering that deals with the mechanical properties of liquids, particularly their behavior when at rest or in motion, and their application in various technologies, Fluid mechanics.

Fluid Mechanics
Fluid mechanics is the study of how fluids (liquids and gases) behave when they are at rest or in motion.
- ➢ Fluid in the substance than can flow.
- ➢ Fluid are the liquid and gas.
- ➢ Fluid is the substance that deform continuously under the motion of shear stress.
- ➢ For Example:- Water, petrol, oil , diseal, movies, concrete, air, bond, toothpaste etc.

2.Fluids
A fluid may be defined as the substance which is capable of flowing.
- ➢ It has No. Definite shape of it's own, but conforms to the shape of the containing vessel.

2.1 Properties of Fluid
i) Mass density
ii) Specific weight/Weight density
iii) Specific volume
iv) Specific gravity
v) Viscosity
vi) Cavitation
vii) Compressibility
viii) Capillarity
ix) Surface tension
x) Fluid/water pressure

i) Mass density
It's ratio of mass of an object to it's volume.
- ➢ Mass per unit volume.
- ➢ It's denoted By ρ.

Mathematically,

$$(\rho) = \frac{mass}{volume} = \frac{M}{V}$$

- ➢ S.I. unit of mass density (ρ) is $= \frac{Kg}{m3}$.

ii) Specific weight or weight density
it can be defined as the ratio of weight of fluids to it's volume.

Weight per unit volume.
- ➢ It's denoted by symbol γ (gamma).

Mathematically,

$$(\gamma) = \frac{weight}{Volume} = \frac{W}{V}$$

$$= \frac{M*g}{V} \qquad [\because W = M \times g]$$

$$=\frac{M}{V} \times g$$

$$\therefore Y = \rho \times g \qquad\qquad [\because \rho = \frac{M}{V}]$$

➢ SI unit of weight density is $\frac{N}{m3}$.

iii) Specific volume

The ratio of volume of object to it's mass.

➢ Volume per unit mass.

➢ It's denoted by V.

Mathematically,

$$V = \frac{v}{M}$$

➢ SI unit of specific volume is M^3/Kg

iv) Specific gravity / Realtive density

It can be defined as the ratio of specific weight of liquid to the specific weight of standard fluids(water).
Or ratio of density of fluid to density of water.

➢ It has unitless and dimension less.

Mathematically,

Specific gravity(s.g.)= mass of certain volume of a liquid/ mass of same volume of water at 4°C.

$$(s. g.) = \frac{\text{density of fluid}}{\text{density of water}} = \frac{\rho}{\rho w}$$

specific weight of fluid/specific weight of water $= \frac{\gamma}{\gamma w}$

Notes:

➢ *Density of any substance = ρ = specific gravity × density of water*

➢ *Specific weight of any substance = γ = specific gravity × specific weight of water*

➢ *Density of water (ρ) = 1000 kg/m3.or 1g/cc*

➢ *Density of mercury γ hg = 13600 kg/m3*

➢ *Specific weight of water (γ) = 9810 N/m3.*

v) Viscosity

Viscosity is defined as the property of a fluid that resists the movement of one layer of fluid over an adjacent layer.

➢ Viscosity is also defined as the shear stress required to produces unit rate of shear strain.

➢ it's also called internal friction between layers of fluids.

vi) Cavitation

Cavitation is the formation and rapid collapse of vapor bubbles within a liquid due to a pressure drop below the liquid's vapor pressure.

vii) Compressibility

Compressibility is that property of liquid by virtue of which liquids undergo a change in volume with the change in pressure.

➢ Property of fluid due to which it can be compressed.

Mathematically,

Compressibility $= \frac{1}{K}$

Where,

K = bulk modulus of elasticity.

➢ bulk modulus of ideal fluid is infinity.

viii) Surface tension

Surface tension is defined as the force per unit length acting along the surface of a liquid, perpendicular to an imaginary line drawn on the surface.

➢ Surface tension exists for liquids only not for gas.

➢ Surface tension is force per unit length.

➢ Due to surface tension liquid drops become spherical (minimum surface area).

➢ Surface tension occurs because of unbalanced intermolecular force of attraction.

➢ Surface tension acts at interface of two fluids.

ix) Capillarity

capillary is phenomenon of rise or fall if a small tube is inserted in the liquid.

➢ Capillary tube s a small tube of diameter less than 6mm.

x) Fluid/water pressure

Fluid pressure is the force exerted per unit area at a point within a fluid, increasing with depth due to the weight of the fluid above.

3. Types of fluids

a. Ideal Fluid

➢ Zero viscosity (no internal friction).

➢ Incompressible, so density remains constant.

➢ No heat conduction, no energy lost or transferred.

➢ Bulk modulus of elasticity is infinite.

➢ Surface tension and viscosity do not exist.

➢ They are imaginary fluids. They do not exist.

➢ Always laminar, with no turbulence or eddies.

➢ Simplifies analysis and used in theoretical models like bernoulli's and potential flow.

b. Real fluids

➢ Real fluids are viscous.

➢ Real fluids are compressible.

➢ Heat conduction, energy lost or transferred.

➢ Bulk modulus of elasticity is finite.

➢ Surface tension and viscosity exist.

➢ All existing fluids are real fluids.

➢ e.g. water, air, petroleum etc.

(Note: fluids have zero or negligible shear strength.

Ideal fluids have zero shear strength.)

c) Newtonian fluids

The fluids which obey newton's law of viscosity are called Newtonian fluids.

➢ In Newtonian fluids, shear stress and velocity gradient have linear relationship.

➢ Example:- water, air, kerosene, glycerin.

d) Non- Newtonian fluids

The fluids which do not obey newton's law of viscosity are called non Newtonian fluids.

  ➢ In Newtonian fluids, shear stress and velocity gradient have non linear relationship.
  ➢ Example:- Blood, Toothpaste, Concrete etc.

e) Ideal plastic fluid

If the shear stress is directly proportional to the velocity gradient, and if the value of shear stress is greater than the resultant, it's referred to as ideal plastic fluid.

f) Compressible fluid

If a fluid's density varies with the application of force, it's called a compressible fluid.

  ➢ Example:- Air, vapour, and stream.

g) Incompressible fluid

If a fluids density doesn't vary with the application of force, it's known as an incompressible fluid.

  ➢ Example:- The stream of water flowing at high speed from a garden hose pipe.

4. Viscosity

4.1 Newton's law of viscosity

The law state that shear stress is directly proportional to velocity gradient.

Shear stress $\propto$ velocity gradient

$\tau \propto du/dy$

$\tau = \mu \, du/dy$ \qquad\qquad equation (i)

Where,

μ = coefficient of viscosity or coefficient of dynamic viscosity.

(Velocity gradient is the rate of change of velocity per unit distance perpendicular to the surface.

$du/dy=1$, then $\tau = \mu$ hence, coefficient of viscosity is also defined as the shear stress required to maintain unit velocity gradient between the layers of fluid.

Fig: velocity profile

Fig: distortion of fluid mass
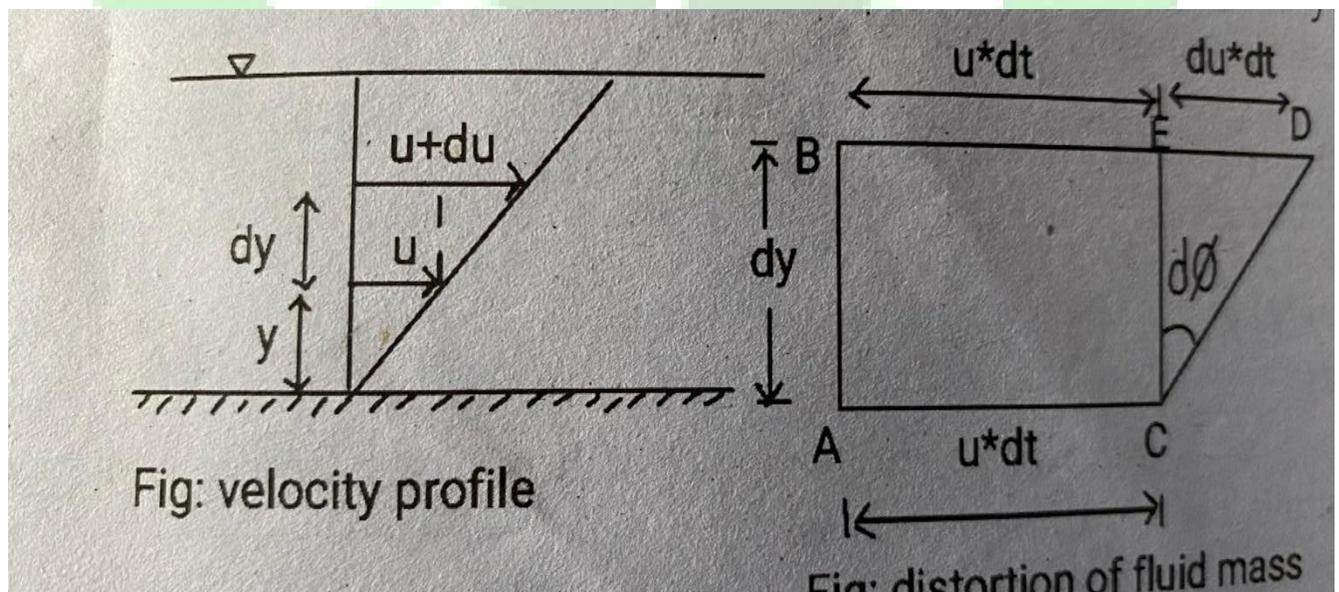
Consider two points A and B in the fluid layer. The two points are separately by distance Ab=dy.

The velocity of the fluid at point A and B are u and u + du.

After time dt,

The fluid particle at A reaches at point C whereas the fluid

4.2 Types of viscosity (Based on measurement)

i. Dynamic viscosity

It's the property of fluid by virtue of which it offers resistance to the movement on layer of fluid over and adjacent layer of fluid.

> ➢ It's also called absolute with low velocity and temperature.
> ➢ SI units of Dynamic viscosity is N.Sec/m2.

ii. Kinematic viscosity

It's defined as the ratio of dynamic viscosity to the density of fluid.

> ➢ It's denoted by γ.(Gamma)

5. Pressure in hydraulics

The force applied by a fluid per unit area is hydraulic system is called pressure in hydraulics.

Mathematically,

P=F/A

Where,

P = Pressure (in Pascal)

F = Applied Force (in Newton)

A = Area (in square meter)

> ➢ Unit of pressure in hydraulics is N/m2 or Pascal.

5.1 Types of pressure

a) Atmospheric pressure

Atmospheric pressure is the pressure due to weight of atmosphere or air above the ground surface which is nothing but the pressure exerted by the earth's atmosphere on objects.

> ➢ Standard value at sea level
>
>   1 atm = 101325 pa = 1.013 bar
>
> ➢ It can be measured by barometer.

b) Gauge pressure

Pressure measured relative to atmospheric pressure is called gauge pressure.

> ➢ Most pressure measuring instrument.

Mathematically,

> ➢ Gauge pressure (Pgauge) = Absolute pressure (Pabs) - atmospheric pressure (Patm).

C) Absolute pressure

The algebraic sum of the atmospheric and gauge pressure is called absolute pressure.

> ➢ It's the pressure measured above the absolute zero or complete vacuum.
> ➢ Absolute pressure can never be negative.

Mathematically,

Absolute pressure = Gauge pressure + atmospheric pressure.

d) Vacuum pressure

When pressure is below atmospheric pressure, it's called pressure measured as the difference both atmospheric pressure and actual pressure.

5.2 Pressure conversion

Pressure can be measured in different unit's, depending on the system (SI, CGS, Imperial etc)

➢ Common pressure units and conversion

S.N.	Unit	Symbol	Equivalent in pascal
1	Pascal	Pa	1 pa
2	Kilopascal	kpa	1 kpa = 1000 pa
3	Bar	bar	1 bar = 100000 pa
4	Atmosphere	atm	1 atm = 101325 pa
5	Milimeter of mercury	mmhg	1mmhg = 133.322 pa
6	Pounds per square inch	psi	1 psi = 6894.76 pa
7	Torr	torr	1 torr = 1 mmhg = 133.322 pa

6. Pascal's law

States that, "When the pressure applied in a fluid at rest in closed vessel, the surface transmit equally in all direction."

i.e. $p_x = p_y = p_z$

where,

p_x = Pressure intensity in x-direction.

P_y= pressure intensity in y direction.

P_z= pressure intensity in z-direction.

7. Hydrostatic law of pressure

When a liquid is at rest the pressure change in vertical direction only.

It states that, "The rate of change of pressure with respect to vertical direction is equal to the weight density of fluid."

i.e. $dp/dz = \gamma$

$dp/dz = \rho g$ $[\gamma = \rho g]$

integrating both side

$$\int \frac{dp}{dz} = \int \rho g$$

$$\int dp = \int \rho g \ dz$$

$$P = \rho gh$$

This is the hydrostatic law of pressure.

8. Pressure measurement

The various devices are used for pressure measurement are classified as;

A. Manometers

B. Mechanical gauges

A. Manometer

In this manometer except piezometer, a manometric fluid is used for pressure measurement.

The manometric fluid should have following properties.

a. High density
b. Low surface tension
c. High boiling point
d. Low vapor pressure
e. Low freezing point
f. Chemically inert
g. Distinct interface

Types of manometers

a. piezometer

it's tube connect to the pipe whose pressure is measured.

➢ Piezometer is used for measures low to moderate pressure.
➢ Piezometer is the simplest for of manometers used for measuring gauge pressure.
➢ As one end is open to the atmosphere so it cannot be used for measuring the gas pressure.
➢ Piezometer is used to measured the static pressure (Gauge) in the pipe.
➢ Pressure at point 'A'

$P_a = \rho gh$

$P_a = \gamma h$

Disadvantage of piezometer

➢ It can not be measured high pressure.
➢ It can't be measured gas pressure.

b. U-tube manometer/U-shaped

➢ It is the tube connected to the U-shaped pipe which is closed at one end and open at another end.
➢ Manometric fluid in U-shaped manometer which have high density and low surface tension.
➢ It can measured gas pressure.

c. Differential manometer

It's used measure difference in pressure between two points at same or different level.

d. One column manometer/single column manometer

In this manometer reading of only one column is sufficient to calculate pressure.

e. Micro-manometer

The micro-manometer which can measured very small difference in pressure is called micro-manometer.

➢ It's used to measure low pressure with high accuracy.
➢ It measure the pressure more accuracy.

B. Mechanical gauge

It's used to measure high pressure with low accuracy.

9. Hydro-kinematic and hydro-dynamic

A) Hydro-kinematics

It's defined as that branch of science which deals with the motion of particles without considering the forces causing the motion.

➢ It's mainly concerned with the velocity of the fluid, once velocity is known, pressure and force can be determined.

a) Continuity Equation

States that, "If an incompressible fluid is continuously flowing through a pipe or open channel (where cross-section are may or may not be constant) the quantity of liquid passing per second is same at all sections."

➢ Continuity equation is based on the conservation of mass.

Assumption made in continuity equation

Following are some assumption made in continuity equation:

➢ The fluid are ideal and uniform

➢ The fluid is incompressible and non-viscous

➢ The fluid flow is steady

➢ The pipe, which is taken into consideration has single entry and single exit point

Derivation,

According to continuity equation;

Mass entering in pipe - mass leaving = change in mass storage

In terms of rate,

Rate of change of mass entering - Rate of change of mass leaving = Rate of change of mass storage_____(i)

Mass of fluid flowing at any section per unit time = ρAV _____(ii)

Where,

ρ = density of fluid

A = Cross-sectional area

V = velocity of fluid

From equation (i)

Continuity equation becomes,

$\rho_1 A_1 V_1 - \rho_1 A_1 V_1 = ds/dt$_____(iii)

But, change in mass storage is zero for security flow. [i.e. ds/dt = 0]

We know,

$\rho_1 A_1 V_1 - \rho_2 A_2 V_2 = 0$

$\rho_1 A_1 V_1 = \rho_2 A_2 V_2$

$A_1 V_1 = A_2 V_2$ [$\rho_2 = \rho_2$ = same]

$Q1 = Q2$

This is the continuity equation for steady flow.

B) Hydro-dynamics

It's defined as the branch of science which deals with the motion of particles considering the forces like elevation, kinetic and potential etc. causing the motion.

➢ Dynamics of fluid is governed by newton's second law of motion.

Types of energy in a flowing fluid/energy of flowing fluid/types of head of a liquid

➢ Energy is the capacity of doing works.

➢ Head is the energy per unit length.

➢ Fluids possesses three types Energ or head;

a) Potential energy/Datum energy

     b) Kinetic energy/velocity energy

     c) Pressure energy/pressure head

a) Potential energy

The energy possessed by a liquid particles by virtue of it's position is called potential energy.

It the liquid particle is 'Z' meters above the horizontal datum then, the particles will be 'z' m per kg of liquid.

It's also known as potential head or datum head.

b) Kinetic head

The energy possessed by a liquid particles by virtue of it's motion or velocity is called kinetic energy head.

Velocity head of liquid will be $V^2/2g$ m of liquid.

∴kinetic energy = $1/2*mv^2$

And kinetic head = $v^2/2g$

c) Pressure energy

The energy possessed by a liquid particle by virtue of it's existing pressure is called pressure energy.

The pressure head under this pressure is = (p/γ) m of fluid

Where,

P = existing pressure

γ=unit weight of water or weight density = ρg

Bernoulli's Equation's and it's application

In a steady ideal flow of an incompressible fluid the sum of potential energy, pressure energy and kinetic energy at any point of the fluid is constant.

➢ Based on law of conservation of energy.

➢ It's derives from euler's formula.

Assumption of bernoulli's equation

Following assumption are made in the derivation of bernoulli's equation;

➢ The fluid is incompressible.

➢ The flow is steady and continuous.

➢ The fluid is ideal i.e. non-viscous.

➢ The flow is irrotational.

➢ The gavity and pressure forces are only considered and other forces are neglected.

➢ The velocity is uniform over the cross-section.

Mathematically,

     Pressure energy + potential energy + kinetic energy = constant

Or,

     Pressure head + potential head + kinetic head = constant

     $p/\gamma + Z + v^2/2g$ = constant_____(i)

where,

Z = Elevation head/datum head/static head

p/γ = pressure head,

V^2= velocity head

Also equation (i) can be expressed as:

$Z_1+P_1/\gamma+ V_1^2/2g = Z_2+P_2/\gamma+ V_2^2/2g$_____(ii)

Bernoulli's equation for real fluid

In read fluid, there always occurs head loss and energy of fluid goes on decreasing along the direction of flow. Bernoulli's equation for real fluid can be expressed as:

$$Z_1+P_1/\gamma+V_1^{2/}2g= Z_2+P_2/\gamma+V_2^{2/}2g$$

Where, hf = head loss between points 1 and 2.

Limitation of bernoulli's equation

- ➢ The velocity of flow isn't constant at every point of cross-section, but bernoulli's has assumed same velocity at every point of cross section.
- ➢ Bernoulli's has been derived on the assumption that their is no loss of energy but actually there is some loss of energy head loss.

Total energy line(TEL), Energy grade line (EGL), and Hydraulic gradient line (HGL)

a) TEL

The line joining sum of static head, potential head, kinematic head for an ideal fluid is called total energy line.

- ➢ It's also called ideal total energy line.
- ➢ This line always goes down in the direction of flow until and unless energy supplied externally.

b) Energy grade line (EGL)

The line joining sum of static head, pressure head and kinematic head of a fluid is called energy grade line.

Therefore, EGL = Z+P/y +v2/2g

- ➢ Energy grade line is slopping downward.

c) Hydraulic gradient line

The line joining the points representing the value of pressure head + elevation head at the various cross section of pipe in pipe flow.

- ➢ Hydraulic gradient line is also called piezometric head line.
- ➢ It's the sum of static head and pressure head.
- ➢ This line may go up or down in the flow direction.
- ➢ Hydraulic gradient line generally lies above the center line. However, if the pressure in the pipe is negative (less than atmospheric pressure), the hydraulic gradient lines is below center line of pipe, for example: the HGL of siphon pipe lies below the center line.
- ➢ it will be always lie below the total energy line in a pipe flow.
- ➢ In open channel flow, Hydraulic gradient line coincides with free surface.
- ➢ In pipe flow, hydraulic gradient line is always above the top surface of flow.

Practical application of bernoulli's equation

a) Venturi meter

A venturi meter is an instrument used for measuring the discharge or flow rate in the pipes.

- ➢ The venturimeter works on the Bernoulli's equation, continuity equation and manometric equation.
- ➢ Venturi meter has three parts named convergent, divergent and throat.

➤ The length of divergent pipe is about 3 to 4 times than of the convergent pipe .

➤ The convergent and divergent pipe is same.

➤ The velocity of liquid at the throat is higher than that of inlet. This increase in velocity, results in decreasing the pressure at the throat.

➤ The velocity of liquid at the outlet is lower than that of throat. This decrease in velocity, results in increasing the pressure at the outlet.

The discharge through a ventumeter is given by,

$$Q = \frac{Cd\ A1\ A2\sqrt{gh}}{\sqrt{A12 - A22}}$$

$A_1{}^2 - A_2{}^2$

Where,

Cd coefficient of discharge

A1 cross section area of convergetn

A2 cross section area of divergent

H difference of pressure head at throat and inlet.

b) Orifice meter or plate.

It's used to measuring the discharge or flow rate in the pipes.

➤ The orifice is also works on the Bernoulli's equation, continuity equation and manometric equation.

➤ It consists of a plate having sharp edged circular hole known as orifice which is fixed inside the pipe whose discharge is required.

➤ The discharge through a orifice meter is given by;

$$Q = \frac{Cd\ Ao\ A2\sqrt{gh}}{\sqrt{Ao2 - A22}}$$

Where,

Cd coefficient of discharge

A1 cross section area of convergetn

A2 cross section area of divergent

H difference of pressure head at throat and inlet.

➤ The diameter of orifice meter vary 0.4 to 0.8 times the pipe diameter but normally 0.5 times the diameter of pipe provided.

c) Pitot tube

It's a type of L type tube used to measure velocity in open channel.

➤ The water in the pitot tube at more height than the piezometer.

➤ If water level in the pitot tube rises by h above the water.

If the pitot tube is pointing upstream, water level rises by v2/2g.

If the pitot tube is pointing downstream, water level falls by v2/2g.

d) Nozzle meter

It's used for measuring discharge or flow rate in the pipes.

➤ It consists of a nozzle which descreases flow area and increase velocity.

➤ The discharge through a nozzle meter is given by

$$Q = \frac{Cd\ A1\ A2\sqrt{gh}}{\sqrt{A12 - A22}}$$

Where,

Cd coefficient of discharge = 0.7 - 0.8

h reading of nozzle meter = piezometric head difference = (Z1 + P1/y) - (Z2+P2/y)

4.3 Measurement of discharge
4.3.1. Weirs and Notches
A. Wier

A weir may be defined as a structure constructed across a river or canal which rises water level on upstream and above which water flows.

➢ Weir may also be used for measuring the rate of flow in the river.

➢ The top level of weir above which water flows is crest.

➢ A weir is made of cement concrete or masonry.

➢ A weir is used to measure large discharges.

➢ Weirs are large in size.

B. Notch

It's defined as an opening provided in one side of a tank or reservoir in which the upstream liquid level is below the top edge of opening.

➢ Notch may be used for measuring the rate of flow in the river.

➢ Bottom level of notch above which water flows is sill.

➢ A notch is usually made of metallic plate.

➢ A notch is used to measure small discharges.

➢ Notches are small in size.

Note:

- *The bottom edge of notch over which water is flow is known as sill.*
- *The to edge of weir over which water is flow is known as crest.*
- *The depth of water over crest or sill is head over the crest.*
  Water flowing over a notch or weir is called nappe/vein.

Classification of notch /weir
A. Based on the shape
a) Rectangular notch/weir

Cd = actual discharge/theoretical discharge

Or, actual discharge = Cd * theoretical discharge

= Cd * area of theoretical velocity

DQ= Cd [l*dh] * $\sqrt{2gh}$

integrating, $\int DQ = \int Cd [l * dh) * \sqrt{2gh}$

$\int DQ = Cd\, l\sqrt{2gh} \int (h)1/2$ dh

$Q = Cd\, l\sqrt{2gh}$ [(h)1/2+1]/(1/2+1)

$Q = Cd\, l\sqrt{2gh}$ $H^{3/2}/(3/2)$

$Q = 2/3\, Cd\, l \sqrt{2gh}\, h^{3/2}$

b) Triangular notch /weir/V-shaped

$Q = \frac{8}{15} Cd * \sqrt{2g} * \tan\frac{\theta}{2} * h^{5/2}$

where,

Cd = coefficient of discharge

θ = Angle of notch

H = head over the crest

➢ The optimum angle of right angular weir is , $\theta = 90°$

c) Trapezoidal notch / weir

Discharge Q = Q rectangular + Q triangular

$Q = 3/2\ Cd_1\ l\ \sqrt{2gh}\ h^{3/2} + \frac{8}{15} Cd_2 * \sqrt{2g} * \tan\frac{\theta}{2} * h^{5/2}$

Cd_1 = coefficient of discharge f[r rectangular notch /weir.

Cd_2 = coefficient of discharge for triangular notch /weir.

d) Cipolleti weir

➢ Cipolleti weir is the special case of trapezoidal in which the side slope is 1 h 4v.

➢ The side slope angle of such weir/notch is 14.2° vertical.

➢ The discharge of cipolleti weir/notch is equal to the discharge of rectangular weir of same width and height without end contraction.

$Q = 3/2\ Cd_1\ l\ \sqrt{2gh}\ h^{3/2}$

e) Steeped notch/weir

➢ It's the combination rectangular notches / weir in series.

Q= Q1 +Q2+Q3

B. Based on the width of crest.

a) Narrow crested weir

➢ a weir is called narrow crested weir if the crest width(B) of the weir is less than half of the head over the crest (h).

i.E. crest width (B) < (head over the crest h)/2

b) Broad crested weir

crest width (B) > (head over the crest h)/2

h<2B

the discharge equations of broad crested weir is given by

$Q = 1705\ Cd_1\ l\ \sqrt{2gh}\ h^{3/2}$

C. Based on submerged condition/ downstream channel

a) Free weir/unsubmerged weir

➢ If the crest of the weir is higher than the tailwater level or downstream water level is called free or unsubmerged weir.

➢ In free weir the tailwater level does not effect the discharge.

b) submerged /Drowned weir

if the downstream / tailwater level is above the crest level of the weir it's called submerged weir.

➢ In submerged weir the downstream water level effect the discharge over the wier.

MCQ

If the crest level is greater than downstream water level than it is called

a. free weir

b. submerged weir

c. cipolleti weir

d. naone of the above

4.4 Pipe flow

4.4.1 types of fluid flow in pipe flow

A) A based on time criteria

a) Steady flow

it's defined as the type of flow in which the fluid characteristic like velocity, pressure density don't change with respect to time.

Mathematically,

$Dv/dt=0, dp/dt=0, d\rho/dt=0$

b) unsteady flow

it's the type of flow in which the fluid characteristic like velocity, pressure,density etc. with respect to time.

Mathematically,

$Dv/dt\neq0, dp/dt\neq0, d\rho/dt\neq0$

B) Based on the space

a) Uniform flow

it can defined as that type of flow in which the fluid properties like velocity, density, pressure etc. at any given time does not change with respect to space.

Mathematically

$Dv/ds=0, dp/ds=0, d\rho/ds=0$

b) Non-uniform flow

it can be defined as that type of flow in whcich fluid characteristic like velocity,density,pressure changes with respect of space.

Mathematically,

$Dv/ds\neq0, dp/ds\neq0, d\rho/ds\neq0$

C) Based on both time and space criteria

a) Steady uniform flow

In this type of flow fluid properties change with space or time.

For e.g. flow on water in a pipe of constant diameter at a constant rate.

b) steady non-uniform flow

in this type of flow fluid properties changes from point to point but not with time.

For e.g. flow of water in a tapering pipe at constant rate.

c)Unsteady uniform flow

in this type of flow fluid properties remains same from point to point but changes with times. For e.g. flow of water through pipe of constant diameter at increasing or decreasing.

d)Unsteady non- uniform flow

in this type of flow , fluid properties changes with respect to time and space.

For e.g. flow of water through tapering pipe at increasing or decreasing rate.

D) Based on reynold's रेनोल्डस number

Reynold's number

It's defined as the ratio of inertia force to viscous force of the fluid.

Mathematically ,

$Re = \rho VL/ \mu$

Where,

V = velocity

L= length

ρ= density

μ = viscosity/ dynamic viscosity

a)A laminar flow

it can be defined as that type of flow in which path taken by individual particles do not cross one another and move well define path.

➢ Reynold number (Re) is less than 2000.

➢ It's also called viscous or streamline flow.

➢ This types of flow occurs in fluid of high viscosity.

➢ Laminar flow is governed by newtons law of viscosity.

➢ The velocity of flow is low and there is no intermix of particles.

➢ Laminar flow is usually rare.

For e.g. flow through smooth pipe having low velocity, ground waterflow, flow of blood in veins.

b) Turbulent flow

a turbulent flow is defined as on in which the fluid particles moving zig-zag way.

➢ In turbulent flow reynold's number is greater than 4000.

➢ This type of flow occurs in fluid low viscosity.

➢ Similar form of equation of newton's law of viscosity is applicable for turbulent flow.

➢ The velocity of flow is high and there is intermixing of fluid particles.

➢ Turbulent flow is common type of flow in nature,

➢ For e.g. flow through river, high flow velocity in conduct of large size.

c)Transitional flow

If the reynold's number is between 2000 to 4000 the flow is transitional.

* Streamlines:

➢ Streamlines are the path lines, if flow is laminar.

➢ Streamlines Do not cross each other.

➢ Tangent to a stream lines gives direction of velocity at that point.

➢ Component of velocity perpendicular to the streamlines is zero.

E) Based on rotation

a) Rotational flow

➢ Particles rotate about their own axis.

➢ In rotational flow angular velocity exists.

b) Irrotational flow
- ➢ Particles do not rotate about their axis.
- ➢ Angular velocity is zero.

c) Vortex Flow

Vrtext flow is rotational flow

4.4 Open Channel flow
- ➢ Flow is due to grvity.
- ➢ Pressure in open channel.
- ➢ Flow is atmospheric.
- ➢ Hydraulic gradient line, HGL coincides with flow surface.
- ➢ For e.g. Flow in canals, rivers, sewers etc.

Types of open channel flow

A) Based on time

a. steady flow

b. Unsteady flow

B) Based on space

a) Uniform flow
- ➢ Flow parameters remain constant along length of channel.
- ➢ In uniform flow depth is constant.
- ➢ For uniform flow, following condition are meet:

i) channel should be prismatic or area of channel should be constant.

ii) Slope of channel should be constant.

iii) Material of channel should be same.
- ➢ In uniform flow channel bed, water surface and EGL are parallel.
- ➢ Energy slope (SF), water surface slope (SW) and channel bed slope (SP) are equal.

b) Non- Uniform flow
- ➢ Flow parameters do not constant along length of channel.
- ➢ Depth of flow changes along length of channel.
- ➢ Non-uniform flow is of a types:
- i) Gradually varied flow : flow depth changes gradually. For e.g. backwater in rivers canals due to weirs, barrage or other obstruction.
- ii) Rapidly varied flow : Flow depth changes gradually. For e.g. Hydraulic jump.

Hydraulic Jump
- ➢ Hydraulic jump forms on mild slope and horizontal floor.
- ➢ Flow changes from super critical to sub critical.
- ➢ The depth y1 and y2 are called sequence depth and conjugate depth.
- ➢ It's also called standing wave or positive surge.

Specific force

The two depths having same specific force are called conjugate depths or sequent depths.

Specific force is minimum for critical flow. (Fr=1)

C) Based of froude number

Foude number

$$Fr = \sqrt{\frac{inertia\ force}{gravitational\ force}}$$

Fr = inertia force/ gravitational force

Fr= v/(gy)

V=velocity=,y=depth

a) Critical flow

➢ Froude number is 1.

➢ This flow occurs on critical slope.

b) Sub-critical flow

➢ Froud number is less than 1.

➢ This flow occurs on mild slope.

c) Super critical flow

➢ Froude number is greater than 1.

➢ This flow occurs on steep slope.

Economical channel section

➢ Wetted perimeter is minimum.

➢ For given discharge area of channel is minimum.

➢ For given area, the discharge is maximum.

➢ for rectangular channel will be economic if b=2d.

➢ Hydraulics radius (m) = d/2.

➢ For economical triangular channel side slope is 1:1 or z=n=1

➢ Side slope = 45° with horizontal.

➢ For economical trapezoidal section top width is 2* side slope length.

➢ Side slope of economical trapezoidal is n=1/$\sqrt{3}$ or side slope angle is 60°.

➢ For economical circular section flow depth (y) is 0.95 * diameter

➢ For economical circular section hydraulics radius R is 0.29 d.

Specific Energy

➢ Specific energy is sum of potential head and kinematic head.

➢ Mathematically specific energy = y+(v²/2g)

Head loss

➢ Head loss refers to the loss of energy in the fluid as it flows through the pipe.

➢ It is caused by friction, turbulence, and other factors, and can be calculated using various formulas and equations.

➢ These energy losses are often referred to as head losses, and can be expressed as the loss of pressure head, velocity head, or potential head.

➢ In Darcy weisbach equation The total head loss in a pipe can be calculated using the following equation:

ΔH= f L V²/2gD

Where:

ΔH = total head loss

f = Darcy friction factor, which depends on the Reynolds number and the roughness of the pipe

L = length of the pipe

D = diameter of the pipe

V = fluid velocity

g = acceleration due to gravity

➤ The term $(V^2/2g)$ is the velocity head of the fluid, which represents the kinetic energy of the fluid in motion.

➤ The Darcy friction factor and the length of the pipe are related to the frictional losses due to the interaction between the fluid and the pipe wall.

➤ The diameter of the pipe affects the overall flow resistance.

➤ Manning's Formula's

$H_f = (V^2 n^2 L)/R^{4/3}$

➤ Chezy's formula

$H_f = (V^2 L)/(c^2 * R)$

➤ Head loss at entrance

$H_f = 0.5 * V^2/2g$

➤ Head loss at exists

$H_f = (V^2)/2g$

➤ Head loss due to sudden contraction

$H_f = 0.5 * V^2/2g$

➤ Head loss due to sudden expansion

$H_f = (V_1^2 - V_2^2)/(2g)$

➤ Bend loss

$H_f = K * V^2/2g$ [k=coefficient of bend loss]

➤ Valve loss

$H_f = (K * V^2)/(2g)$

Flow rate

➤ The flow rate is the volume of fluid that passes through the pipe per unit time.

➤ It is affected by the fluid velocity and the cross-sectional area of the pipe.

➤ The flow rate can be calculated using the following formula:

$Q = A * V$

Where,

Q = flow rate m^3/s

A = cross-sectional area of the pipe

V = fluid velocity

The cross-sectional area of a pipe can be calculated using the formula:

$A = (\pi D^2)/4$

Where: D is the diameter of the pipe

➤ The fluid velocity can be determined by measuring the pressure drop across the pipe and using Bernoulli's equation, or by using flow meters such as a Pitot tube or an electromagnetic flow meter.

Difference between pipe flow and open channel flow

Open channel flow	Pipe flow
Flow due to gravity.	Flow due to pressure.
Surface roughness is varies between wide limits, varies place to place.	Surface tension depends upon the materials of the pipe.
Surface tension negligible.	Surface tension is dominant for small diameter.
Cross sectional Shape of open channel are rectangular, parabolic, triangular, trapezoidal, circular, irregular etc.	Cross sectional shape of pipe flow is generally circular.
It's uncovered, have free surface, atmospheric pressure at free surface.	It's covered, no free surface.

*All Numerical and remaining part discuss in Physical and online class.
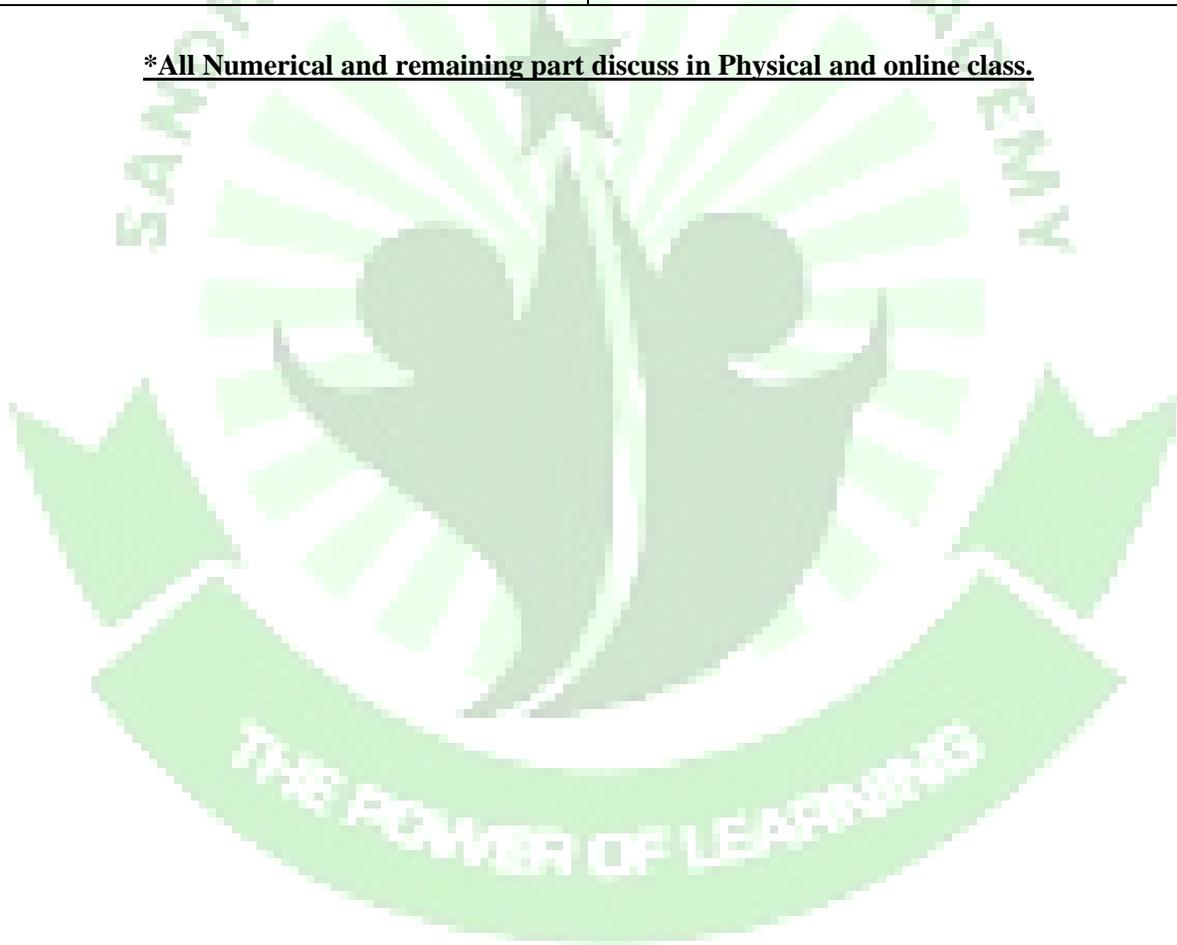
1. **Fluids are**
   A) solid   B) liquid
   C) gas   D) Both (B) and (c)
2. **The unit of mass density is**
   A) kg/m³
   B) m/s
   C) Both A and B
   D) None
3. **Mass density is denoted by**
   A) G   B) Y
   C) m   D) ρ
4. **The weight per unit volume of a liquid at a standard temperature and pressure is called**
   A) specific weight   B) mass density
   C) specific gravity   D) none of above
5. **Specific volume of sea water is**
   A) maximum at surface
   B) maximum at lead
   c) minimum at surface
   D) None of the above
6. **Specific weight of sea water is …….. that of pure water**
   A) same as   B) less than
   C) more than   D) none
7. **A Newtonian fluid is one which**
   A) is non-viscous
   B) is incompressible
   C) is incompressible and has no internal resistance
   D) is non-viscous and friction-less
8. **Shear stress in a Newtonian fluid is directly proportional to**
   A) Velocity
   B) velocity gradient
   C) viscosity
   D) Both b and c
9. **Which fluid property describes internal resistance to flow?**
   A) Viscosity
   B) Surface tension
   C) Specific gravity
   D) Internal energy
10. **What is the unit of kinematic viscosity in the CGS system?**
    A) Poise
    B) Stoke
    C) specific gravity
    D) none
11. **Kinematic viscosity is defined as**
    A) Dynamic viscosity ÷ Density
    B) Density ÷ Dynamic viscosity
    C) Momentum flux ÷ density
    D) All of the above
12. **Relative density (specific gravity) is**
    A) Dimensionless and vector quantity
    B) Dimensionless and scalar
    C) Has dimensions and is scalar
    D) None
13. **Which statement is correct regarding an ideal fluid?**
    A) Has zero viscosity
    B) Has finite viscosity
    C) Has variable viscosity depending on temperature
    D) None
14. **The density of water (≈ 1000 kg/m³) occurs at**
    A) 0 °C
    B) 4 °C
    C) 20 °C
    D) 100 °C
15. **Gauge pressure is**
    A) absolute pressure plus atmospheric pressure
    B) absolute pressure minus atmospheric pressure
    C) the same as absolute pressure
    D) zero at sea level
16. **Hydrostatic pressure on a submerged surface depends primarily on**
    A) velocity and viscosity
    B) depth and fluid density
    C) flow rate
    D) temperature
17. **1 bar pressure is approximately equal to**
    A) 145 psi
    B) 14.5 psi
    C) 1.45 psi
    D) 1450 psi

18. **According to Pascal's Law, if the pressure applied to a fluid at one point changes, what happens?**
    A) Pressure decreases with height
    B) Pressure increases at the point only
    C) Pressure is transmitted undiminished in all directions
    D) Pressure becomes zero

19. **What is the SI unit of pressure?**
    A) Joule
    B) Newton
    C) Pascal
    D) Watt

20. **The unit of surface tension is**
    A) N/m^2
    B) N/m
    C) N/m^3
    D) $N \cdot m$

21. **According to Newton's law of viscosity, viscosity depends**
    A. Shear stress
    B. Velocity gradient
    C. Remains constant
    D. None of the above

22. **The pressure at a point 4 m below the free surface of water is**
    A. 19.24 kPa
    B. 29.24 kPa
    C. 39.24 kPa
    D. 49.24 kPa

23. **When fluid is at rest, the shear stress**
    A. maximum
    B. minimum
    C. constant
    D. zero

24. **Which of the following relation is correct?**
    A. $1 m^2/sec = 10^4$ strokes
    B. 1 poise = 0.1 $N \cdot s/m^2$
    C. 1 SI unit = 10 poise
    D. All of the above

25. **The pressure measured with the help of a pressure gauge is called**
    A. atmospheric pressure
    B. gauge pressure
    C. absolute pressure
    D. mean pressure

26. **The atmospheric pressure at sea level is**
    A. 103 kN/m³
    B. 10.3 m of water
    C. 760 mm of mercury
    D. all of the above

27. **The multiplying factor for converting one poise into MKS unit is**
    A. 9.81
    B. 98.1
    C. 0.981
    D. 1/98.1

28. **A manometer is used to measure**
    A. atmospheric pressure
    B. pressure in pipes and channels
    C. pressure in venturimeter
    D. difference of pressures between two points in a pipe

29. **A manometer is used to measure**
    A. low pressure
    B. moderate pressure
    C. high pressure
    D. atmospheric pressure

30. **A differential manometer is used to measure**
    A. atmospheric pressure
    B. pressure in pipes and channels
    C. pressure in venturimeter
    D. difference of pressures between two points in pipe

31. **Piezometer is used to measure**
    A. pressure in water channels, pipes etc
    B. difference pressure at two point
    C. more than atmospheric pressure
    D. Very low pressure

32. **Hydrokinematics studies which properties of fluid flow?**
    A. Velocity & Acceleration
    B. Pressure & Energy
    C. Density & Viscosity
    D. Momentum & Forces

33. **Which of the following is *not* a kinematic property of a fluid?**
    A. Velocity
    B. Acceleration
    C. Pressure
    D. Vorticity

34. The path traced by a fluid particle over time is known as:
A. Streamline
B. Pathline
C. Streakline
D. Equipotential line

35. In a steady flow, which pair of lines coincide?
A. Streamline & Equipotential line
B. Streakline & Pathline
C. Streamline & Pathline
D. Streamline & Streakline

36. Which of the following is an ideal fluid?
A. Non-viscous
B. Incompressible
C. Both incompressible and no internal resistance
D. Friction-less only

37. Bernoulli's principle explains why pressure decreases as velocity increases. Which force conservation is it derived from?
A. Mass
B. Energy
C. Mass
D. Pressure

38. Which is the SI unit of dynamic viscosity?
A. Pa·s
B. N
C. J
D. m

39. Bernoulli's equation cannot be applied if the flow is
A. Rotational
B. Turbulent
C. Unsteady
D. All of the above

40. Bernoulli's equation states the sum of which energies per unit volume remains constant?
A. Thermal, kinetic, gravitational
B. Pressure energy, kinetic energy, potential energy
C. Kinetic, thermal, internal

D. Pressure energy, internal energy, thermal

41. What is the SI unit for dynamic (kinetic) pressure in a fluid?
A. J/kg
B. Pa
C. Pa·s
D. J/m³

42. Dynamic pressure represents
A. Potential energy per unit volume
B. Kinetic energy per unit volume
C. Pressure energy per unit mass
D. Internal energy per unit volume

43. Which term best describes total energy per unit weight (head)?
A. Pressure head
B. Velocity head
C. Datum head
D. Total head

44. What is the kinetic energy per unit mass of a fluid moving at speed v?
A. $v^2/2$
B. $v^3/2$
C. $\frac{1}{2}\rho v^2$
D. ρgh

45. The continuity equation in fluid flow is based on which conservation law?
A. Energy
B. Momentum
C. Mass
D. Angular momentum

46. For steady, incompressible flow through a pipe of varying cross-section, which equation holds true?
A. $A_1V_1=A_2V_2$
B. $A_1V_1+A_2V_2= 0$
C. $Q = AV^2$
D. $A_1V_2=A_2V_1$

47. Which of the following is *not* an assumption used in deriving Bernoulli's equation?
A. Flow is steady
B. Fluid is incompressible
C. Fluid is inviscid (ideal)
D. Flow is rotational

48. Bernoulli's theorem is applicable only when the flow is

A. Viscous liquid
B. Compressible liquid
C. Rotational fluid
D. Non-compressible (incompressible) fluid

49. In applying Bernoulli's equation along a streamline, which condition must be true?
A. Flow is turbulent
B. Fluid is highly viscous
C. Flow is unsteady
D. No viscous losses (ideal fluid)

50. Head is energy per unit
A. maa
B. Volume
C. Weight
D. Density

51. Bernoulli's equation is commonly applied in which of these flow measuring devices?
a) Venturi meter
b) Orifice meter
c) Pitot tube
d) All of the above

52. Bernoulli's theorem is a consequence of the conservation of:
a) Energy
b) Momentum
c) Mass
d) Angular momentum

53. For which type of fluid flow is Bernoulli's equation strictly valid?
a) Viscous and turbulent flow
b) Non-viscous and incompressible streamline flow
c) Compressible and rotational flow
d) Viscous and compressible flow

54. Water flows through a horizontal pipe that narrows. At the narrow part, compared to elsewhere, the fluid has
a) Maximum pressure and minimum velocity
b) Minimum pressure and maximum velocity
c) Both pressure and velocity are maximum

d) Both pressure and velocity are minimum

55. Bernoulli's equation is not applicable when the flow is
a) Steady
b) Irrotational
c) Rotational
d) Incompressible

56. The piezometric head in Bernoulli's equation consists of
a) Pressure head + velocity head
b) Pressure head + elevation head
c) Velocity head + elevation head
d) Pressure + velocity + elevation heads

57. Bernoulli's theorem is a special case of which law?
a) Pascal's law
b) Torricelli's law
c) Hooke's law
d) Archimedes' principle

58. A Pitot tube measures the fluid's:
a) Static pressure only
b) Total (stagnation) pressure
c) Dynamic pressure only
d) Atmospheric pressure

59. Which of the following phenomena involving flying objects is explained by Bernoulli's principle?
a) Magnus effect
b) Capillary rise
c) Airplane lift
d) Viscosity measurement

60. The vertical distance between the TEL (EGL) and HGL equals
a) Pressure head
b) Elevation head
c) Velocity head
d) Piezometric head

61. EGL (or TEL) represents the sum of
a) Pressure + elevation heads
b) Pressure + velocity heads
c) Velocity + elevation heads
d) Pressure + velocity + elevation heads

62. HGL is defined by the combination of
a) Pressure head only
b) Pressure + elevation heads

c) Velocity + elevation heads

d) All three heads

63. **In an ideal frictionless flow with no work or heat exchange, the TEL is**
a) Sloping down
b) Sloping up
c) Horizontal (constant)
d) Coincident with HGL

64. **HGL's shape in real pipe flow is:**
a) Always horizontal
b) Always upward
c) Always downward
d) May slope up or down depending on pressure changes

65. **TEL and HGL intersecting in a pipe flow implies**
a) Flow is turbulent
b) Velocity head is zero
c) Pressure head is zero
d) Flow has reversed

66. **Which correctly describes the relationship for a constant-diameter pipe?**
a) EGL coincides with HGL
b) EGL lies below HGL
c) EGL lies above HGL and is parallel
d) HGL slopes upward while EGL slopes downward

67. **When comparing TEL and HGL in open-channel flow, the difference equals the**
a) Pressure head
b) Elevation head
c) Total energy head
d) Velocity head

68. **Flow direction in a pipe follows from**
a) Lower to higher elevation head
b) Lower to higher pressure head
c) Higher to lower energy head
d) Center axis to pipe wall

69. **Which of the following devices operates based on Bernoulli's principle?**
a) Venturi meter
b) Orifice meter
c) Pitot tube
d) All of the above

70. **The operation of a carburetor is based on Bernoulli's principle. What does it utilize to mix air and fuel?**
a) Pressure difference
b) Velocity difference
c) Temperature difference
d) Volume difference

71. **Bernoulli's principle is applied in the design of which of the following?**
a) Airplane wings
b) Chimneys
c) Water pumps
d) All of the above

72. **Which of the following is a limitation of applying Bernoulli's equation?**
a) It assumes the fluid is incompressible
b) It assumes the flow is steady
c) It assumes the fluid is non-viscous
d) All of the above

73. **In a horizontal pipe with varying diameter, Bernoulli's equation helps in determining**
a) Pressure at different points
b) Fluid velocity at different points
c) Flow rate
d) All of the above

74. **The principle behind the operation of a venturi meter is based on**
a) Bernoulli's equation
b) Pascal's law
c) Archimedes' principle
d) Newton's law

75. **In the context of fluid dynamics, Bernoulli's equation is primarily used to**
a) Calculate the velocity of a fluid
b) Determine the pressure distribution in a fluid flow
c) Analyze the energy conservation in fluid flow
d) All of the above

76. **Which of the following is NOT a direct application of Bernoulli's equation?**
a) Determining the lift on an aircraft wing
b) Calculating the velocity of fluid in a

pipe
c) Measuring the temperature of a fluid
d) Designing a carburetor

77. **In a trapezoidal weir, the sides are inclined outward with a slope of**
    A) 1 : 3 (V : H)
    B) 1 : 4
    C) 1 : 5
    D) 1 : 6

78. **If the width of a rectangular notch is doubled, the discharge will**
    A) Double
    B) Become half
    C) Remain the same
    D) Increase by three times

79. **Which weir is classified by the shape of its opening?**
    A) Sharp-crested weir
    B) Cipolletti weir
    C) Ogee-shaped weir
    D) Broad-crested weir

80. **Which statement about triangular (V-notch) weirs is correct?**
    A) Accurate for high discharges
    B) Discharge formula is very complicated
    C) Ventilation is necessary
    D) Provides better accuracy at low discharges

81. **What is the horizontal-to-vertical side slope in a Cipolletti weir?**
    A) 1 : 1
    B) 1 : 3
    C) 1 : 2
    D) 1 : 4

82. **The discharge over a rectangular notch is**
    A) Inversely proportional to $H^{3/2}$
    B) Directly proportional to $H^{3/2}$
    C) Inversely proportional to $H^{5/2}$
    D) Directly proportional to $H^{5/2}$

83. **Which of the following is FALSE regarding triangular weirs?**
    A) Flow depends on vertex angle
    B) Cd is fairly constant
    C) More effective at small discharges
    D) Ventilation is necessary

84. **Discharge over a Cipolletti weir with length 200 cm and head 100 cm is (in m³/s)**
    A) 0.366
    B) 36.6
    C) 0.00366
    D) 3.66

85. **Specific energy at critical depth for a given discharge is**
    A) Zero
    B) Minimum
    C) Maximum
    D) Unpredictable

86. **How many types of weirs are there based on the shape of the crest?**
    A) 6
    B) 4
    C) 5
    D) 3

87. **Compound weir combines which of the following?**
    A) V-notch + rectangular crest
    B) Rectangular + trapezoidal crest
    C) Broad-crested + rectangular crest
    D) Multiple designs in one structure

88. **A triangular notch is also called**
    A) Trigonometric notch
    B) Ogee notch
    C) V-notch
    D) Isolated notch

89. **Which weir has a crest significantly wider than the approach channel?**
    A) V-notch weir
    B) Suppressed weir
    C) Broad-crested weir
    D) Submerged weir

90. **What is discharged sheet of water called?**
    A) Head
    B) Nappe
    C) Crest
    D) Tailwater

91. **For rectangular submerged weirs, aeration helps to**
    A) Maintain constant head–discharge relation
    B) Prevent weir submergence

C) Improve water quality

D) Increase Cd to its maximum

92. In a sharp-crested weir, the thickness of the crest is usually less than

A) 1/3 of H

B) 1/2 of H

C) 1/4 of H

D) 2/3 of H

93. Which weir is typically used as a dam spillway?

A) Narrow-crested weir

B) Broad-crested weir

C) Ogee-shaped weir

D) Submerged weir

94. Order the discharge coefficients (Cd) from lowest to highest

- Submerged broad-crested weir

- Free broad-crested weir

- Free sharp-crested weir

- Free ogee spillway

A) B, A, C, D

B) B, A, D, C

C) A, B, C, D

D) A, B, D, C

95. A suppressed rectangular weir is when

A) Crest > channel width

B) Crest = channel width

C) Crest < channel width

D) Crest has shutters

96. When the downstream water level is above the crest of a weir, that weir is called

A) Narrow-crested weir

B) Broad-crested weir

C) Ogee weir

D) Submerged weir

97. In a submerged rectangular weir, aeration under the nappe is essential primarily to

A) Improve water quality

B) Prevent submergence

C) Maintain constant head–discharge relation

D) Maximize coefficient of discharge

98. Which type of weir typically requires special ventilation to prevent suction effects downstream?

A) Free rectangular weir

B) Ogee weir

C) Broad-crested weir

D) Suppressed submerged weir

99. In a submerged weir, the total discharge $Q = Q_1 + Q_2$. What do Q_1 and Q_2 represent?

A) Free nappe and pressed nappe components

B) Upstream and downstream discharges

C) Free portion and drowned portion components

D) Triangular and rectangular portions

100.   The discharge coefficient (Cd) ranking from lowest to highest among the following is

1.Submerged broad-crested weir

2.Free broad-crested weir

3.Free sharp-crested weir

4.Free ogee spillway

A) 2, 1, 3, 4

B) 1, 2, 3, 4

C) 1, 2, 4, 3

D) 2, 1, 4, 3

101.   Select the false statement regarding submerged weirs

A) They require nappe ventilation to stabilize discharge

B) They are also called drowned weirs

C) The nappe emerges freely into the atmosphere

D) Discharge must combine both free and drowned components

102.   Why cannot fluid cross a streamline ?

A) Velocity component perpendicular to it is zero

B) Velocity component perpendicular to it is non-zero

C) Infinite velocity at the streamline

D) Flow is blocked by pressure

103.   In steady flow, which statement is correct?

A) Streamline

B) Pathline

C) Streakline
D) All coincide

104. **The velocity between two adjacent streamlines is inversely proportional to:**
A) Specific weight
B) Volume flow rate
C) Circulation
D) Spacing of the streamlines

105. **Streamlines in fluid flow are:**
A) Parallel to equipotential lines
B) Along which the stream function is constant
C) On which velocity potential is constant
D) Lines of zero vorticity

106. **What type of flow in a channel occurs when flow characteristics at a point do not change with time**?
A) Steady flow
B) Uniform flow
C) Laminar flow
D) Turbulent flow

107. **A channel flow has Reynolds number = 1000. What type of flow is it?**
A) Laminar
B) Turbulent
C) Transition
D) Steady

108. **The Froude number (Fr) is defined as the ratio of:**
A) Inertia force to viscous force
B) Pressure force to viscous force
C) Inertia force to gravitational force
D) Gravitational force to inertia force

109. **The depth of water corresponding to** minimum **specific energy in a channel is called:**
A) Uniform depth
B) Critical depth
C) Normal depth
D) Alternate depth

110. **Hydraulic jump is observed in:**
A) Closed channel flow
B) Open channel flow

C) Flow changes
D) Volumetric changes

111. **Hydraulic jump depends primarily on:**
A) Temperature
B) Pressure
C) Initial fluid speed
D) Volumetric changes

112. **Flow before the hydraulic jump is:**
A) Critical
B) Supercritical
C) Subcritical
D) Dynamic

113. **Flow after the hydraulic jump is:**
A) Normal
B) Rough
C) Smooth
D) Zero

114. **A channel is said to be the most economical section when:**
A) It gives maximum discharge for a given area and slope
B) It has minimum wetted perimeter
C) It involves minimal excavation
D) All of the above

115. **For a rectangular channel, the section is most economical when:**
A) R=y
B) R=y/2
C) R=2y
D) R=y/3

116. **For a trapezoidal channel, the condition for the most economical section is:**
A) R=y
B) R=y/2
C) R=2y
D) R=y/3

117. **For a triangular channel, the most efficient geometry is when the sloping sides make which angle with the vertical?**
A) 30°   **B)** 45°
C) 60°   **D)** 90°

118. **For maximum discharge in a rectangular channel, the width bbb should be:**
A) R=y B) R=y/2
C) R=2y D) R=y/3

119. <mark>Major vs Minor Loss</mark>
A. Frictional loss
B. Shock loss
C. Entry loss
D. Exit loss

120. **Laminar vs Turbulent Head Loss Scaling**
A. Proportional to velocity in laminar flow and to the square of velocity in turbulent flow
B. Proportional to the square of velocity in laminar flow and to velocity in turbulent flow
C. Proportional to velocity in both laminar and turbulent flows
D. Proportional to the square of velocity in both laminar and turbulent flows

121. **If two pipes have the same velocity but diameters are in ratio 3 : 2, what is the ratio of head loss?**
A. 3 : 2 B. 9 : 4 C. 2 : 3 D. 4 : 9

122. **The head loss at the entrance of the pipe is _____ of that at its exit:**
A. Equal to B. Half C. Twice D. Four times

123. **The Darcy–Weisbach equation expresses head loss per length as:**
A. f V^2/(2gD) B. f V/(gD)
C. f D^2/(2gV) D. f V/(2gD^2)

124. **Minor losses include losses due to:**
A. Sudden contraction/expansion
B. Entry and exit
C. Bends and valves
D. All of the above

125. **Flow characteristics unchanged with time at any point is called:**
A. Uniform flow
B. Steady flow

C. Laminar flow
D. Turbulent flow

126. **The flow characteristics of a channel do not change with time at any point. What type of flow is this?**
A. Steady flow
B. Uniform flow
C. Laminar flow
D. Turbulent flow

127. **The Reynolds number in an open channel is 1,000. What is the flow regime?**
A. Laminar
B. Turbulent
C. Transition
D. Steady

128. **The ratio of inertia to gravitational forces is known as:**
A. Reynolds number
B. Stokes number
C. Froude number
D. Euler number

129. **The depth corresponding to the minimum specific energy for given discharge is:**
A. Normal depth
B. Maximum depth
C. Critical depth
D. Minimum depth

Answers

1	D	21	C	41	B	61	D	81	D	101	C	121	C
2		22	C	42	B	62	B	82	B	102	A	122	B
3		23	D	43	D	63	C	83	D	103	D	123	A
4		24	D	44	A	64	D	84	D	104	D	124	D
5		25	B	45	C	65	B	85	B	105	B	125	B
6		26	D	46	A	66	C	86	B	106	A	126	A
7		27	D	47	D	67	D	87	D	107	C	127	C
8		28	B	48	D	68	C	88	C	108	C	128	C
9		29	A	49	D	69	D	89	C	109	B	129	C
10		30	D	50	C	70	A	90	B	110	B		
11		31	D	51	D	71	D	91	A	111	C		
12		32	A	52	A	72	D	92	B	112	B		
13		33	C	53	B	73	D	93	C	113	B		
14		34	B	54	B	74	A	94	C	114	D		
15		35	D	55	C	75	D	95	B	115	B		
16		36	C	56	B	76	C	96	D	116	B		
17		37	B	57	B	77	A	97	C	117	B		
18	C	38	A	58	B	78	A	98	D	118	C		
19	C	39	D	59	C	79	B	99	C	119	A		
20	A	40	B	60	C	80	D	100	B	120	A		

5. Soil Mechanics

5.1 General

Soil mechanics is the application of laws of laws of mechanics to engineering problems dealing with sediments and other unconsolidated accumulations of soil particles produces by the mechanical and chemical disintegration of rocks, regardless of whether or not these contain an admixture of organic constituents.

➢ Karl Terzaghi : father of soil mechanics.

5.1.1 Classification of soil

A. Based on grain size

a. Fine grain soil
- ➢ clay <0.002mm
- ➢ silt = 0.002-0.075

b. Coarse grain soil
- ➢ fine sand = 0.075-0.2mm
- ➢ medium sand = 0.2-2mm
- ➢ coarse sand = 2-4.75mm
- ➢ fine gravel = 4.75-20mm
- ➢ coarse gravel = 20-75mm
- ➢ pebbles = 0.75-0.80mm

c. Very coarse grain soil
- ➢ cobble = 80-200mm
- ➢ boulder = >200mm

B. Based on cohesion

a. cohesive soil
- ➢ fine grain soil
- ➢ cohesive soil are formed by chemical weathering (oxidation, carbonation, hydration)
- ➢ e.g. clay, plastic silt.

b. Non-cohesive soil (cohesionless soil)
- ➢ coarse grain soil
- ➢ cohesion less soil are formed by physical weathering (due to change in temperature, froast action, growth of root of plants)
- ➢ e.g. sand, non-plastic silt, gravel.

C. Types of soil

a. alluvial soil
- ➢ the soil deposited on the bank of river due to flow of water.

b. lacustrine soil
- ➢ the soil deposited at the bottom of lake.

c. Marine soil
- ➢ the soil deposited at sea.

d. Loess, dune land, aeolian soil
- ➢ the soil deposited by wind velocity.

e. talus/colluvial soils
- ➢ transport and deposited due to force of gravity.

f. Peat
- ➢ soil formed by decay of vegetable (highly organic soil)

g. Glacier soil/ drift
 ➤ soil deposited by glacier/ice.
h. Residual soil
 ➤ soil formed by disintegration of rock and may remain at the same place of formation.

5.1.2 Three phase system of soil

A soil mass is a three phase consisting of solid particles (called soil grains), water and air , as shown in fig, 11.1 . The total volume (V) of the soil mass consists of volume of air (Va), volume of water (Vw) and the volume of solids (Vs). The volume of voids (Vv) is , therefore, equal to the volume of air olus the volume of water. Since weight of air (Wa) is considered to be negligible, therefore, the weight of voids (Wv) is equal to the weight of water (Ww).

The weight of solids is represented by Ws which is evidently equal to the dry weight of soil sample. The total weight (W) of the soil mass is , therefore, equal to (Ws+Ww).
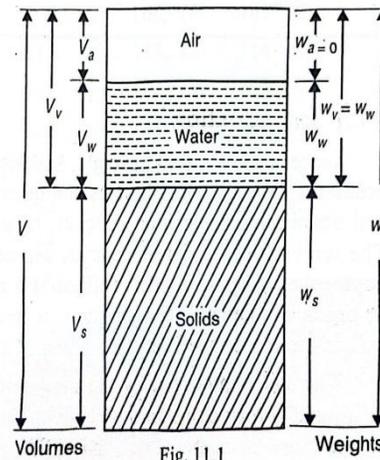
Fig. 11.1

5.1.3 Unit weight of soil mass: Bulk density, saturated density, submerged density and dry density

A. Unit weight of soil mass

The unit weight is expressed in N/m^3 or kN/m^3
 a. bulk unit weight or moist unit weight,

$$\gamma=W/V$$

 b. dry unit weight, $\gamma_d=Ws/V$
 c. unit weight of solids, $\gamma_s=Ws/Vs$
 d. saturated unit weight, $\gamma_{sat}=Wsat/V$
 e. submerged or buoyant unit weight $\gamma_{sub}=Wsub/V = \gamma_{sub} - \gamma_w$
  The unit weight of water (γ_w) is 9.81 kN/m^3.

B. Bulk density or moist density (ρ)

 ➤ It is the ratio of the total mass (M) of the soil to the total volume (V) of the soil. It is expressed in kg/m^3. Mathematically $\rho = M/V$

C. Saturated Density (ρ_{sat})

 ➤ When the soil mass is saturated, its bulk density is called saturated density , it is the ratio of total mass of a fully saturated soil (Msat) to the soil volume (V) of the soil. Mathematically $(\rho_{sat}) = M_{sat}/V$

D. Submerged density or buoyant density (ρ_{sub})

 ➤ It is the ratio of the submerged mass of soil solids (Ms)$_{sub}$ to the total volume (V) of the soil. Mathematically, $\rho_{sub} = (Ms)_{sub}/V$

> The submerged density or buoyant density is also expressed as
>> $\rho_{sub} = \rho_{sat} - \rho_w$
>> ρ_w = density of water = $1000 kh/m^3$

E. Dry density (ρ_d)

> It is the ratio of the mass of solids (Ms) to the total volume (V) of the soil (in moist condition).
> Mathematically $\rho_d = Ms/V$

5.1.4 Interrelationship between specific gravity, void ratio, porosity, degree of saturation, percentage of air voids, air content and density index

A. Specific gravity

> It is the ratio of the unit weight of soil solids to that of water. Mathematically $G = \gamma_s / \gamma_w$
> The ratio of the unit weight of the given soil mass to that of water is called apparent or mass or bulk specific gravity (Gm). Mathematically, $Gm = \gamma / \gamma_w$

B. Void ratio (e)

> It is the ratio of the total volume of voids (Vv) to the volume of soil solids (Vs) in a given soil mass. Mathematically, $e = Vv/Vs$

C. Porosity of soil mass (n)

> It is the ratio of total volume of voids (Vv) to the total volume of the given soil mass (V). mathematically, $n = Vv/V$

D. Degree of saturation (s)

> It is the ratio of the volume of water (Vw) present in a given soil mass to the total volume of the voids (Vv) in it. Mathematically, $s = Vw/Vv$
> For a fully saturated soil mass $Vw = Vv$ and hence $s = 1$. The submerged soils are fully saturated soils.
> For a perfectly dry soil mass, $Vw = 0$ and hence $s = 0$.

E. Percentage of air voids

> It is the ratio of the volume of air voids (Va) to the total volume of the soil mass (V) and is expressed as percentage. Mathematically,
> $n_o = V_o/V = (V_a/V)*(V_v/V_v)$ ....multiplying the numerator and denominator by V_v
> $= (V_a/V_v)*(V_v/V) = a_c*n = (1-s)n$

F. Air content

> It is the ratio of the volume of air voids (Va) to the volume of voids (Vv). Mathematically,
>> $a_c = Va/Vv$
>> $Va = Vv - Vw$, therefore
>> $a_c = 1-(Vw/Vv) = 1-s$

G. Density index or relative density or degree of density of soil mass (I_d)

> It is the ratio of the difference between the voids ratio of the soil in its loosest sate (e_{max}) and it's natural voids ratio (e) to the difference between the voids ratio in the loosest (e_{max}) and densest state (e_{min}). mathematically, $I_d = (e_{max} - e)/(e_{max} - e_{min})$
> The value of I_d varies from zero to unity.

Interrelationship

1. **Relation between void ratio (e) and porosity (n)**

   We know that
   $$e = \frac{V_v}{V_s} = \frac{V_v}{V - V_v}$$

   $$= \frac{V_v/V}{V/V - V_v/V} \qquad \text{...(Dividing the numerator and denominator by } V)$$

   $$= \frac{n}{1-n} \qquad \text{...(}\because V_v/V = n)$$

2. **Relation between porosity (n) and void ratio (e)**

   We know that
   $$n = \frac{V_v}{V} = \frac{V_v}{V_s + V_v}$$

   $$= \frac{V_v/V_s}{V_s/V_s + V_v/V_s} \qquad \text{...(Dividing the numerator and denominator by } V_s)$$

   $$= \frac{e}{1+e} \qquad \text{...(}\because V_v/V_s = e)$$

Note: From above,
$$1 - n = \frac{n}{e} = \frac{e}{1+e} \times \frac{1}{e} = \frac{1}{1+e}.$$

3. **Relation, between void ratio (e), degree of saturation (s), water content (w) and specific gravity of solids (G)**

   We know that
   $$w = \frac{W_w}{W_s} = \frac{\gamma_w \cdot V_w}{\gamma_s \cdot V_s} = \frac{1}{G} \times \frac{V_w}{V_s} \qquad \text{...(}\because G = \gamma_s/\gamma_w)$$

   $$= \frac{1}{G} \times \frac{V_w}{V_s} \times \frac{V_v}{V_v} \qquad \text{...(Multiplying the numerator and denominator by } V_v)$$

   $$= \frac{1}{G} \times s \times e \qquad \text{...}\left(\because \frac{V_w}{V_v} = s \text{ and } \frac{V_v}{V_s} = e\right)$$

   $$\therefore \qquad w \times G = s \times e$$

4. **Relation between dry unit weight (γ_d), bulk unit weight (γ) and water content (w)**

   We know that
   $$w = \frac{W_w}{W_s}$$

   or
   $$w + 1 = \frac{W_w}{W_s} + 1 = \frac{W_w + W_s}{W_s} = \frac{W}{W_s} \qquad \text{...(Adding 1 on both sides)}$$

   $$\therefore \qquad W_s = \frac{W}{1+w}$$

   Dividing both sides by V, we get
   $$\frac{W_s}{V} = \frac{W}{(1+w)V}$$

   $$\therefore \qquad \gamma_d = \frac{\gamma}{1+w} \qquad \text{...}\left(\because \frac{W_s}{V} = \gamma_d \text{ ; and } \frac{W}{V} = \gamma\right)$$

5. *Relation between dry unit weight (γ_d), specific gravity (G), void ratio (e) or porosity (n)*

We know that

$$\gamma_d = \frac{W_s}{V} = \frac{\gamma_s \times V_s}{V} \qquad\qquad \ldots(\because W_s = \gamma_s \times V_s)$$

Since $\gamma_s = G \times \gamma_w$, therefore,

$$\gamma_d = \frac{G \times \gamma_w \times V_s}{V} = \frac{G \times \gamma_w \times V_s}{V_s + V_v} \qquad\qquad \ldots(\because V = V_s + V_v) \ldots(i)$$

$$= G \times \gamma_w \left(\frac{1}{1 + V_v/V_s}\right) = \frac{G \times \gamma_w}{1 + e} \qquad\qquad \ldots\left(\because \frac{V_v}{V_s} = e\right)$$

From equation (i),

$$\gamma_d = \frac{G \times \gamma_w \times V_s}{V} = G \times \gamma_w \left(\frac{V - V_v}{V}\right) \qquad\qquad \ldots(\because V_s = V - V_v)$$

$$= G \times \gamma_w \left(1 - \frac{V_v}{V}\right) = G \times \gamma_w (1 - n) \qquad\qquad \ldots\left(\because \frac{V_v}{V} = n\right)$$

6. *Relation between saturated unit weight (γ_{sat}), specific gravity (G), and void ratio (e) or porosity (n)*

We know that

$$\gamma_{sat} = \frac{W_{sat}}{V} = \frac{W_s + W_w}{V} = \frac{W_s + W_v}{V} \qquad\qquad \ldots(W_w = W_v)$$

$$= \frac{\gamma_s \times V_s + \gamma_w \times V_v}{V} \qquad\qquad \ldots(i)$$

$$= \gamma_s \times \frac{V_s}{V} + \gamma_w \times \frac{V_v}{V}$$

Since $G = \gamma_s/\gamma_w$ or $\gamma_s = G \times \gamma_w$ and $V = V_s + V_v$, therefore,

$$\gamma_{sat} = G \times \gamma_w \left(\frac{V_s}{V_s + V_v}\right) + \gamma_w \left(\frac{V_v}{V_s + V_v}\right)$$

$$= G \times \gamma_w \left(\frac{1}{1 + V_v/V_s}\right) + \gamma_w \left(\frac{1}{V_s/V_v + 1}\right)$$

$$= \frac{G \times \gamma_w}{1 + e} + \gamma_w \left(\frac{1}{\frac{1}{e} + 1}\right) = \frac{G \times \gamma_w}{1 + e} + \frac{\gamma_w \times e}{1 + e} = \frac{\gamma_w}{1 + e}(G + e)$$

From equation (i),

$$\gamma_{sat} = \frac{\gamma_s \times V_s + \gamma_w \times V_v}{V}$$

$$= \gamma_s \left(\frac{V - V_v}{V}\right) + \gamma_w \times \frac{V_v}{V}$$

$$= \gamma_s (1 - n) + \gamma_w \times n = G \times \gamma_w (1 - n) + n \times \gamma_w$$

7. *Relation between submerged or buoyant unit weight (γ_{sub}), specific gravity (G) and void ratio (e)*

We know that $\quad \gamma_{sub} = \gamma_{sat} - \gamma_w$

We have already discussed that

$$\gamma_{sat} = \frac{\gamma_w}{1 + e}(G + e)$$

$$\therefore \quad \gamma_{sub} = \frac{\gamma_w}{(1 + e)}(G + e) - \gamma_w$$

$$= \gamma_w \left(\frac{G + e}{1 + e} - 1\right) = \frac{\gamma_w}{1 + e}(G - 1)$$

5.2 Soil water relation

The soil water relation refers to the intricate interplay between various factors such as soil composition, structure, water content, water potential, and the movement of water through soil. It's a foundational concept in soil physics, agriculture, and hydrology.

5.2.1 Terzaghi's principle of effective stress

Statement it states that "all measurable effect of a change in stress, such as compressive, distortion, displacement and a change of shearing resistance are due to changes in effective stress".
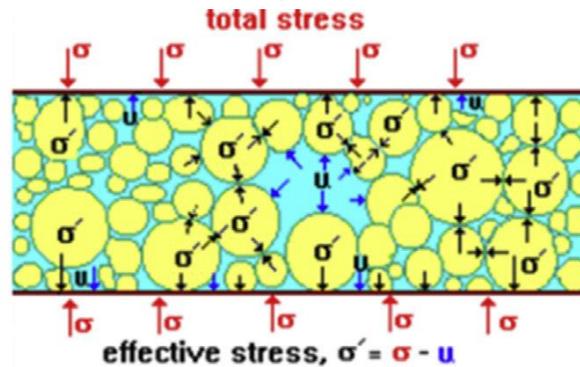
$$\sigma' = \sigma - u$$

Where,
σ'=Effective stress,
σ=Total stress,
u=Pore water pressure,

effective stress, $\sigma' = \sigma - u$

➢ The principle of effective stress is the most important principle in soil mechanics.
➢ Deformations of soils are a function of effective stresses not total stresses.
➢ when seepage pressure, which acts in the upward direction, overcomes the downward direction pressure due to submerged weight of soil and the sand particles are forced apart.
➢ The result is that, the soil has no capability to support a load. Soil losses all the shear strength due to zero effective stress and moves in upward direction . The condition occurring is known as quick sand condition.
➢ The critical exit gradient at quick sand condition is

$$I_c = (G-1)/(1+e)$$

Taking G=2.67, and e=0.67, i_c is equal to one.

5.2.2 Darcy's Law

Statement "The velocity of flow through the void ratio of soil mass is directly proportional to hydraulic gradient."

In the laminar range of flow through soil,
Velocity of flow is
α hydraulic gradient
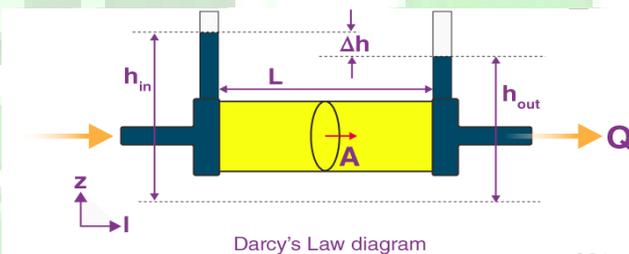
$$V \alpha i$$
$$V = ki$$

where,
k = coefficient of permeability

$$Q = VA = kiA$$

where,
A = Area normal to the flow,
Q = discharge

Darcy's Law diagram

Valid of darcy's law
  i.   For laminar soil

ii. Saturated soil

5.2.3 Factor Affecting permeability
> The property of soil by virtue which it allows to flow of water through the void of soil mass is known as permeability.

A. Particle or Grain Size & Sorting
> Larger particles (like sand or gravel) yield larger pore spaces, making it easier for fluids to flow. Fine particles (like clay) create tiny pores and significantly reduce permeability.
> Well-sorted granules enhance connectivity; poorly sorted mixtures can clog pores and impede flow.

B. Void Ratio and Porosity
> A higher void ratio—indicating more empty space between solid particles, typically boosts permeability.
> Porosity matters, but connected porosity is what really counts: if pore spaces don't link up, fluid flow is still limited.

C. Pore Connectivity & Tortuosity
> Even with high porosity, if pores are isolated or tortuous (winding and indirect), permeability remains low. Straight, well-connected paths facilitate fluid movement.

D. Soil or Rock Structure & Fabric
> Soils with flocculated (loose, aggregated) structures have higher permeability than those with dispersed or compacted arrangements.
> Layering or stratification can cause directional differences: permeability is often higher parallel to layers than perpendicular to them.

E. Degree of Saturation
> In partially saturated materials, air pockets can block flow paths. Fully saturated media allow for much smoother hydraulic flow.

F. Adsorbed Water & Organic Content
> In fine soils like clay, water adheres to particle surfaces, reducing effective pore spaces and hindering flow.
> Organic matter likewise disrupts porosity by clogging pore spaces.

G. Fluid Properties: Viscosity & Temperature
> Viscous fluids flow more slowly so higher viscosity (like cold water or oil) lowers permeability.
> Since viscosity decreases with rising temperature, warmer fluids flow more easily thus increasing effective permeability.

H. Impurities and Compaction
> Foreign materials (like silt, contaminants, or clay) can clog the pore network.
> Soil or rock compaction reduces porosity and pore connectivity, suppressing permeability.

5.3 Compaction of soil
The process where soil particles are mechanically pressed together, decreasing pore space and increasing soil bulk density. This rearrangement of grains is typically achieved through mechanical forces such as heavy machinery, repeated foot or animal traffic, or even the weight of rainfall on bare soil.

*Main Purposes of Soil Compaction
> Increase Load-Bearing Capacity & Shear Strength
> Reduce Settlement under Load
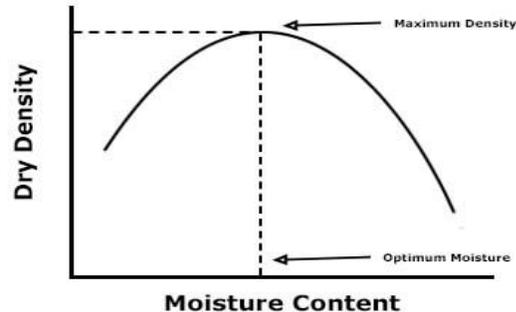> Lower Permeability & Water Seepage

➢ Enhance Stability (Slopes, Embankments, Foundations)
➢ Mitigate Frost Heave, Swelling, & Liquefaction
➢ Prevent Erosion & Maintain Uniformity

5.3.1 Factors affecting soil compaction
A. Soil Moisture Content

Proctor Curve (Moisture Density Curve)

➢ At low moisture levels, strong particle friction and attractive forces (like van der Waals) resist compaction.
➢ As moisture increases, it lubricates particles, enhancing rearrangement and density peaking at the optimum moisture content**,** beyond which excess water reduces dry density.
➢ Wet soils are especially prone to compaction due to lower resistance to deformation.

B. Soil Type & Texture
➢ **Coarse, well-graded soils** (like gravel or sandy loams) compact more effectively, reaching higher densities.
➢ **Fine-grained soils**, especially clays and silts, resist compaction; yet when fines fill coarse soil voids, density can improve but too many fines reduce compactibility.
➢ Soil structure and organic content also matter, stable aggregates and high organic matter buffer against compaction.

C. Compactive Effort (Energy & Equipment)
➢ Greater compactive energy through heavier, vibrating, kneading, or impact-based equipment boosts compaction effectiveness.
➢ Choosing the right equipment is key:
  o **Sheepsfoot rollers** for cohesive clays,
  o **Smooth or vibratory rollers** for sandy or granular soils.

D. Layer Thickness & Number of Passes
➢ Thick soil layers compact less uniformly because compaction energy dissipates with depth. Thin lifts (e.g., 200–300 mm) ensure consistent density.
➢ Multiple compactor passes improve density, especially on heavy or stony soils, dthough returns diminish after a point.

E. Equipment Speed & Contact Pressure
➢ Faster rolling speeds may reduce individual compaction effectiveness, requiring more passes.
➢ Greater contact pressure (from heavier or smaller-area rollers) increases soil density and lowers optimal moisture content.

F. Initial Soil Condition & Organic Matter
➢ **Looser, less dense soils** compact more readily; already dense soils resist further densification.
➢ **Organic matter** enhances soil structure binding particles and reducing compaction risk.

G. Environmental & Operational Factors
➢ **Site conditions** such as weather or wet soils significantly affect compaction outcomes.
➢ **Traffic frequency and equipment loads** increase compaction severity. Heavy machinery and repeated passes deepen compaction, especially in wet conditions.

H. Admixtures & Soil Stabilization (Context-Dependent)
➢ Adding materials like lime, cement, or biochar can alter compaction behavior in engineered applications.

5.3.2 Optimum moisture content

Fig:- Compaction Curve
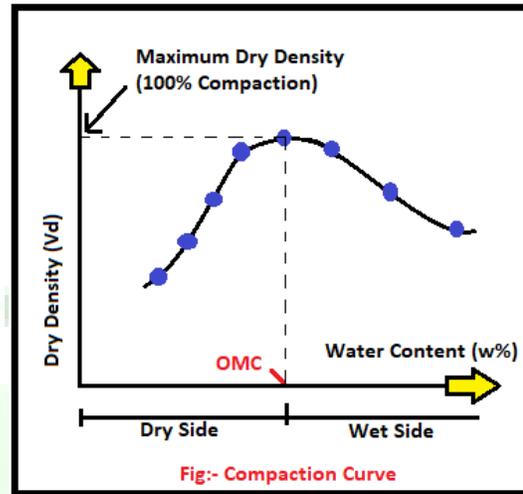
5.4 Shear strength of soils

The shear strength of soil is the resistance to deformation by continuous shear displacement of soil particles due to the action of shear stress. The shear strength is a most important characteristic of the soil. The shearing strength of soil is due to the following components:

a. Structural resistance
b. frictional resistance
c. Cohesion

5.4.1 Mohr-Coulomb failure theory

The shearing strength of soil consists of cohesion and friction between the soil particles. Mathematically,
Shearing strength of soil,

$$\tau = c + \sigma \tan \emptyset.$$

Where,

τ = shear strength of soil

c = cohesion (apparent or actual)

σ = normal stress on the plane of shear and

$\emptyset$ = angle of internal friction or angle of shearing resistance
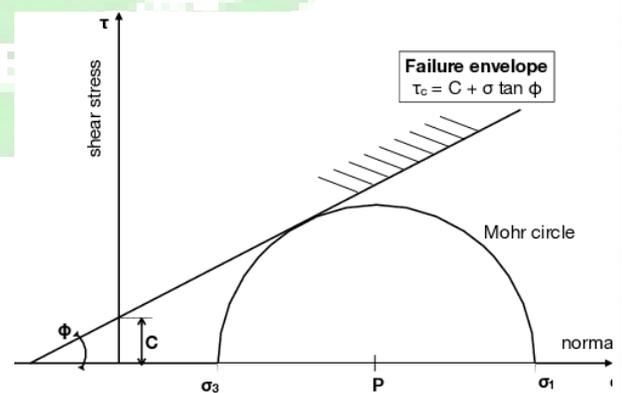
Limitation of mohr-coulomb failure theory
    A. **Linear assumption**: Real soil behavior often results in a non-linear failure envelope at higher stresses.
    B. **Ignores intermediate principal stress (σ_2)** potentially oversimplifying failure conditions.
    C. **Assumes isotropy** may misrepresent behavior in layered or anisotropic soils.
    D. **No tensile behavior** the model doesn't address tensile strength, which can be important for some materials.
    E. **Overlooks strain-softening** changes in strength after peak stress are not accounted for, reducing accuracy in some cases.

5.4.2 Cohesion and angle of internal friction
*Cohesion
   ➢ Cohesion (denoted as c) is the component of a soil's shear strength that does not depend on normal stress, representing the "glue" binding soil particles together.
    ➢ Cohesion plays a vital role in the shear strength and stability of fine-grained soils. It significantly impacts design decisions in:
        o Slope stability
        o Foundation bearing capacity
        o Retaining wall performance
        o Earthwork and trench support

*Angle of internal friction
    To measure of the he shearing resistance of soil to sliding along a plane is termed as angle of internal friction or friction angle ($\emptyset$). It depends upon the shape of the particles, surface roughness, type of interlocking, lateral pressure and the state of packing. The angle of internal friction varies with the normal direct pressure and the density of sand. The angle of internal friction of round grained loose sand and dense sand is about 25° to 30° and 32° to 37° respectively.

5.5 Earth Pressure
5.5.1 Active and passive earth pressure
*Active Earth Pressure (Pa)
    This refers to the minimum horizontal pressure exerted by soil on a retaining structure when the wall moves away from the backfill**,** allowing the soil to expand and fail along an internal surface—known as the failure wedge. Active pressure develops when shear strength is mobilized, reducing the load on the wall until a plastic equilibrium is reached at failure.

*Passive Earth Pressure (Pp)
    This is the maximum horizontal pressure exerted by soil on a wall when the wall pushes into the soil**,** compressing it until failure occurs. This generates a resisting wedge of soil that increases lateral pressure on the wall.

5.5.2 Lateral earth pressure theory
    ➢ The horizontal pressure exerted by soil on retaining structures such as walls, basements, tunnels, or sheet piles.
    ➢ This pressure is critical in geotechnical engineering for assessing stability and designing structures that interface with soil.
    ➢ **Types of lateral earth pressure**
        A. Active earth pressure (Pa)

B. Passive earth pressure (Pp)
C. At-Rest earth pressure (Po)
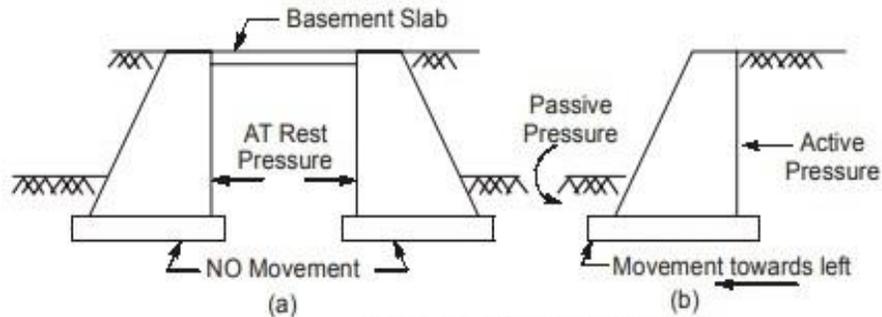
Fig: Types of Earth Pressure

* Lateral earth pressure theory

➢ The design of the retaining structure requires the determination of the magnitude and line of action of the lateral earth pressure.
➢ The lateral earth pressure is usually computed using the classical theories proposed by:

   a. Coulomb (1773)
   b. Rankine's (1857)
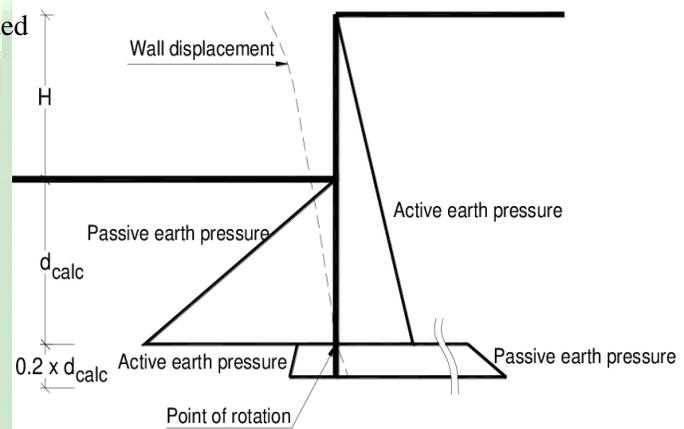
5.5.3 Rankine's earth pressure theory

The Rankine's theory assumes that there is no wall friction ($\delta=0$) , the ground and failure surfaces are straight planes, and that the resultant force acts parallel to the backfill slope. In case of retaining structures, the earth retained may be filled up earth or natural soil.

*Assumptions of rankine's theory

➢ The soil is isotropic and homogeneous.
➢ The rupture surface is a plane surface.
➢ The failure wedge is a rigid body.
➢ The pressure surface is a plane surface.
➢ There is wall friction on the pressure surface.
➢ Failure is two dimension.
➢ The soil is cohesion less and the backfill surface can be inclined.

For a horizontal backfill surface ($\beta = 0$), the lateral earth pressure coefficients are:
   A. **Active Pressure Coefficient (K_a):**

$Ka=(1-\sin(\phi)) / (1+\sin(\phi))$
B. **Passive Pressure Coefficient (K_p):**
$Kp=1+\sin(\phi)/1-\sin(\phi))$
C. **At-Rest Pressure Coefficient (K_0):**
$K0=1-\sin(\phi)$
Where:
φ = Angle of internal friction of the soil

The lateral earth pressure at any depth (h) is calculated as:
A. **Active Pressure**:
$Pa=Ka\cdot\gamma\cdot h$
B. **Passive Pressure**:
$Pp=Kp\cdot\gamma\cdot h$
C. **At-Rest Pressure**:
$P0=K0\cdot\gamma\cdot h$
Where:
γ = Unit weight of the soil
h = Depth below the ground surface

5.6 Foundation engineering
5.6.1 Terzaghi's general bearing capacity formulas and their application
The ultimate bearing capacity (quq_uqu) is calculated using the following formula:
$Q_u = cNc + \gamma DNq + 0.5\gamma BN\gamma$
Where:
c = Effective cohesion of the soil
γ = Unit weight of the soil
D = Depth of the foundation
B = Width of the foundation
Nc,_cN, Nq_qN, and Nγ = Bearing capacity factors dependent on the soil's angle of internal friction (φ)
These factors are determined based on empirical relationships and are typically tabulated for various values of φ.

*Application of Terzaghi's Theory
A. Strip Footing on Cohesionless Soil ($\varphi > 0$)
For a strip footing on cohesionless soil, the ultimate bearing capacity is calculated as:
$q_u = \gamma DNq + 0.5\gamma BN\gamma$
In this case, cohesion (c) is negligible.
B. Square Footing on Cohesionless Soil
For a square footing, the ultimate bearing capacity is given by:
$q_u = 1.3cNc + \gamma DNq + 0.4\gamma BN\gamma$
The factor 1.3 accounts for the shape of the footing.
C. Strip Footing on Cohesive Soil ($\varphi = 0$)
For cohesive soils, where $\varphi = 0$, the ultimate bearing capacity is:
$q_u = 1.3cNc$
This equation assumes that the soil's cohesion is the primary contributor to bearing capacity.

*Terzaghi's theory is based on several assumptions:
- ➢ The soil is homogeneous and isotropic.
- ➢ The foundation is shallow (depth not greater than width).
- ➢ The foundation is rough, preventing sliding between the foundation and the soil.
- ➢ The failure surface beneath the foundation is a combination of log-spiral and planar surfaces.
- ➢ The soil's shear strength follows the Mohr-Coulomb failure criterion.

*All Numerical and remaining part discuss in physical and online class.
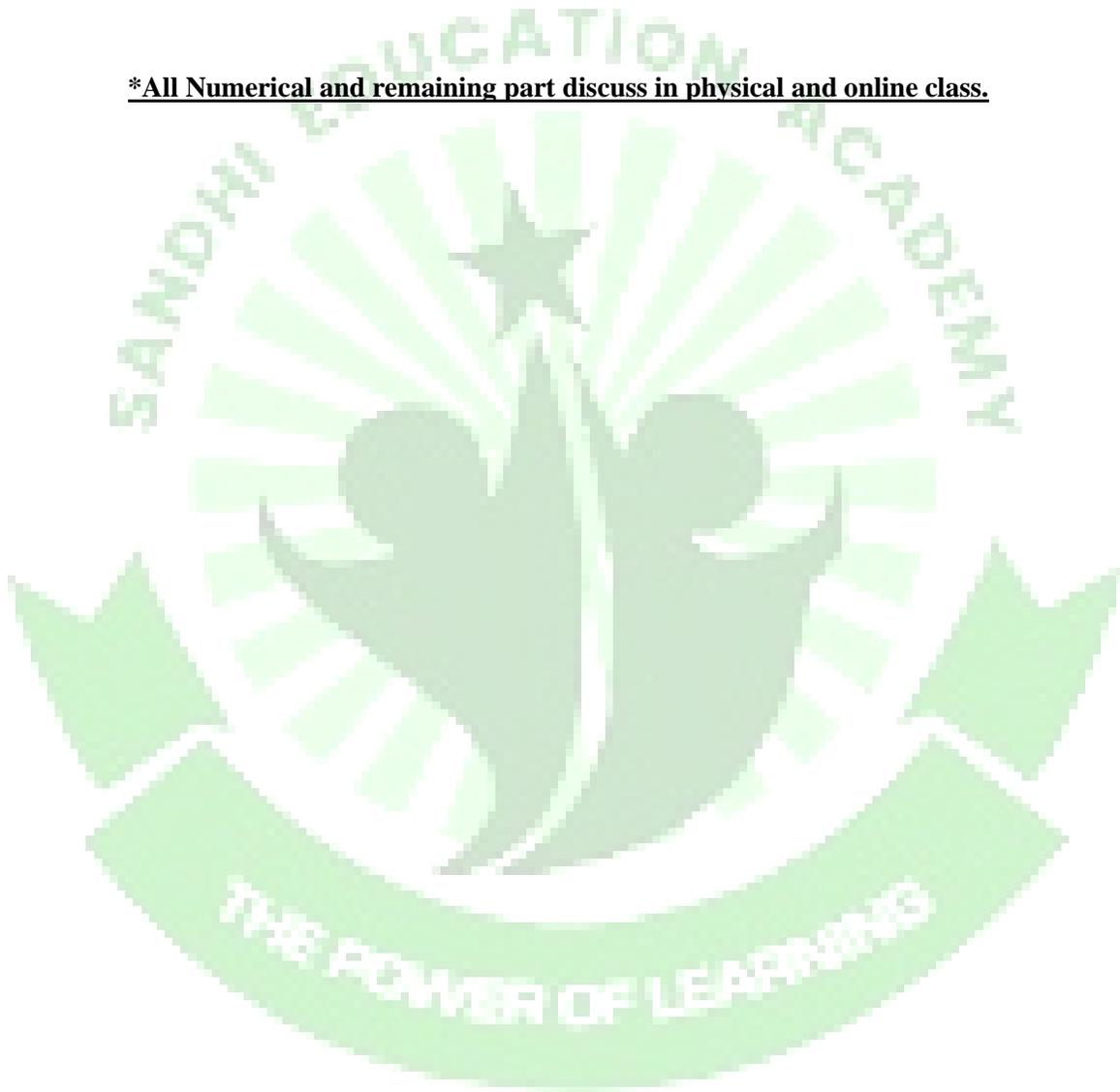
1. Which one of the following statements is true ?
   A. Clays are more porous than sands
   B. Pressure of organic matter in a soil decreases the bearing capacity of the soil
   C. Aluminous cement is used for foundations in soils with chemical deposits
   D. All the above
2. The lateral earth pressure on a retaining wall
   A. is equal to mass of the soil retained
   B. proportional to the depth of the soil
   C. proportional to the square of the depth of the soil
   D. proportional to the internal friction of the soil
3. The quantity of seepage of water through soils is proportional to
   A. coefficient of permeability of soil
   B. total head loss through the soil
   C. neither (a) nor (b)
   D. both (a) and (b)
4. When drainage is permitted under initially applied normal stress only and full primarily consolidation is allowed to take place, the test is known as
   A. quick test   C. drained test
   B. consolidated undrained test   D. none of these
5. The minimum water content at which the soil retains its liquid state and also possesses a <u>small shearing strength</u> against flowing, is known
   A. liquid limit   C. plastic limit
   B. shrinkage limit   D. permeability limit
6. Minimum size of the particles of silt soil, is
   A. 0.002 mm   C. 0.04 mm
   B. 0.06 mm.   D. 0.08 mm
7. Maximum size of the particles of clay soil, is
   A. 0.002 mm   C. 0.04 mm
   B. 0.06 mm.   D. 0.08 mm
8. Under-reamed piles are generally
   A. driven piles   C. bored piles
   B. precast piles   D. all the above
9. Factor of safety against sliding of a slope, is the ratio of
   A. actual cohesion to that required to maintain stability of slope
   B. shear strength to shear stress along the surface
   C. neither (a) nor (b)
   D. both (a) and (b)
10. According to Coulomb's wedge theory, the active earth pressure slides the wedge
    A. down and outwards on a slip surface
    B. up and inwards on a slip surface
    C. horizontal upward and parallel to base
    D. horizontal inward and parallel to base
11. The coefficient of compressibility of soil, is the ratio of
    A. stress to strain   C. strain to stress

    B. stress to settlement   D. rate of loading to that of settlement

12. The liquid limit and plastic limit exist in
    - A. sandy soils   C. silty soils
    - B. gravel soils   D. clay soils

13. The ratio of the weight of given volume of soil solids to the weight of an equal volume of distilled water at the given temperature, is known
    - A. Porosity   C. specific gravity
    - B. void ratio   D. water content

14. The ultimate Settlement of a soil is directly proportional to:
    - A. depth of the compressible soil strata   C. compressive index
    - B. void ratio   D. both (a) and (b)

15. The seepage force in a soil, is
    - A. perpendicular to the equipotential lines
    - B. proportional to the exit graident
    - C. proportional to the head loss
    - D. all the above

16. The maximum shear stress occurs on the filament which makes an angle with the horizontal plane equal to
    - A. 30°   B. 45°   C. 60°   D. 90°
        Hint: Maximum shear stress = 45°
              Zero shear stress = 90°

17. Westergaard analysis is used for
    - A. sandy soils   C. cohesive soils
    - B. stratified soils   D. clayey soils

18. The compression index of a soil
    - A. decreases with an increase in the liquid limit
    - B. increases with an increase in the liquid limit
    - C. decreases with an increase in the plastic limit
    - D. is not related with plastic limit

19. Number of piles required to support a column, is
    - A. 1   B. 2   C. 3   D. 4

20. The equation $\tau = C + \sigma \tan \varphi$ is given by
    - A. Rankine   C. Coulomb
    - B. Culaman   D. Mohr.

21. You are given a sample of soil containing <u>coarse grains</u> to determine its water content, you will use
    - A. Pycnometer   C. oven-drying method
    - B. calcium carbide method   D. alcohol method

22. The angle between the directions of the failure and the <u>major principal plane</u>, is equal to
    - A. 90° + effective angle of shearing resistance
    - B. 90° + half of the angle of shearing resistance
    - C. 45° - half of the angle of shearing resistance
    - D. 45° + half of the angle of shearing resistance
        Hint: C for minor principal plane

23. The compressibility of clays, is caused due to:

    A. expulsion of double layer water from in between the grains

    B. sliping of particles to new positions of greater density

    C. bending of particles as elastic sheets

    D. all the above

24. The specific gravity of quartz, is

    A. 2.65   B. 2.72   C. 2.85   D. 2.90

25. The capillary rise of water

    A. depends upon the force responsible

    B. increases as the size of the soil particles increases

    C. decreases as the size of the soil particles decreases

    D. is less in wet soil than in dry soil

26. Negative skin friction on piles

    A. is caused due to relative settlement of the soil

    B. is caused in soft clays

    C. decreases the pile capacity

    D. all of the above

27. The ultimate bearing capacity of a soil, is

    A. total load on the bearing area   C. safe load on the bearing area

    B. load at which soil fails   D. load at which soil consolidates

28. Over-consolidation of soils is caused due to

    A. erosion of over burden

    B. melting of ice sheets after glaciation

    C. permanent rise of water table

    D. all the above

29. Darcy's law is applicable to seepage if a soil is

    A. Homogeneous   C. isotropic

    B. Incompressible   D. all the above

30. Depending upon the properties of a material, the failure envelope may

    A. be either straight or curved

    B. pass through the origin of stress

    C. intersect the shear stress axis

    D. all the above

31. The maximum net pressure intensity causing shear failure of soil, is known

    A. safe bearing capacity   C. net safe bearing capacity

    B. net ultimate bearing capacity   D. ultimate bearing capacity

32. Soil classification of composite soils, exclusively based on the particle size distribution, is known

    A. particle classification   C. textural classification

    B. High Way Research Board classification   D. unified soil classification

33. The shearing strength of a cohesion-less soil depends upon

    A. dry density   C. rate of loading

    B. confining pressure   D. nature of loading

34. The minimum depth of building foundations on

    A. sandy soils is 80 cm to 100 cm

    B. clay soils is 90 cm to 160 cm

    C. rocky soils is 5 cm to 50 cm

    D. all the above

35. The zero atmospheric pressure is at
    A. mean sea level   C. water table
    B. phreatic surface   D. Both B and C

36. The reduction in volume of soil due to squeezing out of water from the voids, is termed
    A. primary consolidation   C. primary compression
    B. primary time effect   D. all the above

37. A clay subjected to pressure in excess to its present over-burden, is said to be
    A. pre-compressed   C. pre-consolidated
    B. over-consolidated   D. all the above

38. The shear strength of a soil
    A. increases with an increase in the normal stress
    B. is proportional to the cohesion of the soil
    C. is generally known as the strength of the soil
    D. is proportional to the tangent of the angle of internal friction
    E. all the above

39. Soils containing organic matters
    A. are of spongy nature
    B. swell with decrease of moisture
    C. shrink with increase of moisture content
    D. none of these

40. The angle of internal friction is maximum for
    A. angular-grained loose sand   C. angular-grained dense sand
    B. round-grained dense sand   D. round-grained loose sand

41. The angle of internal friction is minimum for
    A. angular-grained loose sand   C. angular-grained dense sand
    B. Clay   D. round-grained loose sand

42. The plasticity of fine soils may be assessed by means of
    A. dry strength test   C. toughness test
    B. dilatancy test   D. all of these

43. The ratio of volume of air voids to the volume of total voids, is known as
    A. air content   C. percentage air voids
    B. percentage voids   D. porosity

44. Pick up the cohesive soil from the following:
    A. Red earth   C. Clay
    B. Black cotton soil   D. Compacted ground

45. Pile foundations are generally preferred to for
    A. bridge foundations   C. sky scrapper buildings
    B. residential buildings   D. runways

46. The specific yield of soil depends upon
    A. compaction of stratum   C. distribution of pores
    B. shape and size of particles   D. all the above

47. Failure of a slope occurs only when total shear force is

A. equal to total shearing strength
B. greater than total shearing strength
C. less than total shearing strength
D. none of these

48. The seepage exit gradient in a soil is the ratio of
    A. total head to the length of seepage
    B. flow line to slope
    C. head upstream to that at downstream
    D. head loss to the length of the seepage

49. If there is no impervious boundary at the bottom of a hydraulic structure, stream lines tend to follow :
    A. a straight line   C. a parabola
    B. a semi-ellipse   D. a semi-circle

50. When a cohesionless soil attains quick condition, it looses
    A. shear strength   C. Both A and B
    B. bearing capacity   D. neither (a) nor (6)

51. Degree of consolidation is
    A. directly proportional to time and inversely proportional to drainage path
    B. directly proportional to time and inversely proportional to square of drainage path
    C. directly proportional to drainage path and inversely proportional to time
    D. directly proportional to square of drainage path and inversely proportional to time

52. Terzaghi's bearing capacity factors Nc, Nq and Nr are functions of
    A. cohesion only   B. angle of internal friction only
    B. both cohesion and internal friction   D. none of the above

53. For better strength and stability, the fine grained soils and coarse grained soils are compacted respectively as
    A. dry of OMC and wet of OMC
    B. wet of OMC and dry of OMC
    C. wet of OMC and wet of OMC
    D. dry of OMC and dry of OMC where OMC is optimum moisture content

54. Uniformity coefficient of a soil is
    A. always less than 1   C. always equal to 1
    B. equal to or less than 1   D. equal to or greater than 1

55. Coefficient of consolidation of a soil is affected by
    A. compressibility   C. permeability
    B. both compressibility and permeability   D. none of the above

56. The angle that Coulomb's failure envelope makes with the horizontal is called
    A. cohesion   C. angle of internal friction
    B. angle of repose   D. none of the above

57. The effect of cohesion on a soil is to
    A. reduce both the active earth pressure intensity and passive earth pressure intensity
    B. increase both the active earth pressure intensity and passive earth pressure intensity
    C. reduce the active earth pressure intensity but to increase the passive earth pressure intensity
    D. increase the active earth pressure intensity but to reduce the passive earth pressure intensity

58. Water content of soil can

    A. never be greater than 100 %   C. take values only from 0% to 100%

    B. be less than 0%   D. be greater than 100 %

59. Compressibility of sandy soils is
    A. almost equal to that of clayey soils
    B. much greater than that of clayey soils
    C. much less than that of clayey soils
    D. none of the above

60. A plane inclined at an angle 'φ' to the horizontal at which the soil is expected to stay in the absence of any lateral support, is known as
    A. Natural slope line   C. Repose line
    B. The φ line   D. All the above

61. Quick sand is a
    A. type of sand
    B. flow condition occurring in cohesive soils
    C. flow condition occurring in cohesionless soils
    D. flow condition occurring in both cohesive and cohesionless soils

62. The coefficient of active earth pressure for a loose sand having an angle of internal friction of 30° is
    A. 1/3   B. 3   C. 1   D. ½

63. Effective stress on soil
    A. Increases voids ratio and decreases permeability
    B. Increases both voids ratio and permeability
    C. Decreases both voids ratio and permeability
    D. Decreases voids ratio and increases permeability

64. Stoke's law is valid only if the size of particle is
    A. less than 0.0002 mm   C. greater than 0.2 mm
    B. between 0.2 mm and 0.0002 mm   D. all of the above

65. The degree of saturation for the moist soil is about
    A. 0%   C. 1 to 25%
    B. 25 to 50%   D. 50 to 75%

66. Which of the following gives the correct decreasing order of the densities of a soil sample?
    A. Saturated, submerged, wet, dry   C. Saturated, wet, submerged, dry
    B. Saturated, wet, dry, submerged   D. Wet, saturated, submerged, dry

67. The standard temperature at which the hydrometer is calibrated is
    A. 10 °C   B. 15 °C   C. 20 °C   D. 27 °C

68. A soil is in a semi-solid state, if the consistency index is
    A. zero   C. one
    B. more than unity   D. none of these

69. The flow index in soils indicates the
    A. ratio of liquid limit to plastic limit
    B. variation of liquid limit
    C. variation of plastic limit
    D. shear strength variation with water content

70. The critical gradient for all soils is normally
    A. 0.5   B. 1   C. 1.5   D. 2.5

71. The coefficient of consolidation is measured in
    A. Cm^2/g B. cm^2/s C. $g/cm^2/s$ D. $cm^2/g/s$

72. The coefficient of consolidation is used for evaluating
    A. stress in the soil   C. total settlement
    B. over consolidation ratio   D. time rate of settlement

73. The plasticity index of sandy soil is
    A. Unity   B. Twice   C. Zero   D. any of above

74. Core cutter method is used to determine density of
    A. Coarse grain soil   C. Fine grain soil
    B. Inorganic soil   D. Both coarse and fine grained soil

75. Calcium carbide method is used to determine water content of soil takes just
    A. 2 to 3 minute   C. 5 to 7 minute
    B. 7 to 10 minute   D. 10 to 20 minute

76. In Unit phase diagram for a soil mass
    A. Total volume is taken as unity
    B. Volume of water is taken as unity
    C. volume of soil solids is taken as unity
    D. none of the above

77. What is the relationship between permeability and viscosity of water?
    A. Directly proportional   C. Inversely proportional
    B. Both are equal   D. None of the mentione

78. What is the relationship between permeability and unit weight of water?
    A. Directly proportional   C. Inversely proportional
    B. Both are equal   D. None of the mentione

79. What is the effect of adsorbed water on the permeability of soil?
    A. Structural arrangement is varied   C. Reduced degree of saturation
    B. Size of the particles is diminished   D. Reduces the pore size

80. What is the approximate value, which can be taken as void ratio occupied by adsorbed water?
    A. 1   B. 0   C. 0.1   D10

81. The effect of structural disturbance is on permeability is more in
    A. Fine-grained soil   C. Coarse grained soil
    B. Clay soil   D. All of the mentioned

82. Higher density and lower optimum water content is easily achieved by
    A. Coarse grained soil   C. Fine grained soil
    B. Cohesion less soil   D. Saturated soil

83. The dry density decreases in cohesion less soil with an increase in water content due to which of the following reasons?
    A. Capillary rise   C. Bulking of sand
    B. Degree of saturation   D. Water content

84. The maximum density is reached in cohesion less soil when the soil is
    A. Zero water content   C. Partially saturated
    B. Fully saturated   D. Maximum specific surface

85. The attainment of maximum density of soil at full saturation is due to
    A. Lubrication action   C. Hydrostatic pressure

B. Bulking of sand   D. None of the above

86. Darcy's law is valid for only _____
    A.   Laminar flow   C. Turbulent flow
    B.   Hydraulic flow   D. All of the above

87. What are the essentials, required to draw a flow net?
    A. Top Flow and Phreatic line   C. Stream line
    B. Both A and B   D. None of the above

88. The phreatic line can be located by which of the following method?
    A. Graphical method   C. Experimental method
    B. Analytical method   D. All of the above

89. Effective stress is
    A. the stress at particles contact
    B. a physical parameter that can be measured
    C. important because it is a function of engineering properties of soil
    D.   all of the above (RK)

90. The slaking of the clay occurs when clayey soil is dried
    A. below the shrinkage limit   C. above the shrinkage limit
    B. below the plastic limit   D. above the plastic limit

91. A failure wedge develops if a retaining wall
    A.   moves away from the backfill
    B. moves towards the backfill
    C. sinks downwards
    D. stresses equally by vertical and horizontal forces

92. A clay subjected to pressure in excess to its present over-burden, is said to be
    A.   pre-compressed   C. pre-consolidated
    B. over-consolidated   D. all the above

93. What is the relationship between permeability and viscosity of water?
    A. Directly proportional   C. Inversely proportional
    B. Both are equal   D. None of the above

94. In consistency of soil, the limits are expressed in terms of_____
    A. Per cent water content   C. Area
    B. Volume   D. All of the above

95. The purpose of soil classification is to _____
    A. To arrange various soils types in to groups
    B.   To use it for various purpose
    C.   For finding its properties
    D. For investigating the soil

96. Darcy's law is valid for only _____
    A.   Laminar flow   C. Turbulent flow
    B.   Hydraulic flow   D. All of the above

97. he phase diagram is also known as _____
    A.   soil grain diagram   C. block diagram
    B. constituents diagram   D. element diagram

98. The reduction in volume of soil which is due to squeezing out of water from the voids is _____

A. effective pressure   C. load increment

B. primary consolidation   D. secondary consolidation

99. In Terzaghi's Theory of one dimensional consolidation, load is applied in __
   A. one direction only   C. two directions only
   B. three directions only   D. none of the direction
      **Deformation also one direction only

100. According to Coulomb, the relationship between shear strength and normal stress could be represented by _____
   A. Linear curve   C. Parabolic curve
   B. Straight line   D. None of the above

Answers

1	D	21	A	41	B	61	C	81	A
2	D	22	D	42	D	62	A	82	A
3	D	23	D	43	D	63	C	83	C
4	B	24	A	44	B	64	B	84	B
5	A	25	A	45	C	65	D	85	C
6	A	26	D	46	D	66	B	86	A
7	A	27	B	47	B	67	D	87	A
8	C	28	D	48	D	68	B	88	D
9	D	29	B	49	D	69	D	89	C
10	A	30	D	50	C	70	B	90	A
11	C	31	B	51	B	71	B	91	A
12	D	32	C	52	B	72	D	92	D
13	C	33	B	53	B	73	C	93	C
14	D	34	D	54	D	74	C	94	A
15	D	35	D	55	B	75	C	95	A
16	B	36	D	56	C	76	B	96	A
17	B	37	D	57	C	77	C	97	C
18	B	38	E	58	D	78	A	98	B
19	C	39	A	59	C	79	D	99	A
20	C	40	C	60	D	80	C	100	C

<u>**6. Structural Design**</u>

Structural design is a methodical approach aimed at specifying the size, grade, reinforcement, and overall configuration of structural elements so they can withstand predicted loads safely and economically.

*<u>Objectives of structural design</u>

    A. **Safety & Stability**
       Ensure the structure can resist all applied loads and remain intact throughout its service life.
    B. **Economy**
       Optimize material usage and member sizing for cost-efficiency without compromising safety.
    C. **Serviceability**
       Maintain comfort and functionality by limiting excessive deflection, vibration, or damage during normal use.
    D. **Durability**
       Account for material behavior over time (e.g., creep, corrosion) to ensure longevity.
    E. **Code Compliance**
       Conform to design standards (e.g., Eurocodes, Limit State Design principles) outlining how loads and resistances are factored.

*<u>Plain cement concrete (PCC)</u>

    PCC is a concrete mix composed of cement, fine aggregate (sand), coarse aggregate (gravel or crushed stone), and water without any steel reinforcement.
    ➢ High compressive strength and low tensile strength .
    ➢ Unit weight=24KN/m^3
    ➢ (M_5-M_{15}) concrete is used in PCC.

*<u>Reinforced cement concrete (RCC)</u>

    Reinforced Cement Concrete (RCC) is a composite building material created by embedding steel reinforcement (bars, mesh, or wires) within concrete. This pairing leverages the strengths of both: concrete's high compressive ability and steel's excellent tensile capacity, enabling structural elements to resist both types of stress effectively.
    ➢ High compressive and tensile strength
    ➢ Unit weight = 25 KN/m^3

*<u>Pre-stressed concrete (PSC)</u>

    Prestressed concrete is a type of structural concrete in which internal compressive stresses are intentionally introduced via high-strength tendons to counteract the tensile stresses that occur during service. This pre-compression enables concrete members to perform more effectively under load, minimizing cracking and increasing structural efficiency.
    ➢ In prestressed concrete, compressive strength is significantly higher than tensile strength.

6.1 R.C. Sections in Bending
6.1.1 Under reinforced, over reinforced and balanced sections

    A. Balanced Sections (Critical section)
       ➢ If the amount of steel (Ast) and amount of concrete (Ac) is provided in a such a way that the failure of steel and concrete occurs same time. (simultaneously)

i.e. Area of steel (Ast) =Area of concrete Ac

Ast=Ac

➤ The tensile steel reaches the yield strain while the concrete reaches failure strain in bending.

➤ The percentage of steel included in the balanced section is known as balanced steel and the neutral axis as the critical neutral axis.

➤ The yielding of steel and crushing of concrete occurs at same time (simultaneously).

➤ The actual depth of neutral axis (x) is equal to critical depth of neutral axis (Xc).

i.e. x=Xc   (Mc=Mt)

B. Under-Reinforced section

➤ If the amount of steel less than, that of the balance section the section is termed as under reinforced section.

➤ Area of steel is less than area of concrete

i.e. Ast < Ac

➤ The yielding of steel occurs earlier than the crushing of concrete.

➤ Tensile failure or ductile failure is also called under-reinforced section.

X < Xc

➤ Actual depth of neutral axis (X) is less than critical depth of neutral axis (Xc) i.e. (X<Xc).

➤ Moment of resistance is less than balanced section.

➤ Structure is always design as under reinforced section.

➤ Ductile/gradual/tensile failure.

C. Over-reinforced section

➤ The percentage of steel provided is greater than that of balanced section.

➤ Area of steel (Ast) > area of concrete (Ac)

➤ In this section, concrete fails first than that of steel.

➤ The failure of such beam is called compression failure (brittle failure).

➤ The moment of resistance is more than balanced section.

(a)   (b) Balanced   (c) Under reinforced   (d) Over reinforced
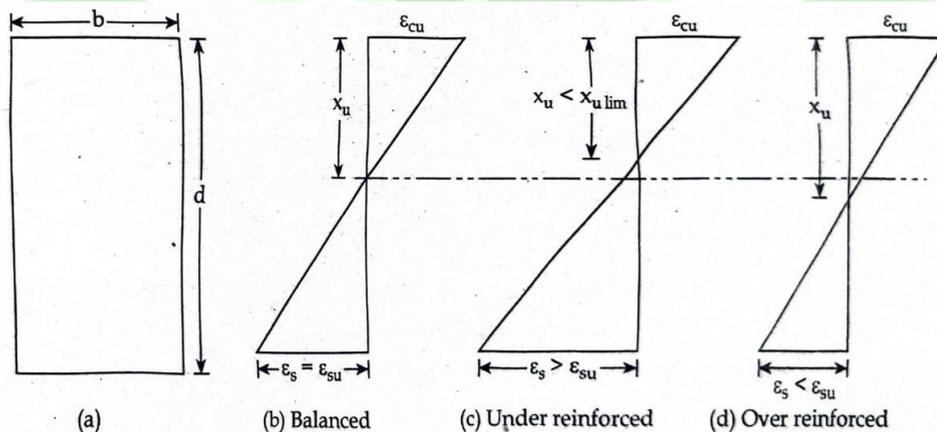
6.1.2 Analysis of single and double reinforced rectangular sections

*Analysis of single rectangular section

➢ steel reinforcement only on the tension side (usually the bottom in simply supported beams).
➢ No steel is provided in the compression zone.
➢ Its design ensures that the steel yields before the concrete crushes, leading to a ductile failure, which is safer and more predictable.

*Analysis of double reinforced rectangular beam

➢ A doubly reinforced beam includes reinforcement on both the tension side and the compression side (known as compression steel)
➢ the concrete section alone (plus tensile steel) cannot resist the required bending moment.
➢ Architectural or height constraints limit the beam's dimensions.
➢ Section dimensions are restricted (e.g., limited beam depth for architectural or structural reasons).
➢ Applied moment exceeds what a singly reinforced section can resist.
➢ Reversal of bending moments is expected, as in continuous beams or piles subject to alternate loading.
➢ Improved ductility is needed, especially for seismic resilience or moment redistribution.
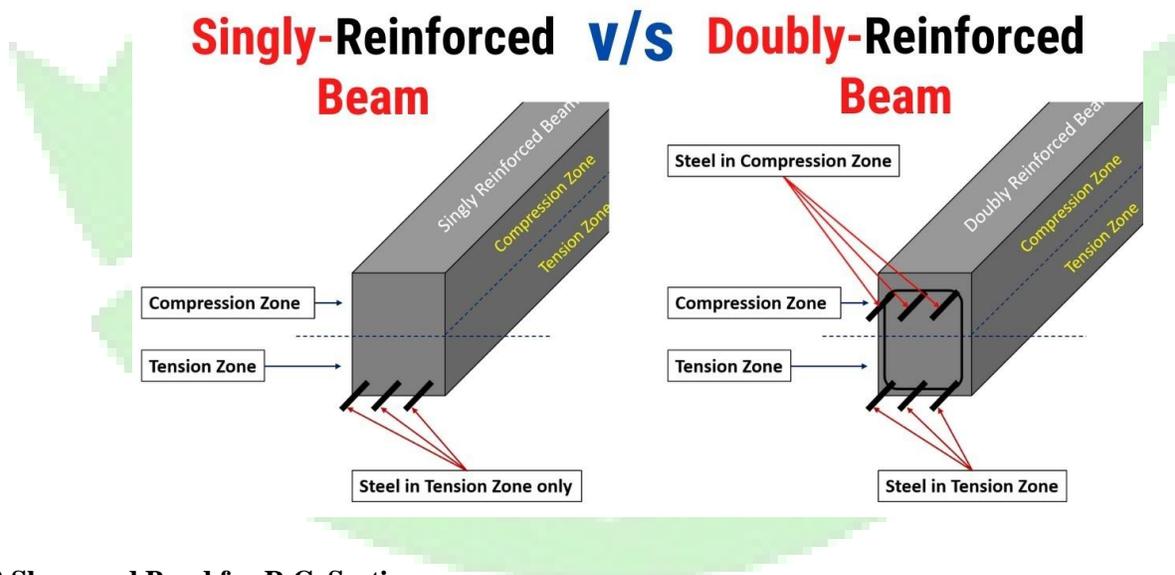
6.2 Shear and Bond for R.C. Sections

*Shear stress in RC section

➢ shear stress occurs due to transverse forces causing a change in bending moment along the beam, leading to internal sliding forces.
➢ The nominal (average) shear stress used for design is calculated as:

$$\tau v = Vu/(b \times d)$$

where Vu is the factored shear force, b is the beam width, and d is the effective depth.

➢ The maximum shear stress in a rectangular section, based on elastic theory, follows a parabolic distribution and occurs at the neutral axis.
➢ The peak value is approximately 1.5 times the average shear stress.
➢ For homogeneous elastic beams, the shear stress distribution is parabolic, zero at the top and bottom fibers and maximum at the neutral axis.
➢ The concrete's contribution to resisting tension is minimal due to cracking.
➢ the actual shear stress distribution deviates from classic theory, tension zone stresses remain nearly constant.

*Bond stress
➢ Bond stress is the shear stress at the interface between the steel reinforcement and the surrounding concrete, critical for preventing slippage and ensuring composite action.
➢ It enables force transfer between steel and concrete under loading.
➢ In flexural zones, bond results from changes in bending moments.
➢ Microscopic cement hydration products adhere to the steel.
➢ Mechanisms of bond is Resistance between the steel surface and concrete friction.
➢ Anchorage bond: At terminations (ends or hooks), bond must resist concentrated bar stresses, often handled via development or anchorage lengths.
➢ Higher compressive strengths enhance bond capacity and reduce slip.
➢ Deformed bars offer stronger mechanical interlock.
➢ Smaller bars typically perform better, reducing bond stresses.
➢ the average bond stress for reinforcing bars in compression can be increased by 25%.

6.2.1 Shear resistance of a R.C. section

6.2.2 Types of Shear reinforcement and their design
*Shear Reinforcement
Shear reinforcement is additional steel, typically in the form of stirrups, bent-up bars, or inclined links, designed to resist shear or diagonal tension stress that the plain concrete alone cannot withstand.
It helps prevent diagonal cracking due to shear, secures the main (longitudinal) reinforcement, and contributes to overall ductility of the beam.

*Common Types of Shear Reinforcement
A. **Vertical Stirrups**: Closed loops placed perpendicular to the beam's axis. They come in one-legged, two-legged, or more configurations.
B. **Inclined Stirrups**: Placed at 45°, aligning more directly with diagonal tension crack paths.
C. **Bent-Up Bars**: Longitudinal bars bent upward (often at 45°) near supports, effective when bending moment is low.
*Functions & Benefits of shear reinforcement
➢ Resists diagonal tension, a prevalent failure mode in shear-critical sections.
➢ Restricts and controls diagonal cracks, preventing brittle failure and enhancing structural ductility.
➢ Helps maintain alignment of longitudinal reinforcement and provides confinement to the concrete in compression zones.

*Design & Spacing Considerations
- ➢ **Minimum diameter**: Stirrup bars must be at least 6 mm, or not smaller than the main reinforcement diameter, whichever is greater.
- ➢ **Maximum spacing** (per IS 456:2000):
  - o Vertical stirrups: spacing ≤ 0.75 d
  - o Inclined stirrups: spacing ≤ d
  - o In all cases: spacing must not exceed 300 mm**.**
- ➢ **Minimum shear reinforcement** is required by code, even when concrete capacity appears sufficient, to ensure ductility and crack control.

6.2.3 Determination of anchorage length
- ➢ The minimum embedment length of a reinforcing bar in concrete required to *develop* its full tensile (or compressive) strength through bond, whether provided as a straight length or with hooks/bends.
- ➢ It's a critical design consideration to avoid bar slip.
- ➢ **Anchoring bars in tension**

Bend type	45°	90°	135°	180°
Anchorage value	4∅	8∅	12∅	16∅

- ➢ 90° bend is called standard bend and 180° bend is called standard hook.

6.3 Axially Loaded R.C. Columns
- ➢ An axially loaded R.C. column primarily resists vertical compressive forces**,** often due to building weight.
- ➢ Minimum size of RC column should not be less than 300mm*300mm.

6.3.1 Short and long columns
*Short Column
- ➢ Designed primarily to resist axial loads through direct compression. They are less susceptible to buckling and are typically used in low-rise buildings.
- ➢ Slenderness ratio is in 3 and 12.
- ➢ For short column $3 < \frac{Left}{h} \le 12$ and $10 < \frac{Left}{rmin} \le 40$

*Long column
- ➢ Design must account for lateral stability, often requiring additional reinforcement like ties or spirals.
- ➢ Slenderness ratio is in greater than 12.
- ➢ It's also known as slender column.
- ➢ For long colum $\frac{Left}{h} > 12$ and $\frac{Left}{rmin} > 40$

  Where,

  L_{eff}= effective length of column

  B = least lateral dimension of column

  r_{min}=least radius of gyration of column

*Slenderness ratio
- ➢ A critical factor in determining column behavior. Columns with a slenderness ratio greater than 12 are considered long and require special design considerations.
- ➢ The slenderness ratio (λ) is calculated using the formula:
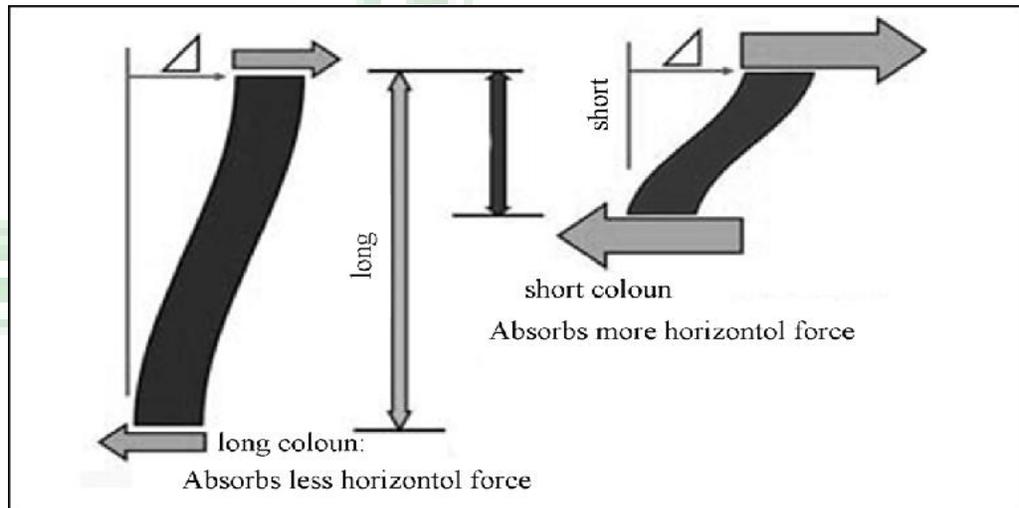
  $λ = L_{eff}/r$

Where,

        L_{eff} is the effective length of the column, which depends on the column's end conditions.

        r is the radius of gyration, calculated as:

        $r=\sqrt{I/A}$

        where I is the moment of inertia of the column's cross-section, and A is its cross-sectional area.

short coloun
Absorbs more horizontol force

long coloun:
Absorbs less horizontol force

6.3.2 Design of a rectangular column section

A. Calculation of effective length of column

    i.e l_{eff} = K*L ---------------(i)

    where, K=constant that depends on end conditions of column

B. Determination column size

    Load (P) = σ_{cc}*Ac+ σ_{cc}Asc---------------(ii)

    Where,

        Ac=99%of Ag

        Determine size of column of square section, b=$\sqrt{Ag}$

    Where Ag = gross area of column (b*d)

C. Check for slenderness ratio

    $\frac{Left}{h} < 12$=short column

    $\frac{Left}{h} > 12$=short column

D. Determine eccentricity of loading

    All columns shall be designed for minimum eccentricity, equal to the unsupported length of column by 500 plus lateral dimension/ 3 subjected to a minimum of 20mm.

        i.e $e_{min}=\frac{L}{500} + \frac{b}{30}$

    if e_{min} <0.05b, it is an axially loaded column.

E. determine area of longitudinal reinforcement

    Longitudinal reinforcement should not be less than 0.8% and more than 6% .(4% in practical)

    Provided Minimum number of longitudinal bar in each corner of column.(4 no.s)

Circular column: 6 numbers

Hexagonal : 6 numbers

Octagonal : 8 numbers

F. Design of lateral ties:

Diameter (Øt) of lateral ties

$(Øt = \frac{(Ø\ largest\ dia}{4}$ or 6mm whichever is greater

Pitch (P) of lateal teis (minimum of all)

=least lateral dimension of column

=16*Ømin

=48*$Øt$

=300mm

Pitch of helical ties (minimum of all)

=(1/6)thof the core diameter

=75mm

Maximum diameter of ties should not be greater than 12mm.

6.4 Design and Drafting of R.C. Structures
6.4.1 Singly and doubly reinforced rectangular beams
6.4.2 Simple one-way and two-way slabs

- ➢ A slab refers to a flat, horizontal structural element
- ➢ Typically made of reinforced concrete
- ➢ Used for floors, ceilings, and roofs. Slabs generally range in thickness from 100 mm to 500 mm, though "mud slabs" for paving can be thinner.

*Types of Concrete Slabs & Their Uses

A. One-Way Slab

- ➢ Supported on two opposite sides.
- ➢ Load is carried in a single direction.
- ➢ Reinforcement placed perpendicular to supporting beams.
- ➢ Ideal for rectangular spans (length more than twice width).
- ➢ Length and breadth ratio is greater than 2 then it is considered as one way slab.
- ➢ The deflected shape of the one way slab slab is cylindrical.
- ➢ The crank is provided in two directions.
- ➢ Chajja and verandah are practical examples of one way slab.

B. Two-Way Slab

- ➢ Supported on all four sides.
- ➢ Load carried in both directions.
- ➢ Common in square or near-square layouts for superior load distribution.
- ➢ Length and breadth ratio is less than 2 then it is considered as two way slab.
- ➢ The deflected shape of the two way slab slab is dish-shape.
- ➢ The crank is provided in four directions.
- ➢ Two way slab are used in construction floor of the multi-stroyed building.

*Design of slab
One-way slab design procedure (IS 456:2000)

A. Decide if it's one-way

If the longer/shorter clear-span ratio ly/lx≥2, design as one-way. (General IS practice; also see IS 456 Sec. 24 for slab rules.)

B. **Choose the effective span lll**
Take the lesser of:
• clear span + effective depth ddd; **or**
• centre-to-centre of supports. (IS 456 Cl. 22.2 & Sec. 24.)

C. **Trial depth for deflection control**
Start with basic span/depth ratios (IS 456 Cl. 23.2.1):
• simply supported = **20**
• continuous = **26**
• cantilever = **7**
Modify with the code's modification factors as needed.

D. **Loads** (service → factored)
• Self-weight = t×25t \times 25t×25 kN/m³ (for slab thickness ttt in m)
• Floor finish / partitions (as specified)
• Live load (from building use)
Combine and factor (typically 1.5× for DL+LL in LSM) to get wu (kN/m²). (IS 456 Ch. 19 & limit-state load combos.)

E. **Analysis (bending moments & shear)**
For a typical one-way, UDL panel of width 1 m:
• **Simply supported:** Mu=wul2/8 at mid-span; Vu=wul/2 at supports.
• **Continuous slabs:** use moment and shear coefficients from IS 456 Table 12 & 13 (Cl. 22.5.1) according to end conditions (e.g., interior spans, partial fixity).

F. **Flexural design (main steel along the span)**
For the 1 m design strip, with effective depth ddd:
• Lever arm z≈0.9d (usual slab range).
• Required area of tension steel: Ast=Mu/(0.87 fy z)
Check neutral-axis limits per code if you go beyond usual ranges. (IS 456 Sec. Governing flexure.)

G. **Minimum & maximum steel checks**
• **Minimum As each direction:**
– HYSD bars (Fe415/500): **0.12%** of gross area
– Mild steel: **0.15%** (IS 456 Cl. 26.5.2)
• **Max bar diameter in slabs:** ϕmax≤D/8.

H. **Shear check (normally governs rarely in slabs)**
Compute τv=Vu/(b d) for 1 m width.
Compare with concrete design shear strength τc\tau_cτc from IS 456 Table 19 using % tension steel; provide shear reinforcement only if τv>τc . Also respect τc,max

I. **Deflection check (serviceability)**
Ensure provided l/d ≤ allowable (basic ratio × modification factors per Cl. 23.2.1). Increase depth or steel (to change modification factor) if not satisfied.

J. **Crack control & spacing limits**
• **Main bars (span direction):** spacing ≤ min(3d, 300 mm)
• **Distribution bars (transverse):** spacing ≤ min(5d, 450 mm)
(IS 456 Cl. 26.3.3(b))**.**

K. Cover
Nominal cover for slabs: 20 mm (mild exposure). May reduce to 15 mm if bar dia ≤ 12 mm (as permitted). (IS 456 Cl. 26.4).

L. Development length & anchorage
Provide Ld=ϕ σs/(4 τbd) beyond critical sections, or hooks/bends as per detailing rules. (IS 456 Cl. 26.2.1).

M. Detailing summary
• Main steel along the **s**horter span; distribution steel perpendicular.
• Check maximum curtailment rules & provide support negative steel if slab is continuous over beams (use Table 12 coefficients and support steel accordingly.

*Two-way slab — step-by-step design procedure (code-based, IS 456:2000 + practical rules)

A. Confirm it is two-way
If the longer span / shorter span ly/lx<2(approximately), the slab will distribute load in both directions → treat as two-way.

B. Geometry & effective span
- Decide panel boundaries (panels are the bays between supports; each bay designed separately).
- Effective span lll: for slabs use the lesser of (clear span + effective depth ddd) or centre-to-centre of supports — apply in both directions lx,ly.

C. Loads (service → factored)
- Self weight = t×25 kN/m³ (with slab thickness t in m) + finishes + imposed (live) loads per building use.
- Combine to get factored uniform load wuw_uwu (e.g. typically 1.5×(DL+LL) for LSM unless other load factors used).

D. Choose preliminary depth (trial depth)
- Use span-to-depth limits / code basic ratios to control deflection: typical basic l/dl/dl/d for simply supported ≈20, continuous ≈26 (modify per IS clauses and exposure). Pick a trial thickness ttt then compute effective depth d=t−cover−ϕ/2.

E. Analysis method — how to get design moments
You have two common practical options:
i. **Direct Design Method (DDM)**, empirical moment distribution to middle and edge strips (IS/ACI give coefficients). Fast for regular, uniformly loaded orthogonal frames that meet code limits. Use moment coefficients (for dead & live loads) from IS-456 / design tables (panels classified by edge continuity: interior, edge, corner panels).
ii. **Equivalent Frame / Rigorous Analysis**, model slab + beams as an orthogonal frame and perform moment distribution / matrix analysis (needed for irregular geometry, openings, or when DDM limits are exceeded). ACI and textbooks describe both EFM and DDM.
(Choose DDM when panel geometry and loading meet the method's limits, it's what IS 456 commonly prescribes for regular floor systems.)

F. Obtain bending moments (use 1-m strip)
- For each panel, use IS moment coefficients (separate coefficients for dead and live loads, and for positive & negative moments) to compute design moments Mu=α wl2M_u = \alpha\, w l^2Mu=αwl2 for both directions and for middle/edge strips. Coefficients differ for interior, edge and corner panels.

G. Design for flexure (reinforcement)
For each 1 m strip in both directions:
  i.   Compute required steel:

Ast=Mu/(0.87fyz)   (take z≈0.9d as initial)

ii.   Provide steel ≥ minimum reinforcement (IS 456: typically 0.12% for HYSD bars in slab) and respect maximum bar diameter & spacing rules. Provide main bars in the shorter span; distribution bars perpendicular.

H. Negative moments at supports / continuity

- For continuous slabs, provide negative (top) reinforcement at supports per the negative moment values from coefficients. For discontinuous edges (free edges) provide top bars equal to a fraction of mid-span steel for a specified length (IS gives detailing rules like % of mid-span reinforcement and anchorage lengths).

I. Shear & punching checks

- For slabs with beams check one-way shear (rarely critical for typical slab depths).
- For flat slabs/plates on columns**,** check for punching shear around columns , use IS provisions and check critical perimeter; provide shear reinforcement (shear heads / drop panels / column capitals) if required.

J. Deflection & crack control

- Recheck l/dl/dl/d against allowable (use code basic ratios and modification factors). If not satisfied, increase depth or alter reinforcement (to change the modification factor).
- Control spacing: main bar spacing ≤ min(3d, 300 mm); distribution bars spacing ≤ min(5d, 450 mm) and follow code crack control limits and cover requirements.

K. Development length, anchorage & curtailment

- Provide adequate development length or mechanical anchorage/hooks as required by IS 456. Curtail bars only where permitted; ensure negative/positive bars continuity rules are followed (minimum extension distances into span/support — IS gives values e.g., 0.15l, 0.3l rules in annex).

L. Final detailing & drawing

- Prepare reinforcement schedule and bar bending schedule showing main & distribution bars, bar sizes, spacing, top bars near supports, drop panels (if any), column strip and middle strip reinforcements and slab thickness, cover, and any shear reinforcement. Follow spacing and cover per IS detailing clauses.

Note: All numerical part and remaining part detail discussion in physical and online class.

1. **In an under-reinforced section, which of the following occurs first?**
   A. Concrete reaches its maximum stress
   B. Steel reaches its yield stress
   C. Both concrete and steel reach their maximum stress simultaneously
   D. None of the above

2. **Which type of section is most commonly preferred in reinforced concrete design due to its ductile behavior?**
   A. Over-reinforced section
   B. Balanced section
   C. Under-reinforced section
   D. None of the above

3. **In a balanced section, which of the following statements is true?**
   A. Concrete reaches its maximum stress before steel
   B. Steel reaches its yield stress before concrete
   C. Both concrete and steel reach their maximum stress simultaneously
   D. Neither concrete nor steel reaches their maximum stress

4. **Which of the following is a characteristic of an over-reinforced section?**
   A. Steel reinforcement is insufficient
   B. Concrete reaches its maximum stress before steel
   C. Steel reinforcement yields before concrete
   D. The section exhibits ductile failure

5. **What is the primary failure mode of an under-reinforced section?**
   A. Sudden brittle failure
   B. Gradual ductile failure
   C. No failure occurs
   D. Immediate collapse

6. **In which type of section is the neutral axis depth greater than that in a balanced section?**
   A. Under-reinforced section
   B. Balanced section
   C. Over-reinforced section
   D. None of the above

7. **Which type of section is most likely to fail suddenly without warning?**
   A. Under-reinforced section
   B. Balanced section
   C. Over-reinforced section
   D. None of the above

8. **Which of the following is a disadvantage of a balanced section?**
   A. Provides no warning before failure
   B. Difficult to design
   C. Requires excessive reinforcement
   D. None of the above

9. **In an under-reinforced section, the strain in steel is:**
   A. Less than in a balanced section
   B. Equal to that in a balanced section
   C. Greater than in a balanced section
   D. None of the above

10. **Which type of section is most economical in terms of material usage?**
    A. Under-reinforced section
    B. Balanced section
    C. Over-reinforced section
    D. None of the above

11. **In a singly reinforced beam, the reinforcement is provided mainly to resist:**
    A. Tensile stresses
    B. Shear stresses
    C. Compression stresses
    D. Torsional stresses

12. **What is the primary difference between a singly reinforced beam and a doubly reinforced beam?**
    A. Amount of reinforcement used
    B. Presence of compression reinforcement
    C. Use of stirrups
    D. Concrete strength required

13. **In a doubly reinforced beam, additional steel is provided to:**
    A. Increase bending strength
    B. Resist shear stresses
    C. Enhance durability
    D. Facilitate construction

14. **The purpose of providing compression reinforcement in doubly reinforced beams is primarily to:**
    A. Increase ductility
    B. Resist compressive forces
    C. Resist tensile forces
    D. Enhance bond strength

15. **A doubly reinforced beam is used when:**
    A. The beam depth is restricted
    B. The beam width is restricted
    C. The concrete amount is restricted
    D. High strength is required

16. **Compared to singly reinforced beams, doubly reinforced beams are:**
    A. Less suitable for long spans
    B. More suitable for long spans and heavy loads
    C. Have lower moment capacity
    D. Require no steel reinforcement

17. **A doubly reinforced beam is considered less economical than a singly reinforced beam because:**
    A. Shear reinforcement is more
    B. Compressive steel is under-stressed
    C. Tensile steel required is more than balanced section
    D. Concrete is not stressed to its full value

18. **In a singly reinforced beam, which fundamental assumption is commonly applied in design?**
    A. Plane sections remain plane after bending
    B. Concrete behaves plastically under all loads
    C. Reinforcement settles within concrete
    D. Reinforcement slips within the concrete

19. **The maximum increase in moment of resistance over the balanced section achieved by using a doubly reinforced beam is:**
    A. 10%
    B. 15%
    C. 20%
    D. 25%

20. **What is the maximum shear stress for a rectangular homogeneous section under shear force V, depth D, and moment of inertia I?**
    A. $V D^2/8 I$
    B. $V D^2/6 I$
    C. $V D^2/2 I$
    D. $V D^2/4 I$

21. **According to IS 456:2000, how is nominal shear stress (ζ_v) calculated?**
    A. $V/b\, d$
    B. $V \cdot b/d$
    C. $V \cdot d/b$
    D. $V \cdot b \cdot d$

22. **In RC design, shear reinforcement is provided to resist:**
    A. Vertical shear
    B. Horizontal shear
    C. Diagonal compression
    D. Diagonal tension

23. **What does the variation of shear stress in a homogeneous beam section look like?**
    A. Elliptical
    B. Hyperbolic
    C. Parabolic
    D. Circular

24. **For a doubly reinforced beam, is shear resistance provided by stirrups or longitudinal reinforcement?**
    A. Longitudinal reinforcement
    B. Shear reinforcement
    C. Compression reinforcement
    D. Torsion reinforcement

25. **Which of the following are common types of shear reinforcement used in reinforced concrete beams?**
    A. Vertical stirrups
    B. Bent-up bars along with stirrups
    C. Inclined stirrups
    D. All of the above

26. **Vertical stirrups are characterized by:**
    A. Bars placed vertically around tensile reinforcement
    B. Being anchored in the compression zone via hanger or compressive

reinforcement

C. Available in one-legged, two-legged, four-legged, or multi-legged configurations

D. All of the above

27. **What is a key design limit when using bent-up bars for shear reinforcement?**
A. They must be inclined at exactly 30°
B. Their contribution should not exceed half of the total shear reinforcement
C. They are only used in slabs
D. They replace the need for vertical stirrups entirely

28. **hy is multi-legged stirrup configuration often used?**
A. To resist higher shear stresses
B. To provide support against buckling of compression bars
C. For thermal expansion
D. To reduce longitudinal reinforcement

29. **A column is classified as a short column if its slenderness ratio (effective length to least lateral dimension) is:**
A. Less than or equal to 12
B. Greater than 12
C. Less than or equal to 40
D. Greater than 40

30. **A long (slender) column is defined as one in which the slenderness ratio is:**
A. Less than or equal to 12
B. Greater than 12
C. Less than or equal to 40
D. Greater than 40

31. **What is the typical failure mode of a short column under axial loading?**
A. Buckling
B. Crushing (direct compression)
C. Torsional failure
D. Lateral-torsional buckling

32. **Long (slender) columns most commonly fail by:**
A. Crushing
B. Shear failure
C. Buckling
D. Torsional-induced failures

33. **Which slenderness ratio corresponds to a short column, based on effective length to radius of gyration (L/r)?**
A. ≤ 40
B. ≥ 40
C. ≤ 50
D. ≥ 50

34. **Compared to a short column of the same cross-sectional area, a long column's load-carrying capacity is generally:**
A. Higher
B. The same
C. Lower
D. Non-determinable

35. **Which formula is used to determine the buckling load for a slender column?**
A. Euler's formula
B. Rankine's formula
C. Perry–Robertson formula
D. ACI empirical formula

36. **A short column's strength is governed primarily by:**
A. Modulus of elasticity
B. Material strength (compressive strength)
C. Effective length
D. End conditions

37. **Summary: Which pair correctly categorizes columns based on slenderness characteristics?**
A. Short column – buckling; Long column – crushing
B. Short column – crushing; Long column – buckling
C. Short column – buckling; Long column – torsion
D. Short column – tension failure; Long column – shear failure

38. **Eccentrically loaded columns must be designed to withstand which combined effects?**
A. Axial load and shear
B. Axial load and bending moment
C. Axial load and torsion
D. Axial load and creep

39. **What defines a singly reinforced beam?**
    A. Reinforcement only in the tension zone
    B. Reinforcement in both tension and compression zones
    C. Reinforcement only in the compression zone
    D. No reinforcement

40. **When is a doubly reinforced beam necessary?**
    A. When beam width is restricted
    B. When beam depth is restricted and moment exceeds balanced capacity
    C. When loads are purely axial
    D. When no reinforcement is needed

41. **Which statement is true about doubly reinforced beams?**
    A. They always result in brittle failure
    B. They improve ductility and moment capacity
    C. They reduce long-term deflection
    D. Both B and C

42. **What is the maximum increase in moment of resistance (MoR) over the balanced section by using a doubly reinforced beam?**
    A. 10%
    B. 15%
    C. 20%
    D. 25%

43. **Which condition favors the use of a doubly reinforced beam?**
    A. Simple static loads only
    B. Eccentric or reversing moment loads
    C. When only shear reinforcement is needed
    D. To reduce cross-sectional deflection only

44. **Compared to singly reinforced beams, doubly reinforced beams are considered:**
    A. More economical
    B. Less economical due to under-stressed compression steel
    C. Equally economical
    D. Economical only in slabs

45. **Which assumption is essential for designing singly reinforced beams?**
    A. Concrete and steel settle equally
    B. Plane sections remain plane after bending
    C. Reinforcement slips in concrete
    D. Only compression steel is active

46. **What is the criterion to classify a slab as one-way?**
    A. Span ratio (longer/shorter) ≥ 2
    B. Span ratio ≤ 2
    C. Supported on four sides
    D. Main reinforcement in both directions

47. **How does a two-way slab transfer loads?**
    A. In one direction only
    B. In two perpendicular directions
    C. Only to adjacent beams
    D. Only to columns

48. **Which support condition generally applies to a one-way slab?**
    A. Supported on all four sides
    B. Supported on two opposite sides
    C. Free on all sides
    D. Supported only at the corners

49. **Which type of reinforcement is required for a two-way slab?**
    A. Only in the shorter span direction
    B. In both perpendicular directions
    C. Only temperature reinforcement
    D. Horizontal bars only

50. **What deflected shape does a two-way slab typically exhibit?**
    A. Cylindrical curve
    B. Dish-like or saucer shape
    C. Flat with no deflection
    D. Triangular distortion

51. **Which statement is true regarding reinforcement quantity?**
    A. One-way slabs require more steel than two-way slabs
    B. Two-way slabs require more steel than one-way slabs
    C. Both require equal steel
    D. One-way slabs don't need distribution steel

52. **A rectangular slab measuring 3 m × 5 m is considered:**
   A. One-way slab
   B. Two-way slab
   C. Flat plate slab
   D. Unable to determine

53. **For which slab type is one-way shear critical (as opposed to punching shear)?**
   A. One-way slab
   B. Two-way slab
   C. Both equally
   D. Neither

54. **How is a short column defined in reinforced concrete design?**
   A. Slenderness ratio ≤10
   B. Slenderness ratio >12
   C. Slenderness ratio ≤12
   D. Slenderness ratio >10

55. **What is the slenderness criterion for identifying a long (slender) column?**
   A. Slenderness ratio ≤12
   B. Slenderness ratio >12
   C. Slenderness ratio ≤50
   D. Slenderness ratio >50

56. **What failure mode is typical of an axially loaded short column?**
   A. Buckling
   B. Crushing (direct compression)
   C. Shear failure
   D. Flexural failure

57. **What is the typical failure behavior for long (slender) columns?**
   A. Crushing
   B. Buckling
   C. Shear failure
   D. Torsional failure

58. **What is the main difference between short and long columns in design?**
   A. Material only
   B. Failure mode and slenderness effects
   C. Shape of cross-section
   D. Type of reinforcement

59. The distribution of shear intensity over a rectangular section of a beam follows:
   A) A circular curve
   B) A straight line
   C) A parabolic curve
   D) An elliptical curve

60. In the context of T-beams, if the main reinforcement of the slab is parallel to the beam, transverse reinforcement shall not be less than:
   A) 50% of the main reinforcement
   B) 60% of the main reinforcement
   C) 75% of the main reinforcement
   D) 90% of the main reinforcement

61. Which of the following is not a type of structural load?
   A) Dead load
   B) Live load
   C) Wind load
   D) Thermal load

62. In the working stress method of RCC design, the factor of safety for concrete is:
   A) 3
   B) 4
   C) 1.5
   D) 2.5

63. The modular ratio method in RCC design is used to:
   A) Determine the equivalent area of concrete
   B) Calculate the moment of inertia
   C) Find the deflection of beams
   D) Estimate the shear capacity

64. Which of the following is a disadvantage of using high-strength concrete?
   A) Increased cost
   B) Reduced durability
   C) Higher shrinkage
   D) Decreased workability

65. In the design of reinforced concrete beams, the neutral axis depth is limited to:
   A) 0.45 times the depth of the beam
   B) 0.50 times the depth of the beam
   C) 0.60 times the depth of the beam
   D) 0.75 times the depth of the beam

66. Which of the following methods is commonly used for the design of steel structures?

A) Limit State Method
B) Working Stress Method
C) Ultimate Load Method
D) Both A and B

67. In the design of tension members in steel structures, the effective length factor is taken as:
A) 1.0
B) 1.2
C) 1.5
D) 2.0

68. The slenderness ratio of a column is defined as:
A) Effective length divided by radius of gyration
B) Effective length divided by cross-sectional area
C) Effective length divided by moment of inertia
D) Effective length divided by section modulus

69. In reinforced concrete design, the partial safety factor for steel is typically:
A) 1.15
B) 1.25
C) 1.50
D) 1.75

70. The strength of concrete is directly proportional to
A. cement water ratio
B. sand cement ratio
C. water aggrement ratio
D. all of the above

71. Strength of concrete increases with
A. increases in water cement ratio
B. decreases in water cement ratio
C. decreases in size of aggregate
D. decreases in curing time

72. Poisson's ratio for concrete
A. increases with richer mix
B. decreases with richer mix
C. remains constant
D. increases with poor mix

73. M20 grade of concrete proportion is
A. 1:4:8
B. 1:3:6

C. 1:2:4
D. 1:1.5:3

74. Presence of oils in water for concreting
A. improves strength
B. gives more slueey
C. reduces workability
D. reduces strength

75. The factor of safety for steel is based on its
A. yield stress
B. ultimate stress
C. both a and b
D. none of the above

76. The tensile strength of concrete for RCC beam design is
A. 0.2fck
B. 0.1fck
C. 0.05fck
D. none of the above

77. Permissible tensile strength of concrete, M150 is
A. 150kg/cm2
B. 15kg/cm2
C. 150N/mm2
D. 15N/mm2

78. The ratio of modulus of elasticity of steel to that of concrete is
A. modular ratio
B. poisson's ratio
C. elasticity ratio
D. none of the above

79. Shear in a concrete beam is caused by
A. props only
B. variation of B.M. along the span
C. weak bond
D. none of the above

80. Bottom reinforcement in beam used are subjected to
A. compression
B. tension
C. both
D. none of the above

81. In a singly reinforced beam the effecting cover is measured from
A. outer face of outer steel
B. centroid of steel

C. inner face of outer steel
D. all of the above

82. In a RCC beam if amount of steel increases the depth of N.A.
A. constant
B. decreases
C. increases
D. none of the above

83. A doubly reinforced beam is used
A. when extra safety factor is required
B. when the depth and width of beam is restricted
C. when depth of beam is more than the width
D. a large moment of resistance is desired

84. Steel beam theory is used for
A. design of simple steel beam
B. steel beam encased in concrete
C. beam if shear exceeds 4 times allowable shear stress.
D. doubly reinforced beams ignoring compression stress in concrete

85. The main reason for placing of main bar at top in case of cantilever slab is
A. compression at top
B. load at top
C. tension at top
D. all of the above

86. The minimum diameter of bars for slab is generally
A. 6mm
B. 8mm
C. 10mm
D. 12mm

87. If a beam fails in bond, then
A. increase the depth of beam
B. use thinner but more number of bars
C. use thicker but less number of bars
D. providing vertical stirrups

88. The safe bond stress between concrete and steel is determined by
A. tensile test
B. compressive
C. shear test
D. pull out test

89. Tensile strength of Fe415 is taken as
A. 415 N/mm2
B. 230 N/mm2
C. 145 N/mm2
D. all of the above

90. The states of concrete are
A. elastic and hardened state
B. elastic and plastic state
C. plastic and hardened state
D. none of the above

91. Laps in bars are equal to
A. bond length
B. twice bond length
C. 1.5 to twice bond length
D. none of the above

92. A flat slab is supported
A. on beams
B. on columns
C. on beams and column
D. on column monolithically built with slab

93. The ratio of ultimate strength to working stress is
A. distribution factor
B. load factor
C. safety factor
D. shape factor

94. If a beam is loaded transversely the maximum compressive stress develops on
A. top fibre
B. neutral axis
C. bottom fibre
D. every cross section

95. The effective span of a simply supported slab is
A. clear span plus effective depth of slab
B. span between outer foces of the two wall
C. distance between the center of bearing
D. none of the above

96. If slenderness ratio for a column is 100 then the column is said to be
A. long
B. medium

C. short
D. none of the above

97. The amount of reinforcement for main bars in a slab, is based upon
A. minimum bending moment
B. maximum bending moment
C. minimum shear stress
D. minimum shear stress

98. The entrapped air in concrete
A. increases workability
B. decreases workability
C. increases strength
D. none of the above

99. Segregation is responsible for
A. honey comb concrete
B. porous layers in concrete
C. sand streaks in concrete
D. all of the above

100. After casting, an ordinary cement concrete on drying
A. shrink
B. expands
C. remains unchanged
D. can expand or shrink

101. the workability of cement can be improved by
A. more sand
B. more cement
C. more fine aggregate
D. fineness of coarse aggregate

102. concrete gains strength due to
A. chemical action of cement with coarse aggregate
B. hydration of cement
C. evaporation of water
D. all of the above

103. inert material of cement concrete mix is
A. water
B. cement
C. aggregate
D. all of the above

104. the maximum bulking factor for sand is
A. 1
B. 1.1

C. 1.2
D. 1.4

105. An RCC roof slob is designed as two way slab if
A. it supports live load in both direction
B. ratio of spans in both directions is less than two
C. slab is continuous over two supports
D. slab is discontinuous at edges

106. For two way slab the main reinforcement is provided along the
A. length of the slab
B. breadth of the slab
C. diagonal of the slab
D. none of the above

107. A circular slab , when subjected to external loading , deforms to axxumes as shape of
A. hemi-sphere
B. ellipsoid
C. semi-hemisphere
D. Paraboloid

Answers

1	B	21	A	41	D	61	D	81	B
2	C	22	D	42	D	62	B	82	C
3	C	23	C	43	B	63	A	83	B
4	B	24	B	44	B	64	D	84	D
5	B	25	D	45	B	65	B	85	C
6	C	26	D	46	A	66	D	86	B
7	C	27	B	47	B	67	A	87	B
8	A	28	B	48	B	68	A	88	D
9	C	29	A	49	B	69	B	89	B
10	A	30	B	50	B	70	A	90	C
11	A	31	B	51	B	71	B	91	C
12	B	32	C	52	B	72	B	92	D
13	A	33	A	53	A	73	D	93	C
14	B	34	C	54	C	74	D	94	A
15	A	35	A	55	B	75	A	95	A
16	B	36	B	56	B	76	B	96	A
17	B	37	B	57	B	77	B	97	B
18	A	38	B	58	B	78	A	98	A
19	D	39	A	59	C	79	B	99	D
20	A	40	B	60	B	80	B	100	A

101	C
102	B
103	C
104	D
105	
106	B
107	D

7. Building Construction Technology

Building construction technology refers to the methods, tools and systems used to plan, design, Build and maintenance building and infrastructure.

7.1 Foundation

7.1.1 Subsoil Exploration
Subsoil exploration Also called subsoil investigation or site exploration. Sub soil exploration is a geotechnical process to understand the underground conditions (soil, rocks, underground water) beneath a project site. Essential for safe and economical construction.

*Purpose of soil exploration
➢ -Identifies soil layers, strengths and weakness.
➢ -determines ground water level.
➢ -supports foundation type, depth and design.
➢ -reveals geohazards (e.g. weak zones, rock strata).
➢ -understand soil stratigraphy and bedrock depth.
➢ -support risk mitigation and long-term planning.

*Common methods of soil exploration

S.N.	Method type	Techniques and tools	Purpose/application
1	Boreholes/test pits	Auger, rotary, percussion drilling	Retrieve soil samples; observe stratigraphy, depth to bedrock and water.
2	In-situ tests	SPT, CPT/CPTu, vane shear, pressuremeter	Measure strength, density, stratigraphy, and groundwater pressure
3	Geophysics	Electrical resistivity, GPR, seismic refraction	Non-invasive profiling for moisture, voids, layer mapping
4	Lab tests	Grain-size, Atterberg, shear, consolidation, permeability	Determine engineering properties for design use

7.1.2 Types of foundation
A. Shallow foundation/Open foundation (D ≤ B)
➢ **-**Depth is less or equal to width. (D ≤ B) , (D/B≤ 1)
➢ -generally constructed above the water table.
➢ -used for depth up to 3m to 4m.
➢ -footing is a part of foundation.
➢ -foundation= footing+ piers+ wall etc).
➢ -footing is bottom most part under column or wall.

a. Isolated footing/Spread footing
➢ **-(** length/breadth)=1 to 2.
➢ **-**also called pad foundation.
➢ -to support individual column.

➢ -such foundation are economical for the depth > 1.5 m. (5' or 5 feet).
➢ -shape of footing is square and rectangle.
➢ -the bearing capacity of soil is high at a shallow depth.

b. Combined foundation
➢ **-**it support two or more column.
➢ -it's used when column are closely spaced.
➢ -If soil is low bearing capacity.
➢ -it's provided along wall of the building at property lines. Where footing can't extend outside the limit of structure.

c. Continuous footing
➢ **-**footing that supports three or more columns in arrow.
➢ -provided near or at property line.
➢ -to prevent differential settlement in the structure.

d. Strap/cantilever footing
➢ **-**two or more isolated beams are connected by a beam.
➢ -the distance between the column is large strap footing is provided.
➢ -used near property line, eccentric loading.

e. Strip footing
➢ **-**also known as wall footing.
➢ -length is very greater than width.
➢ -width of wall foundation is equal to 2-3 times the width of wall and depth of footing is generally limited to 0.9 m.
➢ -it's place on dense sand and gravel.

f. Grillage foundation
➢ **-**it's a special type of isolated footing provided with excessively high steel/timber stanchions that transfer the heavy load from column to the soil having low bearing capacity.

g. Mat foundation
➢ **-**A mat foundation is a thick reinforced concrete slab, supporting the arrangement of the column or walls in a row and transmitting the load to the soil.
➢ -suitability of Mat foundation:-
➢ -If area of isolated footing is covers more than 50%.
➢ -heavy load is expected.
➢ -soil having low bearing capacity.
➢ -chances differential settlement.

B. Deep Foundation
➢ **-**depth of deep foundation is always greater than width of foundation.
➢ -the D/B ratio is usually 4-5 for deep foundation.

a. Pile foundation
➢ **-**It's a long vertical load transferring member composed of either timber and steel or concrete.
➢ -this type of foundation suitable for compressible water logged and made up type soil.
➢ -to ensure stability and durability.
➢ -when structure is situated near water bodies.

b. Pier foundation
➢ **-**it's a this type of foundation which transmits the super structure load the sub-soil by bearing only and is cylindrical in shape.
➢ -it's used in heavy loaded building is situated in sandy soil.

➢ -the size of shaft and spacing of pier depends upon the loading condition, nature of soil and the depth of hard strata.

c. Well foundation

A well foundation can withstand large lateral load and moment that occurs in case of bridge piers tall chimney and tall tower.

➢ -it's economical for the large structure when suitable bearing stratum is found at large depth.

1. Negative skin friction

➢ -It occurs when concrete piles are situated in sub-soil, consolidating soil man etc. Resulting downward force which increase load on pile and reduces the bearing capacity such effect is called negative skin friction.

➢ -if a fill of granular soil is placed over a layers of soft clay.

➢ -sudden lowering of ground water table.

2. Shoring

➢ -it's a temporary structure to support temporary an unsafe structure.

➢ -Used :- when wall are bulge out.

➢ -when an adjacent structure needs pulling down.

➢ -intermediate building to be dismantled.

➢ -avoid failure of structure where removing adjoining structure.

a. Raking shoring

➢ **-**in this type of shoring, in inclined members called rakers are used to provide temporary support to an unsafe wall.

➢ -also known as inclined shores.

➢ **-**inclined member are called rakers.

➢ -it's used for lateral support.

➢ -angle of inclination 45-75°.

➢ -spacing between rakers are 3-4.5 m along the wall of effective support.

➢ -cross-bracing is to prevent buckling.

➢ -rider raker:-used in tall structures to reduce shaft length.

b. Flying shoring

➢ **-**flying shores are used to provide horizontal support to the parallel walls of two adjacent buildings that may collapse without support.

➢ -also known as horizontal shores.

➢ -these type of shores don't rest on the ground.

➢ -distance between two wall isn't much (up to 9m) single flying shore with one bully can be provided.

➢ -inclination angle of struts should be 45-60°.

➢ -spacing between flying shoring are 3-4.5m.

c. Dead shoring

➢ **-**this type of shoring used to support dead loads of structure.

➢ -it consists of vertical bullies or post called dead shores and horizontal members called needle.

➢ -to rebuild the lower part of structure.

➢ -to replace old or deteriorated walls by new walls.

3. Dewatering

➢ **-**it's the process of removing surface and ground water from a construction site to create a safe, dry workspace for excavation, foundation laying, or trenching.

➢ -prevents excavation collapse and punching of the ground from hydrostatic pressures.

➢ -improves worker safety and material handling.

➢ -essential before installing foundation, shoring, caissons or underground structures.

5.1 Methods of dewatering

a. Sump (Opening) Pumping

➢ -dig shallow pits (sumps) in the excavation.

➢ -water collects by gravity, submersible pumps remove it

➢ -ideal for shallow, sandy/gravel soils.

➢ -inexpensive and easy to install.

4. Design of simple brick or stone masonry foundation

➢ **-**Following steps are used to design of simple brick or stone masonry foundation:-

➢ -NBC provides mandatory rule of thumb for design of load bearing masonry building.

➢ -depth of foundation for single storey=800mm

➢ -depth of foundation for multi-storey =900mm

➢ -width/thickness of wall footing:

$T = W/(p*L)$…………(i)   where, W=weight of wall

P=Allowable compressive strength ,

L=length of wall.

1. Calculate total load acting on footing i.e. W= super imposed load + wall column + floor finished load etc.

2. Width of footing (B)= total load transfer to the soil / safe bearing capacity of soil.

total load transfer to the soil= total load + self weight of footing

$=W + 10\%$ of W

$=1.1$ W

width (B) =1.1 W/S.B.C.

3. Depth footing

minimum depth of footing is calculated by using formula,

$D_{min} = q/Y ((1- \sin Ø)/(1+\sin Ø))^2$

4. Thickness of concrete block

thickness of concrete block (t) =a $(3q/m)^{1/2}$

where, a = offsets of footing

q= bearing pressure,

m= modulus of rupture

7.2 Walls

A wall is a vertical, usually thin, continuous structure that divides space, provides shelter, and sometimes carries loads

1. Main Purpose

➢ -To defined the boundaries of a specific area.

➢ -To carries load of building , roofs, slab and transfer it to the foundation.

➢ -To ensure privacy and also provides security.

➢ -To resists lateral stability (wind and seismic activity).

➢ -create a interior space and weather barrier.

➢ -allow design finishes and visual appeal.

2. **Types of wall**
   *Walls may be basically divided into two types
   a. Load bearing wall
   ➤ **-**wall which is design to carry super imposed load in addition with self weight of the wall.
   ➤ -It supports structural members such as beams, slabs, take loads from it and bring to the foundation.
   ➤ -it can be either an internal wall or external wall.
   ➤ -It braces from the roof to the floor.
   ➤ -precast concrete wall
   ➤ -retaining wall
   ➤ -masonry wall
   ➤ -pre panelized load bearing metal stud walls.
   ➤ -engineering brick wall (115 mm, 225mm).
   ➤ -stone wall
   b. Non-load bearing wall
   ➤ **-**also called a partition or curtain wall.
   ➤ -it's design to carry self weight of the wall.
   ➤ -easy to modify or remove without affecting structure.
   ➤ -types of non-load bearing wall are:- hollow concrete wall, façade bricks, hollow bricks, brick wall.

   *Types of wall based on their purpose
   a. Partition wall
   ➤-it's an interior non-load bearing wall.
   ➤-to divide large space into smaller spaces.
   ➤-a load bearing partition wall is called internal wall.
   b. party wall
   ➤ **-**to separate adjoining wall building belonging to different owners or occupied by different person.-it may or mayn't be load bearing.
   -to provide privacy, fir resistance and sound insulation.
   c. Cavity wall
   ➤ **-**it's constructed by 2 leaves/layer with a cavity or open space between the leaves of wall.
   ➤ -to prevent the penetration of rain or external moisture inside the building.
   ➤ -to prevent transmission of heat from external environment to inner side of the building.
   ➤ -to provide good insulation against sound.
   ➤ -cheaper in cost and economical.
   d. Panel wall
   ➤ **-**it's generally made of wood .
   ➤ -it's used for aesthetic of the building both inside and outside.
   ➤ -it remains totally supported at each story but subjected to lateral loads.
   e. Curtain wall
   ➤ **-**non-structural external facades that protect against weather, support their own weight and transfer wind loads via brackets.
   f. Veneered wall
   ➤ **-**it's a single non-structural external masonry wall made of brick, stone or manufactured stone.
   ➤ -it has an air space behind and is called an anchored veneer.

g. Shear wall
  - ➤ **-**to resist lateral forces exerted on the wall due to earthquake, wind or any other lateral load.
  - ➤ -it's a vertical element of the horizontal force resisting systems.
  - ➤ -muiltistoryed building shear wall is built completely in RCC.
  - ➤ -it's typically a wood frame stud walls covered with a structural sheating materials like plywood.

h. Retaining wall
  - ➤ **-**to provide lateral support for soil or rock.
  - ➤ -they prevent soil from eroding and from spilling from roadside and other structures.
  - ➤ example of retaining wall are:- Gravity wall, cantilever wall, counter fort wall, crib wall, etc.

i. faced wall
  - ➤ **-**faced walls has the facing and backing of two different materials are bonded together to ensure common action under load.

3. Thickness of wall and slenderness ratio
  -the thickness of a wall depends on various factors such as the type of wall.

7.2.3 Scaffolding
  - ➤ **-**it's a temporary structure used to support workers, tools, and materials during construction, maintenance, or repairs work at height.
  - ➤ -scaffolding provided if working height exceed-1.5m.

*uses of scaffolding
- to provide safe access to height.
- to provide stable working area.
-to provide support for workers and materials.
- to increase efficiency of work.

*Component of scaffolding
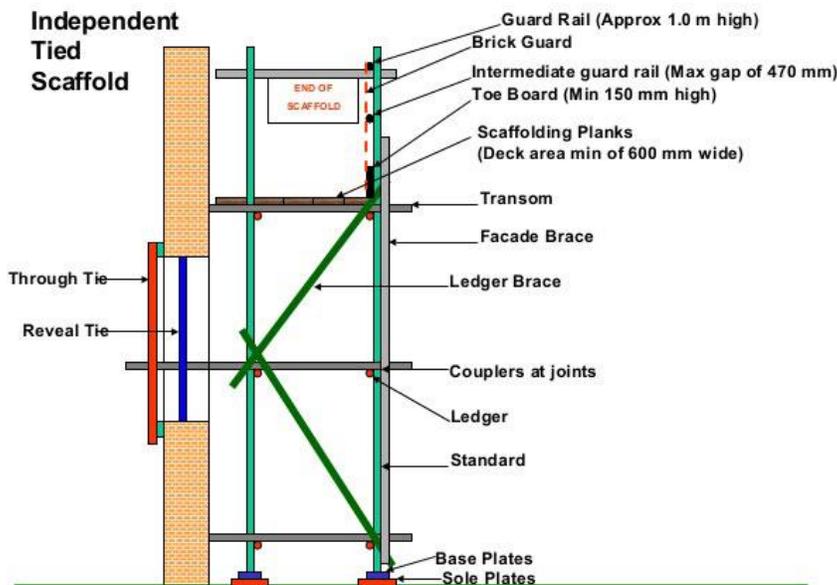
    a. Standard: vertical pipes forming the main structural framework.

    b. Ledger: Run parallel to the structure, connect standards for lateral support.

    c. Ledger brace: provide rigidity and prevent swaying.

7.3 Damp proofing

*Dampness in Building

the presence of unwanted moisture within a building's structure, which can lead to various issues such as mold growth, material decay, and compromised indoor air quality.

*Damp proofing

Damp proofing involves methods and materials used to prevent moisture from entering a building's interior spaces.

7.3.1 Source of dampness

A. **Penetrating Damp**: Occurs when water infiltrates through external walls due to issues like cracked or missing roof tiles, damaged gutters, porous brickwork, and faulty window seals.

B. **Rising Damp**: Moisture from the ground moves upwards through capillary action in porous materials like brick or stone. This is often due to the absence or failure of a damp-proof course (DPC), high external ground levels, or porous masonry.

C. **Condensation**: Occurs when warm, moist air contacts cooler surfaces, leading to water droplets forming on walls and windows. Common indoor activities contributing to this include cooking, dishwashing, and bathing.

D. **Plumbing Leaks**: Leaks from faulty or inadequate pipes can introduce moisture into walls and floors, leading to dampness. This includes leaking pipes, faulty plumbing fixtures, and water seepage from appliances.

E. **Construction Moisture**: Moisture from wet construction materials, such as bricks or mortar, can persist in a building if not properly dried before occupancy. This includes moisture retained in building materials and inadequate drying time during construction.

7.3.2 Remedial measures to prevent dampness

A. **Installation of Damp-Proof Courses (DPCs):** Incorporating barriers like bituminous felt or polyethylene sheets during construction to prevent moisture from rising through capillary action.

B. **Waterproofing and Surface Treatments:** Applying waterproof coatings or membranes to external walls, roofs, and basements to prevent water ingress.

C. **Improved Drainage Systems:** Ensuring proper grading around the building and maintaining gutters and downspouts to direct water away from foundations.

D. **Enhanced Ventilation:** Reducing indoor humidity levels by installing exhaust fans in kitchens and bathrooms, and ensuring adequate airflow throughout the building.

E. **Regular Maintenance and Inspections:** Regularly checking for and repairing leaks, cracks, and other sources of moisture to prevent dampness.

7.4 Concrete technology

7.4.1 Constituents of cement concrete

Concrete is a versatile composite construction material. It consists of aggregates (like sand, gravel, or crushed stone) bound together with a cement paste and water, which chemically reacts and cures to form a strong, rock-like solid

➢ **Aggregates** serve as the structural filler, fine (sand) and coarse (gravel, crushed rock) providing volume and stability.

- ➢ **Cement**, typically Portland cement, acts as the binder when mixed with water, forming a paste that encapsulates the aggregates.
- ➢ **Water** initiates hydration of the cement, enabling curing (hardening) and giving the mix workability.
- ➢ **Admixtures**, supplementary cementitious materials (SCMs), fibers, pigments, or reinforcement may be added to tailor properties like strength, setting time, durability, or aesthetics.

7.4.2 Grading of aggregate

Grading of aggregate is the particle size distribution of aggregates, typically determined via sieve analysis**.** Results are plotted as a gradation curve—cumulative percentage passing (y-axis) vs. sieve size on a logarithmic scale (x-axis).

Concrete Grade and Mix Ratio Table

As per IS 456:2000, the grades less than M20 should not be used in RCC works

Group	Concrete Grade	Mix Ratio	Characteristic Compressive Strength (N/mm2)
Ordinary Concrete	M5	1 : 5 : 10	5 N/mm^2
	M7.5	1 : 4 : 8	7.5 N/mm^2
	M10	1 : 3 : 6	10 N/mm^2
	M15	1 : 2 : 4	15 N/mm^2
	M20	1 : 1.5 : 3	20 N/mm^2
Standard Concrete	M25	1 : 1 : 2	25 N/mm^2
	M30	Design Mix	30 N/mm^2
	M35	Design Mix	35 N/mm^2
	M40	Design Mix	40 N/mm^2
	M45	Design Mix	45 N/mm^2
	M50	Design Mix	50 N/mm^2
High Strength Concrete	M55	Design Mix	55 N/mm^2
	M60	Design Mix	60 N/mm^2
	M65	Design Mix	65 N/mm^2
	M70	Design Mix	70 N/mm^2

7.4.3 Concrete mixes

A. Nominal Mix Concrete
- ➢ **Definition**: Uses fixed, standard ratios of cement, sand, and aggregate (e.g., 1:2:4), generally prepared by volume.
- ➢ **Application**: Suited for simple, non-critical, or smaller-scale works, such as Plain Cement Concrete (PCC), floor leveling, or low-load structures.
- ➢ **Grade Range**: Typically for grades M5 to M20 (and sometimes up to M25)
- ➢ **Typical Mix Ratios**:

  Grade Mix Ratio (Cement : Sand : Coarse Aggregate)

  M5   1 : 5 : 10
  M7.5   1 : 4 : 8
  M10   1 : 3 : 6
  M15   1 : 2 : 4
  M20   1 : 1.5 : 3
  M25   1 : 1 : 2

B. Design Mix Concrete
- ➢ **Definition**: Tailored for specific performance requirements; mix proportions are computed in the lab based on material properties and desired strength, workability, durability, etc.
- ➢ **Application**: Required for higher-grade (typically M30 and above), critical, heavy-load, or structural projects like high-rise buildings, bridges, and pre-stressed elements.
- ➢ **Advantages**: Optimizes cement use, reduces cost and shrinkage, and ensures consistency and durability.

C. Specialty Concrete Mixes
These mixes are designed to serve specific structural or functional needs:
- ➢ **Self-Consolidating Concrete (SCC)**: Flows and levels easily without vibration, maintains segregation resistance and good workability, ideal for complex forms.
- ➢ **Roller-Compacted Concrete (RCC)**: Low-water, stiff mix placed and compacted like asphalt; used in pavements and dam construction, often includes fly ash for reduced heat and cracking.
- ➢ **Foamed Concrete**: Lightweight, air-entrained mix using foam instead of aggregates, great for insulation, void filling, and lightweight structures.
- ➢ **Fiber-Reinforced Concrete**: Incorporates fibers (steel, polymeric, glass) to improve crack resistance, toughness, and impact strength, sometimes allowing reduced rebar usage.
- ➢ **Other Types**: Decorative (coloured, stamped), lightweight, pervious, fluid, and sulphate-resistant mixes, each engineered for unique construction or aesthetic applications.

7.4.4 Water Cement Ratio
The water–cement ratio (w/c ratio) denotes the relative amount of water to cement in a concrete mix and is the single most critical factor influencing the strength, durability, and porosity of the hardened concrete. It's calculated simply as:

$$\text{w/c ratio} = \text{mass of water}/\text{mass of cement}$$

- ➢ Standard water–cement ratios generally fall between 0.40 and 0.60**.**
- ➢ Lower w/c ratio → denser, less porous concrete → higher strength and durability.
- ➢ Higher w/c ratio → more porosity → lower strength, higher permeability, reduced lifespan.
- ➢ High w/c ratio: easier to work with—flows smoothly, simple to place and finish.
- ➢ Low w/c ratio: stiffer, challenging to place and compact.
- ➢ High-performance mixes (e.g. high-strength) often use superplasticizers to improve workability without increasing the w/c ratio.

➢ Concrete typically has pores from excess water evaporating after placement.

7.4.5 Factors affecting strength of concrete
A. **Water–Cement (W/C) Ratio**
➢ A lower W/C ratio leads to higher strength by reducing porosity; however, too little water can make the mix unworkable. Typical practical range: 0.4–0.6.
B. **Quality and Proportioning of Materials**
➢ Clean, well-graded aggregates and quality cement are essential. The cement–aggregate ratio influences water demand and strength.
C. **Compaction**
➢ Thorough compaction removes air voids. Even 5–10% entrapped air can reduce strength by ~30–40%.
D. **Curing & Age**
➢ Proper curing (moisture and temperature control) is critical. About 90% of strength develops within 28 days.
E. **Temperature During Hydration**
➢ Elevated temperatures speed curing but may lower long-term strength by increasing porosity; very high temperatures (>300 °C) degrade strength further.

7.4.6 Form Work
➢ Form work is a temporary or permanent mold used in concrete construction to shape and support fresh concrete until it hardens.
➢ It ensures accuracy in dimensions, supports weight and pressure during curing, influences surface finish, speeds up construction with cost-effective reuse, and enhances safety on site.
➢ Common materials include timber, steel, aluminum, plastic, and fabric.
➢ Specialized options such as climbing formwork are used for tall structures.

*Purpose and Importance of Formwork
A. **Shape and Dimension Control**
Enables precise molding of concrete into required forms like beams, slabs, or walls.
B. **Structural Support**
Holds the **weight of wet concrete** and resists hydrostatic pressure during curing.
C. **Surface Finish Quality**
The contact surface of formwork determines concrete finish—smooth or textured as needed.
D. **Efficiency and Cost-Effectiveness**
Reusable and well-designed formwork reduces labor, saves time, and cuts material waste.
E. **Safety**
A robust formwork system ensures safe construction operations and avoids form blowouts.

7.4.7 Curing
Curing is the controlled maintenance of moisture, temperature, and time for freshly placed concrete, ensuring continued cement hydration and proper hardening.
➢ It's a vital process for achieving the designed strength, durability, and integrity of the structure.
➢ **Minimum Duration**: Typically, concrete should be cured for at least 7 days, or until it reaches approximately 70% of its designed strength**.**
➢ Under hot, dry conditions**,** the period extends to 10 days (OPC) **or** 14 days (with admixtures)**.**

*Common Curing Methods
A. Water (Wet) Curing
➢ **Ponding**: Creating shallow water "ponds" over horizontal surfaces such as slabs.
➢ **Spraying/Fogging**: Continuous misting or water spray, useful for vertical or irregular surfaces.
➢ **Wet Covers**: Using wet burlap, hessian, gunny bags, or mats to maintain surface moisture.

B. Membrane Curing
➢ Applying a film-forming compound (e.g., wax or resin-based) to seal in moisture and reduce evaporation.
C. Steam or Heat Curing
➢ Using elevated temperatures to accelerate hydration—common in precast or controlled environments.
**D. Shading**
➢ Protecting concrete from sun, wind, and rapid drying using cloth or canvas shading.
E. Curing Blankets and Covers
➢ Using insulating blankets or plastic sheets, especially in cold weather, to maintain proper temperature and moisture.

7.5 Wood work
**7.5.1 Frame and shutters of door and windows**
*Door
➢ A door is a movable barrier used to close and open an entryway in a building.
➢ It typically swings or slides and is made of materials wood.
➢ Doors provide access, security, and privacy.
➢ Main Component of door are door frame and door shutter.
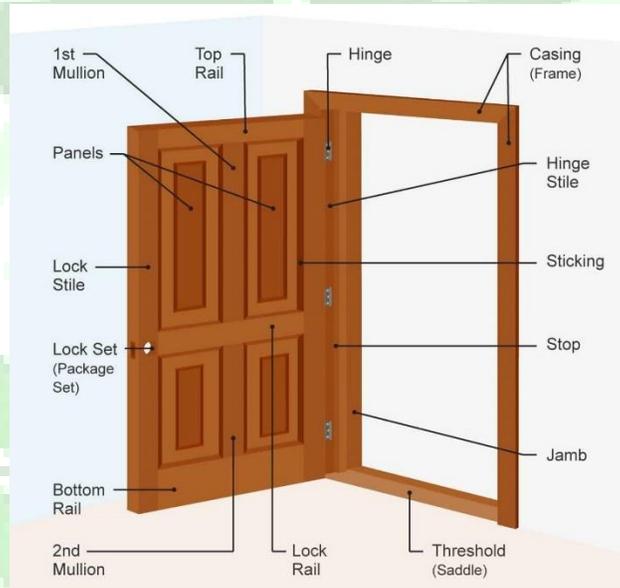
*Types of Door

*Windows
➢ A window is an opening in a wall or structure, usually fitted with Wood.
➢ It allows light and air into a space and can be opened or closed.

➢ Windows enhance ventilation, illumination, and aesthetic appeal.
➢ Main Component of windows are windows frame and windows shutter.

Window Shutter Components

* **Top Rail**
* **Stiles**
* **Slats/Louver**
* **Panel**
* **Hinge**
* **Bottom Rail**
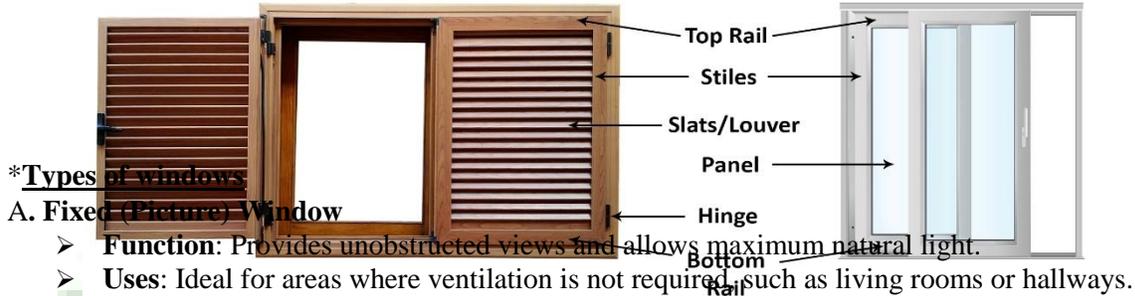
***Types of windows**

A. **Fixed (Picture) Window**
   ➢ **Function**: Provides unobstructed views and allows maximum natural light.
   ➢ **Uses**: Ideal for areas where ventilation is not required, such as living rooms or hallways.

B. **Single-Hung Window**
   ➢ **Function**: Features a fixed upper sash and a movable lower sash for ventilation.
   ➢ **Uses**: Commonly used in bedrooms and bathrooms for space efficiency.

C. **Double-Hung Window**
   ➢ **Function**: Both sashes are operable, allowing for improved ventilation and ease of cleaning.
   ➢ **Uses**: Suitable for various rooms, especially where airflow control is desired.

D. **Sliding Window**
   ➢ **Function**: Opens horizontally by sliding along a track.
   ➢ **Uses**: Often used in kitchens, living rooms, and offices for easy operation.

E. **Casement Window**
   ➢ **Function**: Hinged at the side, it opens outward like a door, providing excellent ventilation.
   ➢ **Uses**: Ideal for areas where unobstructed views and maximum airflow are desired.

F. **Awning Window**
   ➢ **Function**: Hinged at the top, it opens outward, allowing for ventilation even during rain.
   ➢ **Uses**: Suitable for bathrooms, basements, and areas requiring continuous airflow.

G. **Bay Window**
   ➢ **Function**: Projects outward from the wall, creating a nook and allowing more natural light.
   ➢ **Uses**: Common in living rooms and dining areas to enhance space and aesthetics.

H. **Bow Window**
   ➢ **Function**: Similar to bay windows but with a curved projection, offering panoramic views.
   ➢ **Uses**: Adds elegance to living spaces and is often used in reading corners or lounges.

I. **Skylight**
   ➢ **Function**: Installed in the roof to bring natural light into interior spaces.
   ➢ **Uses**: Ideal for attics, bathrooms, or hallways lacking wall space for windows.

J. **Garden Window**
   ➢ **Function**: Extends outward from the wall, providing a shelf for plants and herbs.
   ➢ **Uses**: Commonly installed above kitchen sinks to allow for gardening indoors.

7.5.2 Timber construction of upper floors

A. Types of Timber Floor Systems
   ➢ **Solid Timber Joist Floors**: Traditional and cost-effective, using solid timber beams (joists) spaced at regular intervals. Suitable for shorter spans and lighter loads.
   ➢ **Engineered Timber Joists**: Includes I-joists and metal-web joists. These are prefabricated, allowing for longer spans and easier integration of services.

> **Cassette Floors**: Prefabricated timber panels that are craned into position, reducing on-site labor and ensuring consistent quality.

B. Construction Components
> **Joists**: Horizontal supports that carry the floor decking.
> **Binders/Girders**: Provide intermediate support for joists, especially in longer spans.
> **Floor Decking**: Materials like tongue-and-groove chipboard or OSB (Oriented Strand Board) laid over joists to form the walking surface.
> **Ceiling Finish**: Typically plasterboard fixed to the underside of joists.
> **Insulation**: Mineral wool or rigid boards placed between joists to enhance thermal and acoustic performance.

C. Advantages of Timber Upper Floors
> **Sustainability**: Timber is a renewable resource, and engineered timber products like CLT (Cross-Laminated Timber) and glulam (Glued Laminated Timber) have a lower carbon footprint compared to concrete and steel.
> **Speed of Construction**: Prefabricated elements reduce on-site labor and construction time.
> **Aesthetic Appeal**: Exposed timber surfaces offer natural beauty and warmth to interiors.
> **Acoustic Performance**: Properly designed timber floors can provide good sound insulation between storeys.

7.5.3 Design and construction of stairs
*Stair
> A stair is a single step within a staircase, which is a series of steps designed to bridge a vertical distance between two levels.
> Stairs are essential architectural elements in buildings, providing access between different floors.

*Component of stair

Fig 1 Elevation and section
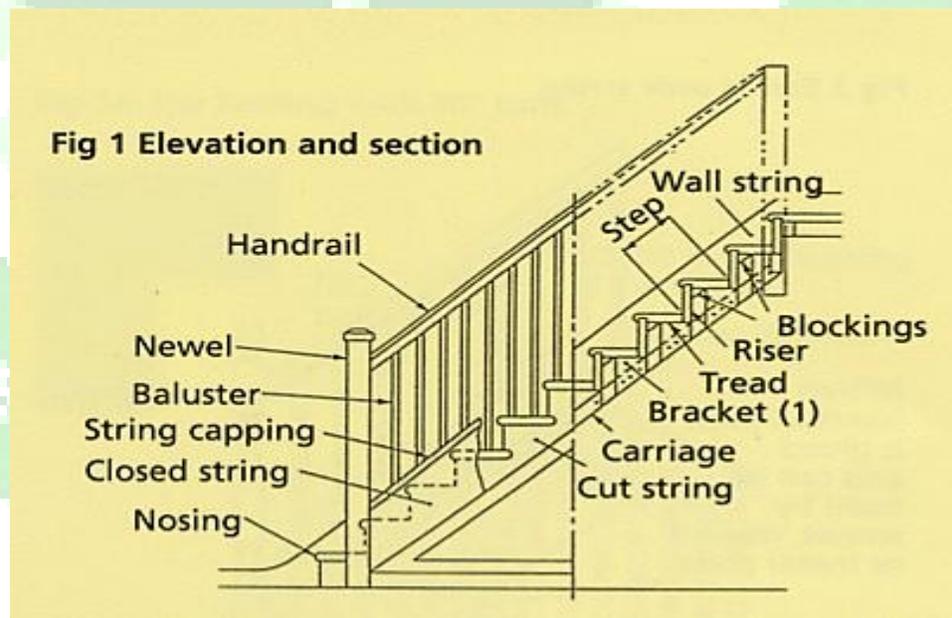
> **Riser**: The vertical part between two treads.
> **Tread**: The horizontal part where one steps.
> **Stringer**: The inclined support structure that holds the treads and risers.

> **Landing**: A flat platform between flights of stairs.

*Types of Stairs
   A. **Straight Staircase**: The simplest form, with no turns.
   B. **L-Shaped Staircase**: Features a 90-degree turn, often with a landing.
   C. **U-Shaped Staircase**: Consists of two parallel flights with a 180-degree turn.
   D. **Spiral Staircase**: Winds around a central pole, saving space.
   E. **Curved Staircase**: Features a continuous curve, adding elegance.

*Design Considerations:
   > **Dimensions**: Standard dimensions include a maximum riser height of 7¾ inches and a minimum tread depth of 10 inches.
   > **Width**: Residential stairs typically have a minimum width of 36 inches.
   > **Headroom**: A minimum clearance of 6 feet 8 inches is required.
   > **Nosing**: The protruding edge of the tread should be rounded or beveled to reduce tripping hazards.s

*Materials:
   A. **Wood**: Common in residential settings for its aesthetic appeal.
   B. **Concrete**: Used for durability and in multi-story buildings.
   C. **Steel**: Offers strength and is used in modern designs.

*Safety Features:
   > **Handrails**: Should be between 34 to 38 inches above the stair tread.
   > **Lighting**: Adequate lighting is essential to illuminate the stairs, especially at night.
   > **Anti-slip Surfaces**: To prevent accidents, especially in commercial settings.

7.6 Flooring and Finishing
   Flooring is the permanent surface covering applied over a floor structure to provide a durable and aesthetically pleasing walking surface.
   > It serves both functional and decorative purposes in buildings, enhancing comfort, safety, and the overall interior design.
7.6.1   Floor finishes: Brick, concrete, flagstone
A. Brick Flooring
Brick flooring utilizes clay pavers arranged in patterns like herringbone or basketweave, offering a rustic and timeless aesthetic.
*Advantages:
   > **Durability**: Resistant to wear, fire, and heavy foot traffic.
   > **Thermal Comfort**: Retains warmth, making it comfortable underfoot, especially in colder climates.
   > **Aesthetic Appeal**: Develops a patina over time, enhancing its rustic charm.
*Considerations:
   > **Maintenance**: Requires sealing to prevent staining and moisture absorption.
   > **Comfort**: The hard surface can be uncomfortable for prolonged standing.
   > **Installation**: May involve complex laying techniques and requires a stable subfloor.
B.   Concrete Flooring
Concrete floors are versatile surfaces that can be polished, stained, or stamped to achieve various finishes.
*Advantages:

> ➤ **Durability**: Highly resistant to scratches, stains, and heavy loads.
> ➤ **Low Maintenance**: Easy to clean and maintain with periodic sealing.
> ➤ **Design Flexibility**: Offers a range of finishes, including polished, stained, and stamped designs.

*Considerations:
> ➤ **Cold Surface**: Can be cold underfoot; radiant heating systems are often incorporated.
> ➤ **Hardness**: The rigid surface may be uncomfortable for extended standing.
> ➤ **Cracking Potential**: Prone to cracking if not properly installed or maintained.

C. Flagstone Flooring

Flagstone consists of natural stone slabs laid in irregular patterns, offering a rustic and natural appearance.

*Advantages:
> ➤ **Durability**: Resistant to cracking and suitable for high-traffic areas.
> ➤ **Aesthetic Appeal**: Provides a unique, natural look with varied colors and textures.
> ➤ **Versatility**: Suitable for both indoor and outdoor applications.

*Considerations:
> ➤ **Installation Complexity**: Requires skilled labor for proper laying and grouting.
> ➤ **Surface Variability**: Uneven surfaces can pose tripping hazards if not properly leveled.
> ➤ **Maintenance**: Natural stone may require sealing to prevent staining and moisture absorption.

7.6.2 Plastering

Plastering is the process of applying a protective and decorative layer of plaster (a mixture of binding materials like cement, lime, or gypsum with sand and water) over surfaces such as walls and ceilings.

> ➤ This technique enhances the surface's appearance, provides durability, and offers protection against environmental factors.
> ➤ Internal wall plaster 1:5, External wall plaster 1:4, Brick work (230mm or more thick) 1:6, brick work (115mm or less thick) 1:4 and celling 1:3.
> ➤ Minimum thickness of stone masonry = 20mm.
> ➤ Minimum thickness of brick masonry = 12.5mm
> ➤ Thickness of ceiling =6mm to 8mm.

*Objectives of plastering
> ➤ Protection from moisture, weathering, and damage.
> ➤ Smooth Finish Provides a level surface for painting or wallpapering.
> ➤ Enhances the visual appearance of walls and ceilings.
> ➤ Increases the lifespan of building materials.
> ➤ Improves thermal and acoustic performance.
> ➤ Some plasters, like gypsum, offer fire-resistant properties.

*All numerical and remaining part discuss in physical and online class.

1. The treatment given to the roof of a building to prevent the roof from the leakage of water is known as
    A. Fire proofing
    B. Damp proofing
    C. Termite proofing
    D. Sound proofing
2. Which of the following is not a function of a window
    A. To admit light into the building
    B. To admit air to the building
    C. To admit water to the building
    D. To provide thermal insulation
3. Which type of foundation should be adopted in a clayey or lose type of soil which considerably swells and shrinks by variation in the moisture content.
    A. Raft foundation
    B. Inverted arch foundation
    C. Cantilever foundation
    D. Grillage foundation
4. The window which is provided in flat roof of a room, is known
    A. Dormer window
    B. Lantern window
    C. Louvered window
    D. Sky window
5. To obtain good bonding in brick masonry
    A. First class bricks are used
    B. Vertical joints in alternate courses are kept in plumb line
    C. Bats are used where necessary
    D. All the above
6. For plastering the exposed brick walls, the cement sand mortar should be
    A. 1 : 2
    B. 1 : 3
    C. 1 : 4
    D. 1 : 6
7. The number of steps in a flight generally should not be less than
    A. 2
    B. 3
    C. 5
    D. No limit
8. The bearing capacity of a water logged soil can be improved by
    A. Compacting the soil
    B. Draining the soil
    C. Increasing the depth of foundation
    D. Grouting
9. The form Work including the props can be removed from beams, only after
    A. 3 days
    B. 7 days
    C. 14 days
    D. 21 days
10. The vertical members fixed between steps and hand rail, are known

A. Balusters
B. Strings
C. Newel posts
D. Soffits
   Shown in figure:
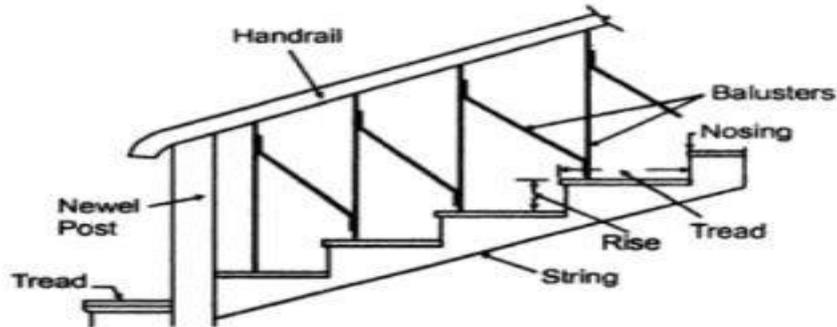
11. The stone masonry of finely dressed stones laid in cement or lime, is
    A. Random rubble masonry
    B. Coursed rubble masonry
    C. Dry rubble masonry
    D. Ashlar masonry
12. The form work from the sides of beams can be removed only after
    A. 1 day
    B. 4 days
    C. 7 days
    D. 14 days
13. The form work from the underside of slabs, can be removed only after
    A. 1 day
    B. 4 days
    C. 7 days
    D. 14 days
       Shown in table below

| Types of formwork	Formwork Removal Time
Side of wall, Columns and Vertical face of beam	24 hrs to 48 hrs
Slab Excluding props	3 days
Beam Excluding props	7 days
Slab including props span upto 4.5m	7 days
Slab including props > 4.5 m	14 days
Beam including props span upto 6m	14 days
Beam including props span > 6m	21 days

14. The minimum thickness of walls built in cement mortar (1 : 6) for a single storey building, is
    A. 10 cm
    B. 15 cm
    C. 20 cm
    D. 25 cm
15. In ordinary residential and public buildings, the damp proof course is generally provided at
    A. Ground level

      B.   Plinth level

      C.   Water table level

      D.   Midway ground level and water-table level

16. The type of roof suitable in plains where rainfall is meagre and temperature is high is

      A.   Pitched and sloping roof

      B.   Flat roof

      C.   Shell roof

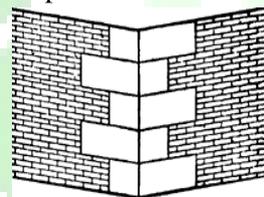   D.   None of the above

17. The inclined surface of an abutment to receive the arch, is known as

      A.   skew back

      B.   soffit

      C.   spandril

      D.   haunch

       Explain :
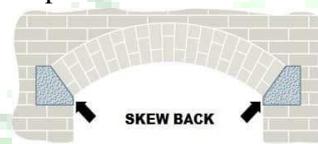
18. Dado is usually provided in

      A.   dinning halls

      B.   bath rooms

      C.   living rooms

      D.   verandah

19. The exterior angle between outer faces of a wall, is known as

      A.   turn

      B.   junction

      C.   quion

      D.   all the above

       Explain :

20. Raft foundation are generally preferred to when the area required for individual footing, is more than

      A.   25% to total area

      B.   30% of total area

      C.   40% to total area

      D.   50% of total area

21. Which of the following is not a type of structural load?

    A) Dead load

    B) Live load

    C) Wind load

    D) Thermal load

22. The modular ratio method in RCC design is used to:

    A) Determine the equivalent area of concrete

B) Calculate the moment of inertia

C) Find the deflection of beams

D) Estimate the shear capacity

23. Which of the following is a disadvantage of using high-strength concrete?
    A) Increased cost
    B) Reduced durability
    C) Higher shrinkage
    D) Decreased workability

24. Which of the following methods is commonly used for the design of steel structures?
    A) Limit State Method
    B) Working Stress Method
    C) Ultimate Load Method
    D) Both A and B

25. The slenderness ratio of a column is defined as:
    A) Effective length divided by radius of gyration
    B) Effective length divided by cross-sectional area
    C) Effective length divided by moment of inertia
    D) Effective length divided by section modulus

26. What is the primary objective of site investigation in geotechnical engineering?
    A) Cost estimation
    B) Material procurement
    C) Determination of soil and rock properties
    D) Project scheduling

27. Which of the following is not a method of subsoil exploration?
    A) Auger boring
    B) Wash boring
    C) Rotary boring
    D) Concrete pouring

28. In subsoil exploration, what parameter is measured by the standard penetration test (SPT)?
    A) Electrical resistivity
    B) Soil moisture content
    C) Soil density
    D) Soil strength

29. The type of boring used for making deep excavations is:
    A) Cylindrical augers
    B) Percussion boring
    C) Rotary boring
    D) Wash boring

30. Most suitable sampler for obtaining a sample of soft and sensitive clay is:
    A) Open drive thin-walled sampler
    B) Standard split-spoon sampler
    C) Stationary piston sampler
    D) Rotary sampler

31. Foundations can be broadly classified into:
    A) Shallow foundation and Deep foundation
    B) Pile foundation
    C) None of the mentioned
    D) All of the mentioned

32. A foundation is said to be shallow if its depth is _____ than its width.
    A) Equal to and Less than
    B) Greater than
    C) None of the mentioned
    D) All of the mentioned

33. Which of the following is a type of shallow footing?
    A) Spread footing
    B) Pile foundation
    C) Pier foundation
    D) Well foundation

34. Which type of foundation is typically used for bridges built on stable soil conditions?
    A) Shallow foundations
    B) Deep foundations
    C) Pneumatic caissons
    D) River training works

35. The most commonly used shallow foundation is:
    A) Strap footing
    B) Spread footing
    C) Combined footing
    D) Raft footing

36. The foundation whose length is considerably greater than its width is called:
    A) Footing

B) Pile foundation
C) Raft foundation
D) Strip foundation

37. The foundation which is constructed deep down and disperses weight at a depth of at least three meters is called:
A) Shallow foundation
B) Pile foundation
C) Raft foundation
D) Deep foundation

38. What is the primary purpose of shoring in construction?
A) To support temporary structures during construction
B) To remove groundwater from excavations
C) To provide ventilation in deep excavations
D) To reinforce the foundation of existing structures

39. Which of the following is a common method of dewatering in construction?
A) Well point system
B) Deep well system
C) Sump pumping
D) All of the above

40. In the well point dewatering system, what is the typical maximum depth of excavation?
A) 5 meters
B) 10 meters
C) 15 meters
D) 20 meters

41. Which type of shoring is characterized by inclined members that transfer loads to the ground?
A) Raking shore
B) Vertical shore
C) Flying shore
D) Dead shore

42. What is the primary function of a sump pump in dewatering?
A) To remove surface water
B) To lower the groundwater table
C) To prevent soil erosion
D) To support excavation walls

43. Which of the following is NOT a method of dewatering?
A) Well point system
B) Deep well system
C) Soil stabilization
D) Sump pumping

44. What is the purpose of using tiebacks in shoring systems?
A) To provide lateral support to the shoring walls
B) To anchor the shoring walls to the ground
C) To prevent soil movement behind the shoring walls
D) All of the above

45. Which of the following is a disadvantage of the well point dewatering system?
A) High installation cost
B) Limited to shallow excavations
C) Requires continuous monitoring
D) Ineffective in sandy soils

46. What is the primary risk associated with inadequate shoring during excavation?
A) Soil erosion
B) Collapse of excavation walls
C) Groundwater contamination
D) Soil compaction

47. Which of the following is a common material used in constructing shoring systems?
A) Steel
B) Timber
C) Concrete
D) All of the above

48. Which type of foundation is most suitable for buildings constructed on sloping ground?
A) Simple foundation
B) Pad foundation
C) Stepped foundation
D) Pier foundation

49. What is the primary function of a foundation in building construction?
A) To add aesthetic value
B) To transmit loads to the ground
C) To provide insulation
D) To decorate the structure

50. What is the purpose of curing brick masonry after construction?
   A) To enhance color
   B) To increase strength
   C) To prevent drying shrinkage
   D) To improve bonding

51. Which of the following is **not** a main classification of walls based on load-bearing function?
   A) Load-bearing wall
   B) Non-load-bearing wall
   C) Partition wall
   D) Shear wall

52. A **partition wall** is best described as:
   A) Load-bearing interior wall
   B) Non-load-bearing wall that separates rooms
   C) External wall resisting lateral loads
   D) Load-bearing façade

53. What type of wall consists of **two leaves separated by a gap** (air cavity)?
   A) Cavity wall
   B) Party wall
   C) Separating wall
   D) Curtain wall

54. Which wall type is built primarily to **resist lateral loads** such as wind or earthquake?
   A) Load-bearing wall
   B) Non-load-bearing wall
   C) Shear wall
   D) Cavity wall

55. A **party wall** is a wall that:
   A) Separates rooms within the same unit
   B) Divides adjacent buildings owned by different people
   C) Supports external façade only
   D) Resists soil pressure

56. The function of a **retaining wall** is to:
   A) Support building loads
   B) Divide interior spaces
   C) Hold back soil or water on a slope
   D) Provide an external non-structural façade

57. A **curtain wall** is best described as:
   A) A load-bearing external wall
   B) A non-load-bearing external wall that protects against weather
   C) A fire-resistant interior wall
   D) A soil-retaining wall

58. According to Sanfoundry, the width of a wall compared to its thickness is typically:
   A) Two times
   B) Four times
   C) Six times
   D) Eight times

59. What is the primary structural function of a wall in a building?
   A) To provide aesthetic appeal
   B) To support roofs, floors, and ceilings
   C) To improve thermal insulation
   D) To act as a decorative element

60. Which function of walls pertains to dividing spaces and ensuring privacy?
   A) Structural support
   B) Enclosure and space division
   C) Fire resistance
   D) Moisture control

61. Walls help protect a building from external elements. Which of the following is *not* part of this protective function?
   A) Resistance to weather
   B) Sound insulation
   C) Resistant to moisture intrusion
   D) Enhancing seismic resistance

62. Walls often house building utilities. Which of the following is a common utility that may be routed through walls?
   A) Roofing tiles
   B) Electrical wiring or plumbing
   C) Exterior insulation only
   D) None of the above

63. What is the primary purpose of scaffolding in construction?
   A) To serve as a permanent structure
   B) To shape concrete during forming
   C) To provide a safe platform for workers at heights
   D) To act as a decorative façade

64. Which of the following is **not** a common type of scaffolding?
    A) Suspended scaffolding
    B) Bamboo scaffolding
    C) Retaining scaffolding
    D) Tube and coupler scaffolding
65. What type of scaffolding is built on wheels for easy movement across a job site?
    A) Suspended scaffolding
    B) Cantilever scaffolding
    C) Rolling (mobile) scaffolding
    D) Bamboo scaffolding
66. Which scaffolding type is ideal where direct ground support isn't feasible, using projecting supports instead?
    A) Single scaffolding
    B) Cantilever scaffolding
    C) Trestle scaffolding
    D) System scaffolding
67. What describes suspended scaffolding?
    A) Built from the ground up
    B) Mounted on wheels
    C) Hung from above and adjustable in height
    D) Made of bamboo
68. What does **DPM** stand for in damp proofing?
    A) Damp Proof Material
    B) Damp Proof Mix
    C) Damp Proof Member
    D) Damp Proof Membrane
69. Which of the following materials is **most commonly used** for damp proofing?
    A) Bitumen
    B) Paraffin wax
    C) Cement solution
    D) Cement mortar
70. What is the **primary function** of a damp proof course (DPC)?
    A) To support walls
    B) To improve aesthetic appeal
    C) To prevent moisture penetration into walls and floors
    D) None of the above

71. Which type of material is used to **slow down** moisture absorption but doesn't fully prevent water under pressure?
    A) Waterproofing treatment
    B) Damp proofing
    C) Vapor barrier
    D) Waterproof membrane
72. hich material is categorized as a **flexible type** used in damp proofing?
    A) Mastic asphalt
    B) Slate
    C) Bitumen felts
    D) Plastic sheeting
73. Which of the following is considered a **rigid type** of DPC material?
    A) Mastic asphalt
    B) Slates
    C) Plastic sheeting
    D) Bitumen felts
74. At what **concrete mix grade** is DPC typically laid at plinth level?
    A) M10
    B) M15
    C) M20
    D) M25
75. Where is the **relative location** of DPC laid in a masonry wall?
    A) Above the walls
    B) Below the walls
    C) Inside walls
    D) Outside walls
76. Which material is **semi-rigid** and forms an excellent impervious barrier in damp proofing?
    A) Hot bitumen
    B) Mastic asphalt
    C) Bitumen felts
    D) Metal sheets
77. How many main components are typically used to prepare concrete?
    A) 3
    B) 4
    C) 5
    D) 2
78. What is the usual range for the water–cement ratio (w/c) for ordinary concrete mixes?
    A) 0.2 – 0.3

B) 0.4 – 0.6
C) 0.6 – 0.8
D) 0.8 – 1.0

79. What is the main role of cement in concrete?
    A) To provide workability
    B) To act as a binding material
    C) To add color
    D) To improve drainage

80. Which of the following is *not* a type of admixture used in concrete?
    A) Water reducer
    B) Air-entraining agent
    C) Plasticizer
    D) Paint pigment

81. The distribution of particle sizes in an aggregate sample, determined by sieve analysis, is known as:
    A) Compaction
    B) Grading
    C) Segregation
    D) Fineness modulus

82. Which type of aggregate grading has particles predominantly of the **same size**, resulting in high void content?
    A) Well-graded
    B) Gap-graded
    C) Uniformly-graded
    D) Open-graded

83. The **minimum** compressive strength required from structural consideration is referred to as:
    A) Nominal
    B) Minimum
    C) Maximum
    D) None

84. Approximate mix proportion for **M10** grade concrete:
    A) 1 : 3 : 6
    B) 1 : 2 : 4
    C) 1 : 1.5 : 3
    D) 1 : 1 : 2

85. What does the water–cement ratio represent?
    A) Volume of water to volume of cement
    B) Weight of water to weight of cement

C) Volume of cement to volume of water
D) Weight of cement to weight of water

86. Within what range is the water–cement ratio typically used for concrete?
    A) 0.20 – 0.35
    B) 0.40 – 0.60
    C) 0.60 – 0.80
    D) 0.80 – 1.00

87. What is the effect of using a **lower** water–cement ratio?
    A) Increased strength and durability
    B) Increased porosity
    C) Reduced strength
    D) Higher permeability

88. What happens if the water–cement ratio is too high?
    A) Concrete becomes stronger
    B) Concrete becomes highly porous and weak
    C) Concrete shows improved durability
    D) No effect on concrete quality

89. For concrete exposed to very aggressive environments, the w/c ratio should be:
    A) Higher than 0.50
    B) Lower than 0.40
    C) Exactly 0.60
    D) Around 0.70

90. What is the **primary function** of formwork in construction?
    A) To provide structural support to the building
    B) To shape and support freshly poured concrete until it sets
    C) To decorate the exterior of the building
    D) To facilitate easy demolition after construction

91. What is the correct term for the process of removing formwork after the concrete has sufficiently hardened?
    A) Stripping
    B) Demolding

C) Disassembly
D) Deformulation

92. What is a key advantage of steel formwork compared to timber formwork?
    A) Lower cost
    B) Reusability and durability
    C) Lightweight
    D) High flexibility

93. hich type of formwork system allows slabs and walls to be cast in a single pour?
    A) Modular formwork
    B) Table formwork
    C) Tunnel formwork
    D) Traditional slab formwork

94. What is the primary purpose of curing concrete?
    A) To increase the temperature of the concrete
    B) To maintain adequate moisture, temperature, and time to allow the concrete to achieve its desired strength and durability
    C) To remove formwork from the concrete
    D) To add color to the concrete

95. Which of the following is a common method of curing concrete?
    A) Sprinkling water
    B) Using curing compounds
    C) Covering with wet burlap or plastic sheeting
    D) All of the above

96. How long should concrete be cured under normal conditions?
    A) 1 day
    B) 3 days
    C) 7 days
    D) 14 days

97. What is the effect of inadequate curing on concrete?
    A) Increased strength
    B) Reduced durability and potential for cracking
    C) Improved workability
    D) No significant effect

98. Which curing method is most effective in hot weather conditions?
    A) Ponding
    B) Membrane curing
    C) Sprinkling water
    D) Steam curing

99. What is the primary benefit of using curing compounds?
    A) They accelerate the setting time of concrete
    B) They reduce the need for water during mixing
    C) They form a moisture-retaining film on the concrete surface
    D) They enhance the color of the concrete

100. What is the term used for the openable part of a door or window?
    A) Frame
    B) Shutter
    C) Sill
    D) Jamb

101. Which type of window shutter rotates about a fixed pivot?
    A) Casement
    B) Pivoted
    C) Sliding
    D) Louvered

102. The bottom surface of a door or window opening is known as?
    A) Lintel
    B) Sill
    C) Threshold
    D) Jamb

103. What is the upper horizontal member of a door frame called?
    A) Sill
    B) Head
    C) Crown
    D) Frame

104. A window projecting outward from the wall of a room is termed as?
    A) Panelled window
    B) Corner window
    C) Bay window
    D) Clerestory window

105. Which part of a door frame is known as the "Horn"?

A) Head
B) Jamb
C) Sill
D) Rebate

106. Which window is provided on a sloping roof?
A) Table window
B) Lantern window
C) Dormer window
D) Clerestory window

107. What is the vertical portion between each tread on a stair called?
A) Going
B) Nosing
C) Winder
D) Riser

108. What is the minimum number of steps recommended before providing a landing in a staircase?
A) 5
B) 10
C) 12
D) 16

109. Which type of stair consists of two or more straight flights arranged in such a manner that a clear space occurs between the backward and forward flights?
A) Dog-legged stair
B) Open newel stair
C) Spiral stair
D) Quarter-turn stair

110. The horizontal portion of a step upon which the foot is placed is known as:
A) Tread
B) Riser
C) Nosing
D) Stringer

111. Which type of stair turns through one right angle (90°)?
A) Quarter-turn stair
B) Half-turn stair
C) Dog-legged stair
D) Spiral stair

112. What is the term for the part of the building where the stair is located?

A) Staircase
B) Stairwell
C) Flight
D) Landing

113. Which type of stair consists of a single flight with no landing?
A) Straight flight stair
B) Dog-legged stair
C) Spiral stair
D) Quarter-turn stair

114. What is the first step in the flooring process?
A) Topping
B) Base coat
C) Sand filling
D) R.C.C. layer

115. Which type of flooring is made by mechanically combining wool and synthetic fibers?
A) Rubber flooring
B) Carpet flooring
C) Vinyl flooring
D) Wooden flooring

116. Which of the following is NOT an advantage of brick flooring?
A) Waterproof
B) Cost-effective
C) Slip-resistant
D) Fireproof

117. Which type of concrete flooring is commonly used for its durability and ease of maintenance in industrial settings?
A) Polished concrete
B) Terrazzo
C) Epoxy-coated concrete
D) Stained concrete

118. What is the primary purpose of a cement screed over a concrete floor?
A) To provide insulation
B) To level the surface
C) To add color
D) To increase strength

119. Which of the following is a disadvantage of using polished concrete flooring?
A) High maintenance

B) Prone to staining
C) Slippery when wet
D) Expensive installation

120. What is the primary purpose of plastering in construction?
A) To provide insulation
B) To enhance aesthetic appeal
C) To prevent moisture ingress
D) All of the above

121. Which of the following is a common type of plaster used for interior walls?
A) Cement plaster
B) Lime plaster
C) Mud plaster
D) All of the above

122. In plastering, what is the purpose of adding additives to the mortar mix?
A) To improve workability
B) To enhance adhesion
C) To increase durability
D) All of the above

123. Which of the following is a defect that can occur in plastered surfaces?
A) Blistering
B) Crazing
C) Cracking
D) All of the above

124. Which of the following tools is commonly used in plastering work?
A) Trowel
B) Float
C) Hawk
D) All of the above

Answers

1	b	21	d	41	a	61	b	81	b	101	b	121	d
2	c	22	a	42	b	62	b	82	c	102	c	122	d
3	a	23	d	43	c	63	c	83	b	103	b	123	d
4	b	24	d	44	d	64	c	84	a	104	c	124	d
5	d	25	a	45	b	65	c	85	b	105	b	125	
6	c	26	c	46	b	66	b	86	b	106	c		
7	b	27	d	47	d	67	c	87	a	107	d		
8	b	28	d	48	c	68	d	88	b	108			
9	c	29	b	49	b	69	a	89	b	109	b		
10	a	30	c	50	b	70	c	90	b	110	a		
11	d	31	a	51	d	71	b	91	a	111	a		
12	a	32	a	52	b	72	c	92	b	112	a		
13	c	33	a	53	a	73	b	93	c	113	a		
14	c	34	a	54	c	74	b	94	b	114	b		
15	b	35	b	55	b	75	b	95	d	115	b		
16	b	36	d	56	c	76	b	96	c	116	a		
17	a	37	d	57	b	77	b	97	b	117	c		
18	b	38	a	58	b	78	b	98	b	118	b		
19	c	39	d	59	b	79	b	99	c	119	c		
20	d	40	a	60	b	80	d	100	b	120	d		

Water Supply and Sanitation Engineering

1. General

-A water supply system is an engineered network designed to provide safe and potable water sufficient quantities for diverse needs, such as drinking, washing, cooking, industrial process, commercial activities etc.

- It encompasses the collection of raw water, its treatment to meet quality standards, storage in reservoirs or tanks, and distribution through pipelines and pumps to end users.

Water supply sector

MOWSS- ministry of water supply and sanitation

DWSS - department of water supply and sewerage

Water resources act - 2049 (1992)

PH value of drinkable water is 7

Human need 3-4 liters of water in one day

First water supply system in Nepal Bir dhara system (1891-1893)

Melamchi start date nov 1998

2. Objective of water supply system

-provide safe, wholesome, and potable water.
-ensure adequate quantity and continuous supply.
-ensure easy accessibility and convenience.
-support hygiene, sanitation and public health.
-provide water for firefighting and emergencies.
-Facilitate economic and community development.
-ensure equitable distribution and affordability.
-protect sources and maintain water quality integrity.
-promote efficiency, sustainability, and long-term resilience.
-build local capacity and institutional strength.

3. Types of water

a. Wholesome water:-
-safe and drinkable water (free from pathogens, harmful chemical and undesirable elements).
-pleasant experience (should look, taste, and smell acceptable to consumers).
-wholesome in a broader sense (used in ritual, ayurvedic, or cultural contexts to denote spiritually or physically nourishing water)

b. Potable water
-safe and uncontaminated (free from pathogens, harmful chemical and toxic substance)
-Aesthetic quality (should be clear, colorless, odorless and pleasant to taste)
-Contains essential minerals (includes beneficial minerals like calcium and magnesium)

c. Infected water
- water contaminated with harmful agents (such as microbes, parasites, or toxins)
-not drinkable water.

d. Contaminated water
water contaminated with harmful agents (such as microbes, parasites, or toxins)
-not drinkable water.

e. Polluted water
water contaminated with harmful agents (such as microbes, parasites, or toxins)
-not drinkable water.

f. Distilled water
- Distilled water is created by boiling water into steam and then condensing that steam into liquid. This removes nearly all minerals, dissolved solids, microbes, chemicals, and other impurities.
-ED=Electrical conductivity =Zero=0

g. Sterilized water
-Free from bacteria
-use for medical purpose
-sterilization can be achieved through various methods including boiling, chemical treatment, filtration, and ultraviolet light exploser.

h. Pure water
- Chemically pure H2O (Not drinkable water)
g. impure water
- Impure water is any water containing substances beyond pure H_2O—and those impurities can pose serious risks depending on type and concentration.

4. Selection of source
a. Location
-as near as possible.
-gravity flow (source to consumers area without pumping)
b. Quantity
-sufficient
c. Quality
-water safe, wholesome, potable.
-if safe water isn't available it should be chiefly treated.

4. **Types of sources**

4.1 Rainwater
-soft water
-generally low in dissolved solids but may require treatment for domestic use.
-maximum percentage of water is runoff in ground surface.

4.2 Surface water (LP SIR)
a. Lakes
-It's generally found in the mountain regions.
-Quality of water is good elevated lake (High elevation).
-contaminated obtaining large quantities of soluble salt and other impurities.

b. Ponds

-It's a man-made body of standing water smaller than a lake.

-quantity of water is very small and often it contains many impurities.

-normally use for bathing washing of clothes or for animals.

-It's not used for water supply purpose.

c. Streams

-streams are the naturally drainage channel found in the mountains region.

-discharge is much in rainy season than other season.

-quantity of water in streams is much less in compared to river due to catchment area.

- streams are the first priority for large scale drinking water supply in the hilly area.

-quality of water is normally good except the water of first runoff.

=first streams=second spring)

d. Impounded reservoir

-Near the bank of river and stream through constructed of weir (बाँध).

- it may carry much in rainy season than other season.

e. Rivers

-rivers are naturally channel which carries surface runoff received by it from its catchment or drainage basin.

-rivers moves forward discharge in the river increase due to increases in the catchment area.

-rivers are the first priority for large scale drinking water supply in the terrai.

=rivers(large project= well(domestic)

4.3 Ground water

4.3.1 Spring

- A spring is Naturally outflow of ground water.

a. gravity spring

b. Non- gravity spring

a. Gravity spring

-water flow under hydrostatic pressure types.

i. Depression spring

ii. contact/surface spring

iii. Artesian spring

i. Depression spring

- Trench is used to collect water.

-springs is formed due to over flow from the ground water table.

-more discharge in rainy season and less in dry season.

-deeper the trench more continuous water flow.

ii. Surface/contact spring

-spring are created by impervious stratum.

-Relatively small amount of underground storage.

-more discharge in rainy season and less in dry season.

-these spring can also be constructed with trench.

iii. artesian spring

-release of water under pressure.

-amount of relatively large.

-more catchment area large amount of water.

b. Non-gravity spring

-volcanic spring= from volcanic rock

-fissure spring= fracture rock

-extended to great depth in earth crust.

-they are usually thermal spring.

-hot spring=temperature higher than normal ground water.

-contains highly mineralized i.e. Sulphur.

-not used for domestic purpose.

-use for cure and skin disease.

4.3.2 Wells

-a well is a hole vertically excavated in the ground for bringing ground water to surface.

a. open well

b. Tube well

a. Open well/dug well

-large diameter hole (1 to 10m).

-not very deep. (2 to 20m).

-low yields.

-discharge (3-6 ltr/sec.

-bottom-open and wall- dry masonry

i. shallow open well

ii. deep open well

i.Shallow open well

-rest in the top water bearing strata.

-more chance of contamination.

-draw water from surrounding materials.

-quantity is variation with variation of ground water table.
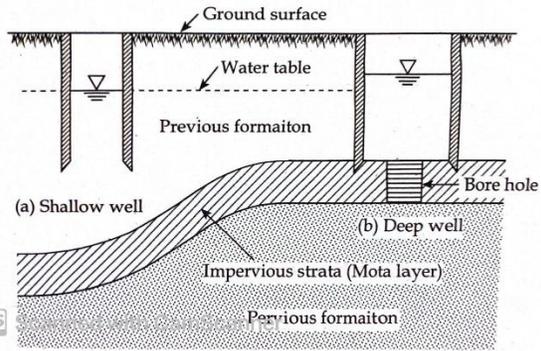
-diameter-6m.

-depth-7m (in terrai), 30m (hilly area/Kathmandu) and 50m (for special case).

-use for rural areas and small town.

- as compare to deep well shallow well have less discharge.

ii. Deep open well

-rest in impervious strata.

-more reliable and pure.

-draw water from below impervious strata.

-quantity is constant.

-use for water ==supply to community.==

-as compare to shallow well have more discharge.

b. Tube well

-it's a long pipe sunk in to the ground intercepting one or more water bearing strata.

-diameter of tube wells is much less than open well.

i. strainer type tube well (mostly used in Nepal, unsuitable for fine sand strata).

ii. cavity type tube well (blind folded pipe is used, water is formed by the critical velocity)

iii. slotted type tube well (shourding= it's the process of filling coarse aggregate/gravel to avoid the entry of sand, clay or other impurities)
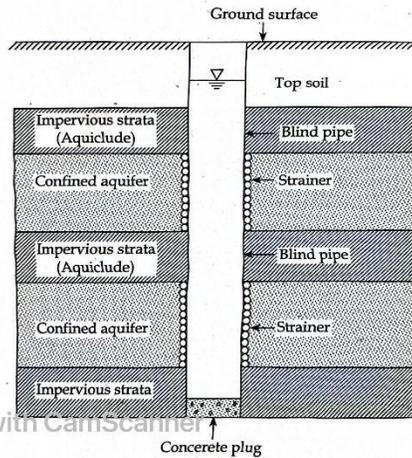
4.3.3 Infiltration Galleries

-it's horizontal tunnel dug to a shallow depth to intercept
 ground water from river, streams and lakes.

-the best location of infiltration galleries is coarse aggregate.

-constructed by cut and cover method.

-wall is made by brick or stone and cover is covered by RCC.

-wall of galleries are provided with opening.
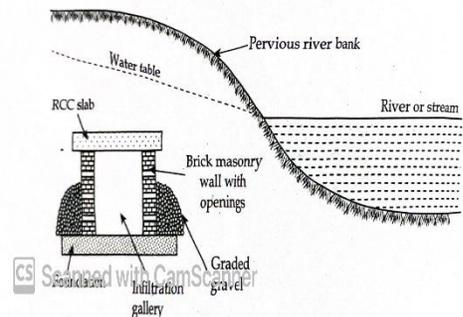
4.3.4 Infiltration well

-infiltration well are the shallow well constructed in series along the bank of river in order to collect the river water seeping through their bottom.

-constructed by brick masonry with open joints or concrete rings.

-all infiltration well water is collect in jack well by porous pipe.
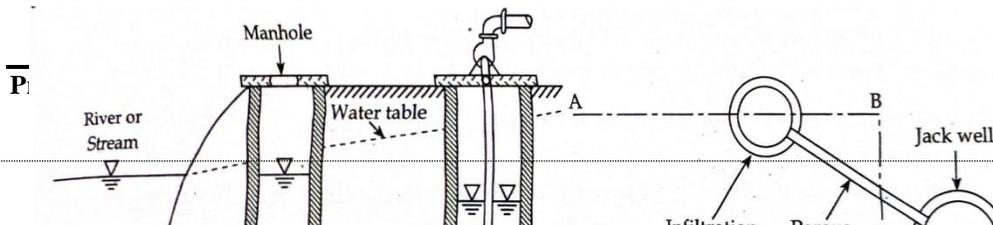
Technical terms

-Aquifer:- it's a geological formation that can store, transmit and yield significant amounts of ground water to wells or springs. More porous and highly permeable.

-Aquitard: moderate porosity and permeability. Silt, sandy clay, poorly consolidated sediments.

-Aquiclude: high porosity but low permeability. Clay,shale, dense

-Aquifuge: very low porosity and impermeable. Dense Igneous and metamorphic rock)

Confined/Unconfined Aquifers
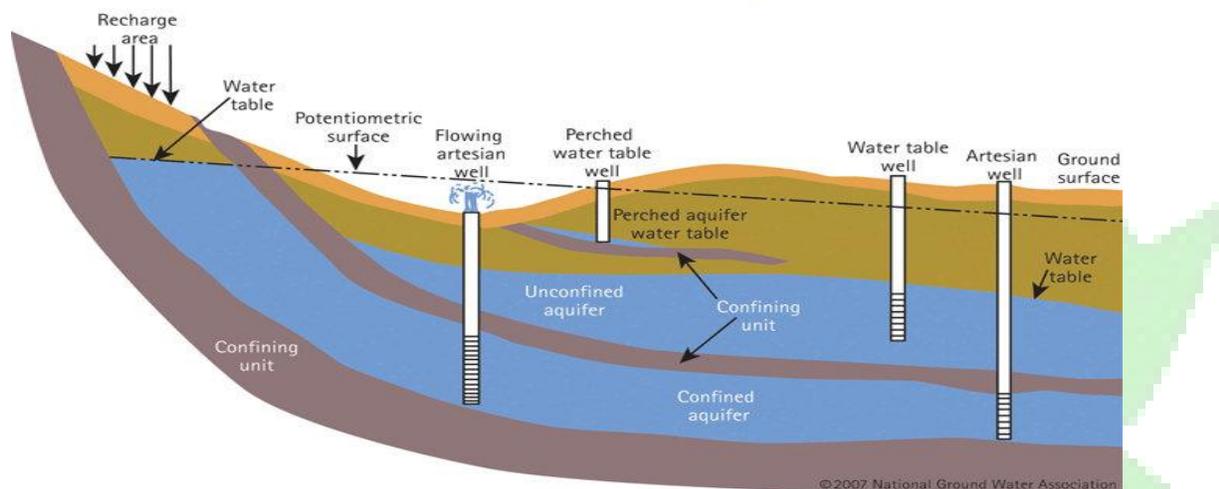
4.4 Selection of water sources

a. Location

- close to community to reduce pipe costs and maintenance cost.

- prefer uphill sources to enable gravity flow and reduce pumping infrastructure.

- source should be consider road access, flood safety and long term stability.

- protected from contamination and support by locals.

- Non-conflict among user.

b. Quantity

-the quantity of water available in source during the driest period should be sufficient to catch the demand of the community.

c. Quality

- the quality of water should be good for drinking.

d. Economy

-the cost of water supply project should be minimum.

-chief treated water source is select.

e. Continuity and reliability

- the source must be selected such that it is able to supply water continuously to the consumer and sources need to be reliable as well.

4.4 Quality of water

- Absolutely pure water is never found in nature.

- Inpure water 2 part of hydrogen and 1 part of oxygen.

- Impurities are:

a. According to it's characteristics

i. physical impurities- Affect the color, odour,, taste and turbidity.

- Example: algae, organic matter, industrial waste, sewage minerals etc.

ii. Chemical impurities- Affect the suspended and dissolved solids, PH, Hardness, chloride, nitrogen, salt etc.

iii. Bacteriological impurities- Affect the pathogenic and non pathogenic micro-organisms present in water.

b. According to it's taste

i. Suspended solids- Clay, algae, fungi, organic and inorganic matter, minerals matter etc**.**

ii. colloidal impurities- Can't remove by filtration.

iii. dissolved impurities- Form of solid , liquid, or gas and may be organic they are invisible.

4.5 Water related disease

a. Water borne diseases
- Caused by drink of infected/contaminated/polluted water.
- Example: diarrhea, typhoid, cholera, hepatitis A, dysentry, parathyphoid etc.

b. Water washed disease
- Caused by insufficient water for hygiene not contaminated drinking water.
- 70% water in our body.
1% reduce- thirsty.
5% reduce- feels fever
10% reduce -weakness
12% reduce- great trouble

c. Water based disease
- Caused by contact with impure water.
- Example : skin related problem

d. Water vector disease
- Through biting of mosquito, blackflies, sandflies.
- Example: malaria, yellow fever, filariasis.

*Gravity water supply system

1. Introduction
- A gravity water supply system is a method of delivering potable/wholesome water using natural gravitational pull instead of mechanical pupm.
- Used: Hilly/rural regions, Traditional systems.
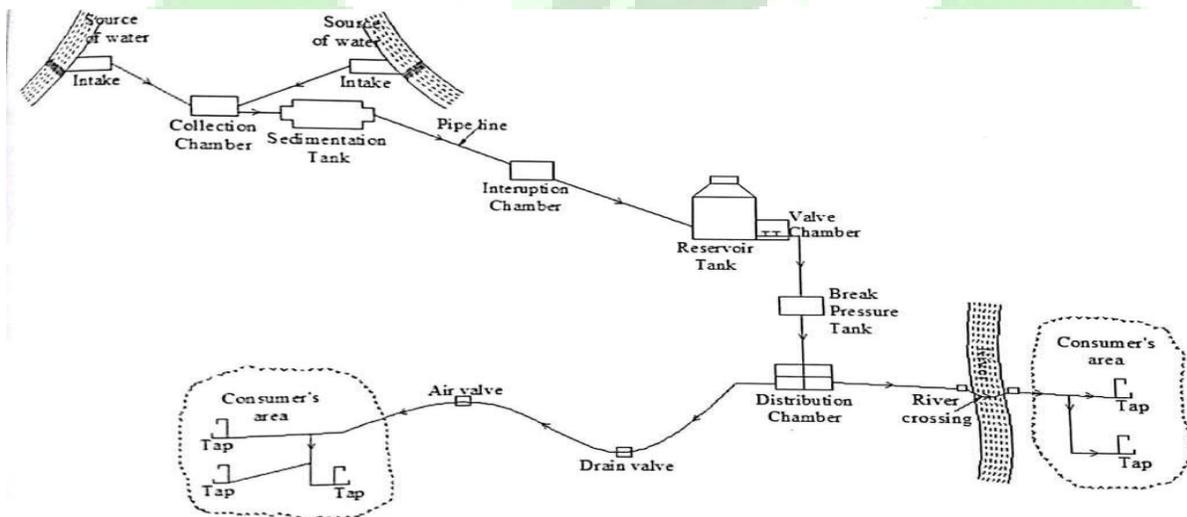
2. Component of gravity water supply system

Fig: Layout of gravity water supply system

a. Elevated source- A water source (spring, stream, river) positioned higher than the community.

b. Intake- Intake structure collect water and then transmit water to transmission line.

c. Collection Chamber- Collect water from two or more than two intakes.

c. Sedimentation tank- Sedimentation tanks near the source allow heavy particles to settle out before further conveyance.

d. Transmission Main- Large-diameter pipeline conveying water from the source to storage.

e. Interruption Chamber/tank - Tanks or chambers that relieve excessive pressure in long downhill pipelines to prevent pipe bursts.

- It's provided in Transmission line when static head exceeds 60 meters.

- Checked valve is not used

f. Storage Reservoir- Storage tanks or reservoirs for balancing daily demand peaks, providing supply when inflow is low.

g. Distribution Network- Secondary pipe network (smaller mains) carrying water from reservoirs to end-use points.

h. Break pressure chamber- Tanks or chambers that relieve excessive pressure in long downhill pipelines to prevent pipe bursts.

- It's provided in distribution line when static head exceeds 60 meters.

- Checked valve is used.

i. Air-Release Valves & Washout Points- Air-valves eliminate trapped air; washout valves enable flushing of sediments.

j. Tap stand - for community water withdrawal; typically one per 100–150 persons.

k. Crossing Structures- Supports, anchors, or bridges to carry pipelines across rivers, gullies, or difficult terrain.

3. Design period and base period

*Survey year= Collect all field data such as population counts, current water demand, source details, site visits, etc

*Base period= Time needed after the Survey Year to finish design, procurement, and construction, typically 2-3 years.

*Base year= The year water starts flowing to consumers.(survey year + base period).

*Design period= 15 years in rural regions, and up to 20 years in urban areas.

* **Design Year (Service Year)**= The point in the future when the system reaches its designed service level.(design year = base year + design period).

3.1 Selection basis of the design period
a. Availability of funds- if limited fund is available then a shorter design period will have to be considered and vice-versa.

b. Availability of water- water should be sufficient available for that design period.

c. Population growth rate-

- It's a major factor.

- If higher the growth rate less design period and vice-versa.

d. Economic development- If economic development is rapid design period considered should be less.

e. Life of pipe and construction material- Design period should not be greater than component useful life.

f. Rate of interest of loan- If more rate of interest lesser will be the design period and vice-versa.

3.2 Population Fore casting
- Also called population projection.

- Practice of estimating future population size, structure, and distribution using current demographic data and assumptions about future trends.

- Population forecasting method are:

a. Graphical Method

- Logistic Curve

b. Numerical Method

i. Arithmetical increase method

- Suitable: Old city, large city, developed city

ii. Geometrical increase method

- Mostly used in Nepal (urban).

- Mostly suitable for haphazardly growing cities.

- $Pn = Po\left(1 + \frac{r}{100}\right)$

Where Pn = Population at the nth decade

      p = Population at the base year (forecasted population)

      r = Rate of population growth

iii. Incremental increase method

- This method is the improvement of above two method.

- Suitable for rate of population growth shows upward trend.

      $P_n = P_O + Ni + n(n+1)$

iv. Decreasing rate of growth

- Also called changing rate of increasing method.

- Suitable for rate of population growth shows downward trend.

3.3 Advantage of gravity water supply system
- No external energy consumption

- Low operational cost

- Environmentally friendly

- Reliable

3.4 Disadvantages & Design Challenges

- Elevation dependence,
- Pressure management needed,
- Potential pressure variability,
- Increased leakage risk.

4. Determination of daily water demand

4.1 Water demand

- Quantity of water required for different purpose such as domestic, livestock, commercial, industrial, public/municipal, fire fighting, loss and waste.
- Unit of water demand is liter per capita day (LPCD).

4.2 Types of water demand

a. Domestic demand

b. Livestock demand

c. Commercial demand

d. Public/municipal demand

e. Industrial demand

f. Fire fighting demand

g. Loss and waste

a. Domestic demand

- Quantity of water required for domestic purpose such as cocking, drinking, bathing, washing etc.
- Fully plumbed house = 112 LPCD
- Partially plumbed house = 65 LPCD
- Public stand post = 45 LPCD

b. Livestock demand

- Quantity of water required for animals and birds.
- For big animals (cow, buffalo, horse) = 45 liter/animal/day.
- For Medium animals (pig, sheep, goat etc) = 20 liter/animal/day.
- For birds (chicken, duck) = 20 liter/100 birds/day.
- Livestock demand should not be more than 20% of domestic demand.

c. Commercial demand

- Quantity of water required for commercial and institutional purpose such as hospital, school, hotel.
- Educational institute = 65 liters/capita/day (boarders).

  = 10 liters/capita/day (day schooler).
- Hotel with bed = 200 liters/bed/day.
- Hospital with bed = 500 liter/bed/day.
- Hotel without bed/restaurant/tea stalls/office = 500-1000 liter/hotel/day.
- Hospital without bed (clinic) = 500 liter/hospital/day.

d. Public/Municipal Demand
- Quantity of water required for washing and sprinkling on road, cleaning of sewers, watering public parks, garden etc.
- (5-10)% of total consumption.

e. Industrial demand
- Quantity of water required for industry.
- (20-25)% of total consumption.

f. Fire fighting demand
- Quantity of water is required for fire fighting purpose.
- Quantity of fire demand should not be more than 1 LPCD.
- Indian water supply manual and treatment formula, Q=$100\sqrt{P}$($P = Population\ in\ 1\ lakh, P = 100$)
Q = Quantity of water
- Buston's formula Q = 5663*$\sqrt{P}$ (where Q=Quantity of water required to meet fire demand in liters/min. and P=Population in thousands).
- Kuichling's formula Q = 3182*$\sqrt{P}$(where Q=Quantity of water required to meet fire demand in liters/min. and P=Population in thousands).

g. Loss and wastage
- This demand is considered for defective pipe joints, cracked and broken pipes, faulty valves and fittings.
- Consumers keep open their taps or public taps even when they are not using the water and allow continuous wastage of water.
- loss hardly exceed 15%.
(Total water demand = DD+LD+CD+PD+ID+FD+LW)

4.3 Variation of water demand
a. Seasonal/Monthly variation
- Demand varies from season to season.
- Water demand is more in summer than in winter.
- Peak seasonal factor =1.4 (Indian Standard)
- Peak seasonal factor = 1 (Nepal standard)
- factor = Maximum seasonal demand/average seasonal demand.

b. Daily variation
- Demand varies from day to day.
- Water demand is more in Saturday(holiday) and festivals.
- Peak daily factor = 1.8 (Indian standard)
- Peak daily factor = 1 (Nepal standard)
- factor = Maximum daily demand * average daily demand

c. Hourly variation
- Demand varies form hour to hour in a single day.
- Maximum water demand = 5-7 Pm.
- Peak hourly factor = 1.5 (Indian standard)
- peak hourly factor = 2-4 (Nepal standard)
- factor = Maximum Hourly demand * average hourly demand

(***Peak factor-** It's the ratio of maximum or peak demand of water to that of average annual demand of water.

design demand = Peak factor * average demand

Peak factor = seasonal peak factor * daily peak factor * Hourly peak factor.

-The peak factors is adopted 2 to 4 for continuous system and 4 to 6 for intermediate system.

- Maximum peak factor 2.5 in Nepal.

4.3 Factor affecting the water demand

a. Size of community- Water demand is more for highly populated area.

b. Living standard of people- Higher income areas exhibit greater per capita demand.

c. Climatic conditions- Water demand is more in Hotter and dryer climates.

d. Quality of water- Safe to use, Water is supplied demand increase.

e. Metering and cost- Minimum wastage so water demand decrease.

f. Sewerage system- flush toilets, sewer networks, and sanitation infrastructure demand increase.

g. Pressure in the distribution system

5. Determination of storage tank capacity

- Fluctuation of water from sources.

- Methods:- i. Analytical method

               ii. Mass curve method

i. Analytical Method:

- Simple Method

- No graph use

In this method, both demand and supply are analyzed. The process is as follows:

i) The total water inflow is determined by subtracting losses such as evaporation, downstream regulation, etc., from the rainfall and other inflows.

ii) The adjusted or actual inflow for each month is subtracted from the required water demand for that month.

   ► This gives the monthly deficiency (shortage) or surplus.

iii) If the demand is less than the supply, the surplus water is stored.

iv) If there is a deficiency for two or more successive months, the storage capacity of the reservoir is determined accordingly.

Example

Water demand = 4.4 Mm3/ month

Month	Inflow	Demand	Cumulative Inflow	Cumulative Demand	Cumulative Surplus	Cumulative Deficit
	Mm^3	Mm^3	Mm^3	Mm^3	Mm^3	Mm^3
January	1.5	4.4	1.5	4.4		2.9
February	2.0	4.4	3.5	8.8		5.3
March	2.5	4.4	6.0	13.2		7.2
April	5.0	4.4	11.0	17.6		6.6
May	6.0	4.4	17.0	22.0		5.0
June	8.2	4.4	25.2	26.4		1.2
July	9.0	4.4	34.2	30.8	3.4	
August	7.5	4.4	41.7	35.2	6.5	
September	5.0	4.4	46.7	39.6	7.1	
October	3.5	4.4	50.2	44.0	6.2	
November	3.1	4.4	53.3	48.4	4.9	
December	2.0	4.4	55.3	52.8	2.5	
Total	55.3	52.8				

Capacity of storage tank

= Maximum cumulative surplus + maximum cumulative deficit - total inflow + total demand

ii. Mass Curve Method:

This method is more commonly used for determining reservoir capacity.

- In this method, a flow hydrograph for multiple Month is taken.

- From this, a mass curve is prepared showing the cumulative volume of water.

- If the demand rate is constant, the demand line will be a straight line.

- The maximum vertical distance between the demand line and the mass curve gives the required capacity of the reservoir.

Example

Month	Inflow	Demand	Cumulative Inflow	Cumulative Demand	Cumulative Surplus	Cumulative Deficit
	Mm^3	Mm^3	Mm^3	Mm^3	Mm^3	Mm^3
January	1.5	4.4	1.5	4.4		2.9
February	2.0	4.4	3.5	8.8		5.3
March	2.5	4.4	6.0	13.2		7.2
April	5.0	4.4	11.0	17.6		6.6
May	6.0	4.4	17.0	22.0		5.0
June	8.2	4.4	25.2	26.4		1.2
July	9.0	4.4	34.2	30.8	3.4	
August	7.5	4.4	41.7	35.2	6.5	
September	5.0	4.4	46.7	39.6	7.1	
October	3.5	4.4	50.2	44.0	6.2	
November	3.1	4.4	53.3	48.4	4.9	
December	2.0	4.4	55.3	52.8	2.5	
Total	55.3	52.8				

*Selection of pipe

A **pipe** is a hollow cylindrical component

-typically of circular cross-section

-used primarily to **transport fluids** (liquids, gases, slurries)

1. Requirement of good pipe materials *(DR. SWEC SIR)*

a.Durability

- Pipe material should be durable.

- Pipe material should be more than design period of water supply system.

b. Resistance or abrasion

- Pipe material should possess enough resistance to abrasion.

c. Structural strength

- Pipe material should be strong enough to bear both internal and external pressure.

d. Weight

- it should be minimun so it can be easily handled and transport.

e. Easy to join

- it's easy to join the different pipe and fittings and joints are absolutely watertight.

f. Cost

- the cost of pipe including handling, transportation and installation is less.

g. Smoothness

- pipe material should be smooth so minimum head loss occurs.

h. Imperviousness

- Pipe material should be impervious.

-prevent from wastewater and ground water.

i. Resistance to corrosion

- Pipe material capable of offering resistance to corrosion.

2. Types of pipe material

Common types materials are:

A. Metallic pipe *(S DC GC)*

i. Steel pipes
- **Use**: High-pressure systems, fire fighting
- **Types**: Mild steel (MS), stainless steel (SS)
- **Features**: Strong, but corrosion-prone if uncoated
- **Joint:** Welding and knot-bolt joint.

ii. DI (Ductile) Pipes
- **Use** : Distribution line,
- **Features**: Much stronger, more flexible, corrosion resistance,long life service
- **Life:** 100 years.

iii. Cast Iron (CI) Pipes
- **Use**: Water supply, sewage
- **Features**: Durable, corrosion-resistant (with coating), heavy
- **Life**: 50–100 years
- **Joint:** Flanged joint, threaded, spigot and socket

    iv.   **Galvanized Iron (GI) Pipes**
- **Use**: Domestic water supply
- **Features**: Coated with zinc, prone to corrosion over time and length 6m.
- **Life**: 20 years.
- **Joints:** Socket joint and screw joint are used.

    v.   **Copper Pipes**
- **Use**: Hot and cold water systems
- **Features**: Corrosion-resistant, expensive
- **Joint:** Collar joint

B. **Non-Metallic Pipes** *(HA PCL uP GC)*

i.   **HDPE (High-Density Polyethylene) Pipes**
- **Use**: Water supply, gas pipelines, irrigation
- **Features**: Flexible, durable, corrosion-resistant
- it can found in full roll.
- Length of one roll = 50,100,300 m.
- Joint: Butt

Colour	Working pressure kg/cm2
Red	2.5
Blue	4
Green	6
Yellow	10
White	2

ii.   **Asbestos Cement (AC) Pipes**
- **Use**: Water supply (old systems)
- **Features**: Lightweight but brittle, health hazards
- **Joint:** Ring the coupling

iii.   **PVC (Polyvinyl Chloride) Pipes**
- **Use**: Cold water supply, drainage, irrigation
- **Features**: Light, cheap, easy to install, not suitable for hot water
- **Life:** 100 years.
- **Joint:** - Solvent joint

iv.   **uPVC (Unplasticized PVC) Pipes**
- **Use**: Potable water supply
- **Features**: Stronger than PVC, long-lasting

v.   **Polypropylene random copolymer plastic** (**PPR) Pipes**
- **Use**: Hot and cold water supply, industrial liquid transfer and Plumbing in residential and commercial buildings
- **Features**: High resistance to heat and pressure, Corrosion-free and scale-free, Easy installation (using heat fusion)
- **life:** 50+ years

vi. **Concrete Pipes**
- **Use**: Sewer, stormwater drains
- **Types**: Plain, reinforced (RCC)
- **Features**: Strong, heavy, used in large-diameter applications, Use ratio 1:2:2(C:S:A).
- **Life :** 75 years
- **Joint:** Collar

3. Distribution system

A. System of supply
Treated water may be supplied to the public by the following two systems:
a. **Continuous system of supply-** Water is supplied to the public for all 24 hours of day.
b. **Intermittent system of supply-** Water is supplied to the consumers for the period of fixed hours of the day only.

B.Layout of distribution system
a. Dead-end or tree system:
- Used for hapazardly cities like Kathmandu.
- Calculation of discharge is wasy.
- Difficulty in repair.
b. Grid-iron system or reticulation/interlaced system
-Used for rectangular palnned cities.
- Calculation of discharge is difficult.
- Easy to repairs
c. Circular or Ring system
- Used for any well planned city road.
- Sub mains take off from the main pipe lines and run on the interior of the area.
d. Radial System
- Used for radially planned roads.
- Main lines is lifted into the distribution reservoir.

4. Valves
a. Gate/Sluice/Cut off valve
- Cheaper and offer less resistance to flow.
- Provided in 150 to 300 m interval in straight portion.
- These vlave are operated by rotating the spindle in clockwise and anticlockwise direction.

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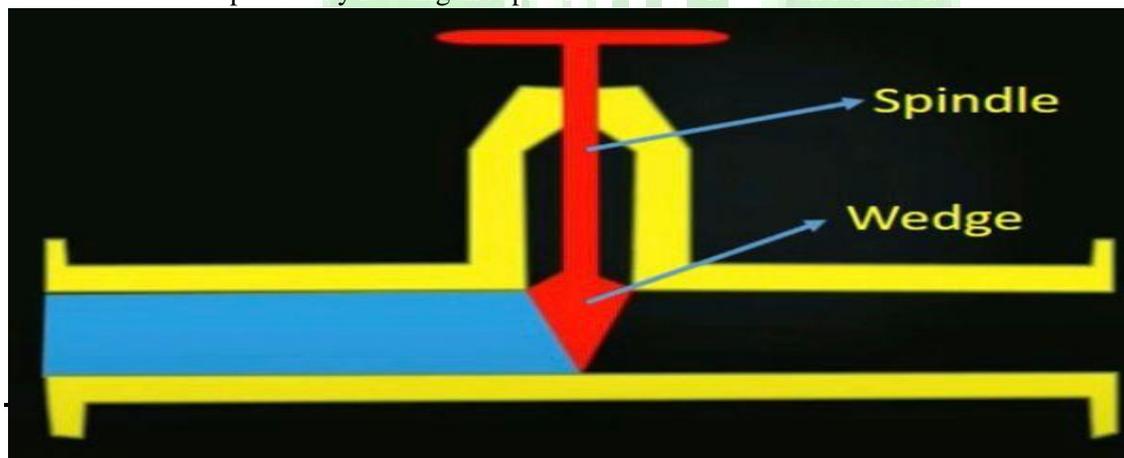
b.Reflux or check or Non-Return valve

- To maintain a flow in only one direction, this valve is used.

- Normally, It's placed after pump component.
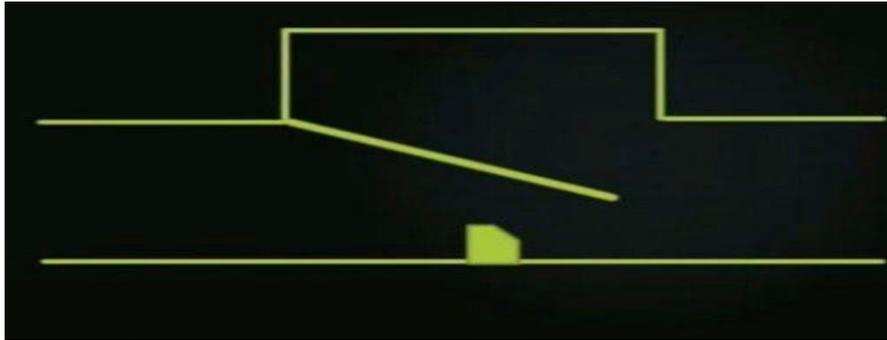
c. **Safety or pressure valve**

- Provided to release from pipeline to prevent from burshing.

- Consists of disc controlled by spring.

- When pressure exceeds, Disc is forced off and excessive pressure is released, after this disc comes down automatically down due to force of spring.
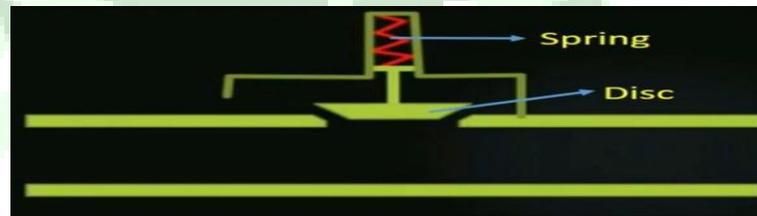
d.Air Relief valve

- When water enters in pipe, air comes with it, due to which blockage of flow occurs at summit points.
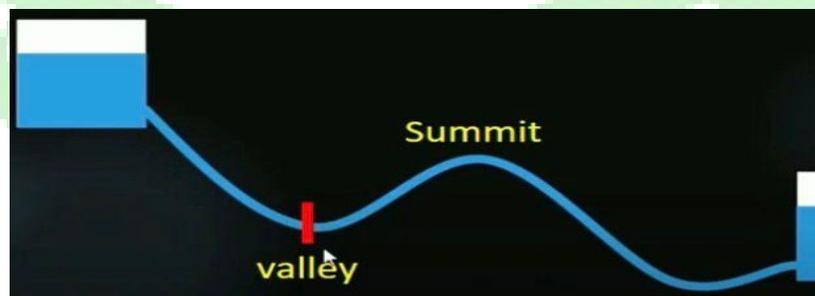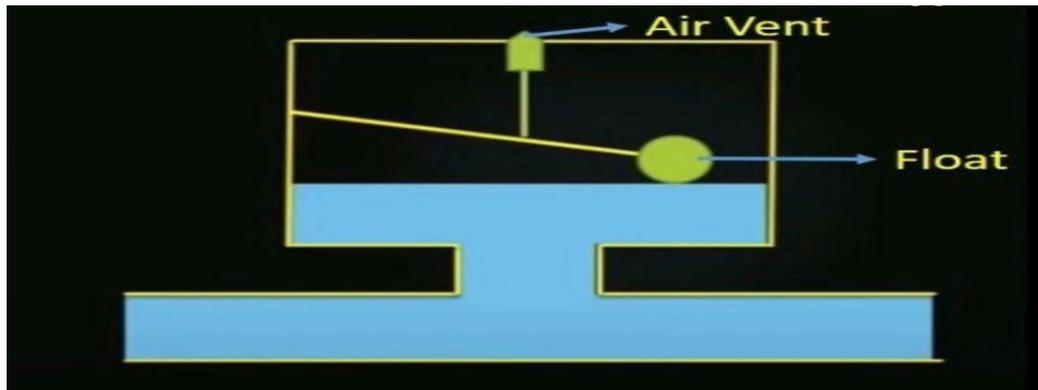
e. Drain or scour or blow off valve

- Water may carry sand and silt which may be deposited in the pipeline (Generally in case of intermittent system of supply).

5. Fittings

- Flow direction = Elbow, Bend, Miter

- Branching = Tee, Cross, Wye

- Size changing = Reducer, Bushing, Reducing Elbow/Tee

- Joining straight = Coupling, Union, Nipple

- Feedback/termination = Cap, Plug, Blind flange

- Specialized = Adapters, Olets, Barb, Mechanical Sleeves

6. Design of pipe

6.1 Pipe Hydraulics

- The size of pipe may be determined by using two basic equations namely continuity equation and bernoulli's equation:

a. Continuity Equation

$Q = A*V = (\pi d^2/ 4)*V$

$A_1 V_1 = A_2 V_2$

Where, Q = Discharge through pipe(M3/Sec)

A= cross sectional area of the pipe

d= Diameter of the pipe

V= Mean velocity in pipe (m/s)

b.Bernoullis Equation

$p_1/Y + v_1^2/2g + Z_1 = p_2/Y + v_2^2/2g + Z_2 + h_f$

where P pressure at consider section

v= velocity of water in the section

z elevation of consider section from references datum

hf= head loss through the pipe length

1,2 = section of the pipe

- The loss of head due to friction can be determined by the following formula

a. Darcy's weisbach formula

$H_f = flv^2/2gd$

Where, v=velocity of flow in m/s

f =friction factor

l =length of pipe

h_f =head loss in meter

d =Diameter of pipe in meter

b. Manning's formula

$h_f = (10.294n^2 l Q^2)/d^{16/3}$

Where, n=Manning's rugosity coefficient

l = length of pipe

d = diameter of pipe

c.Hazen Williams formula

$h_f=\{(10.68l)/d^{4.87}\}\{Q/C\}^{1.852}$

Where,

C =Roughness coefficient

Q=Discharge

h_f =head loss in meter

d =Diameter of pipe in meter

6.2 Design criteria

a. Velocity

- Neither too low nor to high.

-Too low velocity causes settlement of sediment resulting obstruction to flow.

- Too high velocity causes abrasion of suspended particle with interior surface of pipe.

- Minimum velocity = 0.3 m/s

- maximum velocity = 3m/s

 b. **Pressure**

- Too Low pressure will result low flow or water will not rise up to desired height in consumers building.

- Higher pressure may result in bursting of pipes.

- For a system with private connection, Minimum pressures = 15 m

- For a system without private connection, Minimum pressures = 5 m

- At public stand post, desirable pressure = 15m

- At public stand post, absolute minimum pressure = 5m.

- At public stand post, Maximum pressure = 55m

c. Pipe size

- The pipe size available commercially in the market should be recommended.

- Available pipe size are given below:-

15,20,25,100,120,150,500,600,1000 etc.

7. Hydraulic Gradient line and Total Energy line

a. Energy of flow water

- Pressure head = $P/\rho g$ = p/r r= unit weight of water

- velocity head = v2/2g

- Elevation head= z

- Piezometric head = z+ $P/\rho g$

HGL

-It's a line connecting plezometric heads at different sections.

- In case of pipe flow the HGL doesn't coincide with free- surface of water.

TEL

- It's the line connecting total energy of flowing water at different sections.

- Discharge(Q) = A*V

- Velocity of flowing water is more in section with less cross-sectional area.

- If cross- section of pipe is constant, HGL and TEL are parallel with each other.
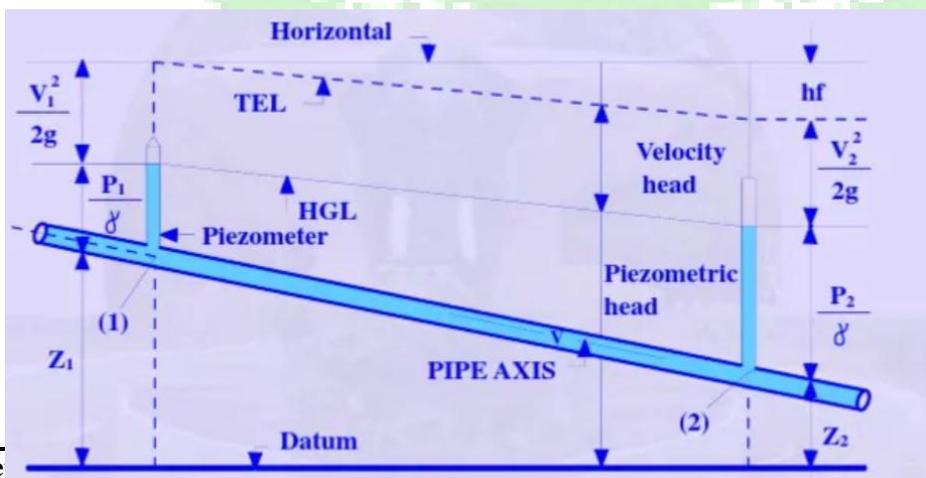
Sanitary Engineering

The branch of engineering focused on designing and managing systems for wastewater and solid waste disposal to protect public health.

1.Design of sewer
The design of a sewer system involves selecting a suitable system, calculating sewage flow, determining pipe size and slope, and ensuring proper flow velocity to prevent sediment builup.
*Technical Terms Used in Sanitary Engineering
a. Wastewater: Water that has been used in homes, industries, or businesses and contains contaminants.
b. Sewage: Wastewater from a community, often categorized as domestic or industrial sewage.
c. Domestic sewage: Wastewater generated from residential buildings.
d. Industrial sewage: Wastewater from industrial process.
e. Rubbish: Dry, combustible waste like paper and broken furniture.
f. Refuse: All rejected solid, semi-solid, and liquid waste.
g. Garbage: Decomposable organic waste like food scraps.
h. Sullage: Wastewater from bathrooms and kitchens, excluding human excreta.
i. Storm Water: Rainwater runoff that enters sewer systems.
j. Sewer: Underground pipes or conduits that carry wastewater.
k. Sewerage: The entire system of sewers for collecting and transporting wastewater.
l. Infiltration: The entry of groundwater into sewers through cracks or leaks.
m. Sanitation: The promotion of health through the prevention of human contact with environmental hazards, including waste management and water quality.
n. Excreta: Fecal, urine, sweet.
o. Night soil: Human excreta.
p. Boning rod: Transfer the center line of pipe from ground level to trench is called boning rod.
r. Effluent: Any liquid waste discharged from a facility or system.
s. Sludge: Semi solid or slurry byproduct formed during the treatment of water, wastewater or from other industrial processes.

1.1 Types of sewage
- Sewage are two types:
a. Storm sewage
b. Sanitary sewage
i. Domestic sewage
ii. Industrial sewage

1.2 Sanitation system
a. Dry/Conservancy System *(Traditional system)*
b. Water carriage system *(99.9% water and 0.1% solid).*

1.3 Source of sanitary sewage
a. Domestic sewage:

Wastewater generated from residential building, individual houses, from commercial, institutional and similar public buildings.

- Houses, Hotels, cinemas, offices and schools etc.

b. Industrial sewage:

Wastewater from industrial process.

c.Infiltration and inflow

Ground water infiltrating into sewer through the pipe joints and entry point,

- 2 to 5 % of DWS shall be considered as for the infiltration in the sewer network.

1.4 Colour of sewage

- Fresh/domestic sewage = light grey and greyish brown. (Recent discharge, oxygen still present)

- Stale/ septic = Dark grey, brown and black.(Anaerobic decomposition and H2S/metal sulfides.

- **Industrial mixture** = Green grey, red etc.(Chemicals dyes, heavy metals from industry)

- **Surface runoff inflows** = Reddish, soil like.(clay/silt from stormwater or infiltration)

1.5 Size of sewer

- Minimum Diameter of sewer pipe = 15cm

- Maximum diameter of sewer pipe is = 3m

- Minimum diameter of sewer pipe in house/ hilly area = 10cm=100mm.

1.6 Types of sewer pipe

According to shape

a.Circular sewer

- Mostly used pipe.

- Minimizing sedimentation.

- Economical and easy to manufacture.

b. Non- circular sewer

i. Rectangular sewer:

- Easy to build and maintain.

- Less hydraulically efficient.

ii. Egg Shape sewer

- Maximum value of R isegg shape.

- Maximum discgarge.

- Less stable.

According to materials *(PVC BC)*

a.Concrete pipe

i. PCC (Plain cement concrete)

ii.RCC (Reinforced cement concrete)

- Maximum Diameter of sewer pipe 60m.

- pressure = 15 m of water head

- Mostly used pipes in sewer.

- Economical.

b. Stone ware/ vetrified clay

- Set at a high temperature.

- Surface is smooth.

- Brittle and less resistance in tension.

- Clay (soil) + shale of special quality.

c. Cast iron (CI Pipe)

- Suitable in landslide prone area, high internal and external pressure more variation.

d. Plastic pipe

- PVC and UPVC (Minimum Diameter at house sewer).

1.7 Sewer gradient

- Minimum sewer gradient = 1:100

- Maximum sewer gradient = 1:20

Types of sewer	Maximum velocity m/sec
Earthen sewer	0.6 - 1.2
Brick sewer	1.5-2.5
Concrete sewer	2.5-3.5
Stone ware sewer	3-4.5
CI sewer	3.5-4.5
Glazed brick sewer	5

2. Types of sewerage system

a. Separate system

Two distinct networks—one for sanitary (domestic/industrial) wastewater and another for stormwater runoff.

- Reduces load on treatment plants

- minimizes pollution of natural waterways.

- Higher construction and maintenance cost.

- Suitable heavy rainfall in short duration.

b. Combined system

A single sewer system carries both sewage and stormwater together.

- Simplified infrastructure, larger pipes that self-clean.

- cost-effective in areas with limited space.

- Risk of overflow during heavy rain.

- Suitable average rainfall in long duration.

c. Partially system

- Rain water coming from roof, pavement, yard and sanitary sewage carries both in single sewer pipe.

- Balances costs and capacity.

- utilizes stormwater for sewer self-cleansing.

- Stormwater still adds treatment load

3. Quantity of s anitary sewage

Generally, the quantity of sewage should be equal to the quantity of water supplied.

- Some addition and substraction are done to determine approximetly correct quantity of sewage.

- Average quantity of sanitary sewage (DWF) = 70-90% of population * Rate of water supply

- Maximum Quantity of sanitary sewage = Peak factor * average flow.

- The peak factor of 2 to 4 is generally adopted.

- Minimum flow = 1/3 of average flow

- The minimum rate of sewage flow of domestic or sanitary sewage may vary half to 1/3 of average rate of sanitary sewage.

3.1 Determination of quantity of sanitary sewage/(DWF)

- Average quantity of sanitary sewage (DWF) = Water supply * Rate of return factor * population.

Where, Rate of return factor = (70-90)%

-Maximum or peak quantity of sanitary sewage= peak factor * average quantity.

- Peak factor= (2to 4) in Nepal

- Minimum flood = (1/2 to 1/3) of average quantity.

3.2 Quantity of storm sewage (WWF)

The quantity of storm water is estimated from the following two methods:

a.Rational method

b.Empirical formula

Empirical formula methods are commonly used to estimate stormwater runoff in large drainage areas (typically > 500 ha), where the Rational Method becomes less accurate.

a.Rational method

Q = (CiA)/360

Where, Q = Storm water flow or runoff (WWF).

C = Runoff coefficient or impermeability factor.

I = Intensity of rainfall in mm/hour.

A = Area of catchment in hector (q Ha = 10^4 m2).

4. Maximum, minimum and self-cleaning velocity

- Sewer have to be design to ensure neither silting nor scouring velocity.

- The velocity remains between the minimum self-cleansing velocity and maximum velocity.

a. Self-Cleansing Velocity

In order to keep the solid material in suspension a certain minimum velocity of flow is required such a minimum velocity is called self-cleansing velocity.

-Self-cleansing velocity for different size:-

Diameter(cm)	Self-Cleansing Velocity (m/s)
15-25	1
30-60	0.75
>60	0.6

-Self Cleansing velocity (minimum velocity) (0.6-0.9) for separate system.

- The self-cleansing velocity of flow in sewer can be determined using shield's formula is given by the following expression:

$$V_1 = \sqrt{\left(\frac{8\beta}{f}\right)(s-1)gd}$$

Where,

$\beta = a\ dimesionless\ constant\ which\ represents\ the\ charactestics\ of\ the\ sediments.$

F= Darcy-weisbatch friction factor which may be taken as 0.03.

S= specific gravity of sediments

G = acceleration due to gravity

d = diameter of the solid particles

For a combined system minimum velocity is irrespective of diameter of pipe. Self-cleansing velocity is 0.75m/s for all diameter in combined system.

c. Maximum velocity

The upper limit velocity of flow so that interior surface of the sewer should not damage by wear.

-the maximum velocity in the sewer line at which no scouring action or abrasion takes place is called non-scouring velocity.

-for general limiting velocity is considered as 3m/sec and not less than 0.6 m/sec.

5. Different between Self-cleansing velocity and non-scouring velocity

Self-cleansing velocity	Non-scouring velocity
Prevents solid deposition & blockages	Prevents pipe surface erosion

Maintaining smooth flow	Cleaning pipe surface from settled particles
Typical value 0.6m/s to 1 m/s	Typical value 1.2m/s to 2 m/s
To maintain a clean pipe and prevent clogging	To remove debris and sediment already present.
Prevents buildup solids	Dislodges and carries away accumulated solids

7. Excreta disposal and unsewered area

A. Pit latrine

It's most suitable for rural areas where least development.

-It's constructing manually dug or bored vertically hole in to the ground or shallow pit.

-Daimeter (90-120) cm for circular and Length, breadth (1*1) m plan for rectangular.

-Depth 1 to 2 meter.

- Dry sanitation system.

- Requires less water.

- Technology is simple and under stanable.

- Permeable soil is required for drainage.

- Required regular emptying.

- Control smells and flies.

- Construction cost is low.

B. VIP latrine (ventilated improved pit)

- Improvement over pit latrine by adding ventilation pipe and superstructure slightly offset.

- Construction:-

Diameter = 1.2m

depth = 1.5 m

vent pipe diameter = 90mm

Layers of filling soil = 50-75mm

- after 2 years can be used.

- In case of school.

1 pit for 100 students first.

after that 1 pit for 50 students.

- Volumn (v) = NRT

where, N = number of the user

R = digested sludge accumulation rate (0.04 to 0.05 m3/person/year)

T = design period (2 years)

- Height of ventilation pipe 2m.

c. Pour flush latrine

-it can be made inside building

- the excreta is cleaned by pouring 1.5-2 liter of water.

-Minimum diameter of pipe is 100 mm/10 cm.

-No. vent pipe.

- Slop requirements:

Squatting pan → manhole: slope between 1:5 and 1:15.
Manhole → pit: slope between 1:5 and 1:15.
- Clear size of collection chamber is 300mm*300mm.
- Pit can be reused after 3 years.
- Capacity of cistron = 10-14 liters.

D. Septic tank

Septic tank is underground tank in which sewage is collected and allowed to decompose through bacterial activity before draining by means of soak way.

- Sedimentation+ digestion tank.
- shape = rectangular
- water tight

Design criteria

minimum width = (0.75-4)m

Length/width = (2-4)m

Minimum effective depth = 1m

Detention time = 1-3 days (22-24 hrs) for minute (30 minute)

free board = 30-45cm.

wall thickness if brick > 20cm.

wall thickness if stone > 38cm.

Plaster thickness > 12 mm = 1:3 mortar.

- inlet and outlet pipe are provided with 'T' joint.

Downward flow

- Diameter of vent pipe = 75mm to 100mm.
- Height of vent [i[e = 2m.
- Slope = 1:30.
- Anaerobic reaction.
- Desludging period = 6 months to 3 years.

E. Soak Pit

- Disposal of effluent by soaking in surrounding soil.
- shape circular.
- distance between bottom of soak pit and water table = 2m.
- Construction :-

Minimum diameter = 90cm

Maximum diameter = 3.5 m (3m)

Depth depends on ground water table

Minimum effective depth = 1m = 100cm.

Space between soak pit = 3 times large diameter of pit.

F. Manhole

Purpose: for inspection testing, cleaning, repair and maintenance of sewer etc.

Location: Every change in alignment, Bends, junction, change in gradient, size and direction.

Interval 50-150m (depending open the size of the sewer.

Classification of manhole

Shallow manhole: depth 0.75-0.9 m

Medium manhole: depth 0.9-1.5m

Deep manhole: depth >1.5.

Note: Minimum diameter of manhole=45cm - 60 cm or 450mm - 600mm.(50cm)

G. Drop manhole

Purpose: to avoid splashing of sewage on the man working in manhole, smooth fall and not scouring.

Height difference= 0.5 to 0.6 m.

H. Lamphole

Only inspection/detection by inserting lamp.

Size = Nearly 20-30cm.

I. Street inlet

to intercept and collect surface runoff, such as rainwater, and direct it into a storm drainage system to prevent flooding and erosion.

- Spacing 100-130m.

- Stoneware pipes 25-30cm diameter used for convey storm water into sewer.

Note: house- lateral-sub-main-thrunk-outfall.

*Ferro cement tank

The tank which is formed by plastering inner as well as outer surface on chicken wire mesh supported through 8 mm steel rod, is known as ferro cement tank.

- Used in gravity water supply system (in hilly area).

Construction :-

Vertical rod -8mm

Form work   -25mm or 32mm Diameter HDPE pipe

Cement sand ratio - 1:2 (first external than internal)

Curing - minimum 7 days

Thickness of wall- 5cm(2")

Location - underground/semi UG/over ground

Capacity - >1000 liters.

- Storage capacity = 25m3.

*Operation and maintenance of water supply

Types

a) Regular

b)Emergencies

c)preventive

*Water treatment

A) Screening:

Bar are provided at 30-45° angle.

Bar screening

Coarse screening - bar dia.= 25mm

Fine screening- dia. less than 6 mm.

Spacing = 75-100mm

b) Aeration:

- Contact with air

- Remove odour, taste, dissolved gas.

c) Sedimentation:

i) Plain sedimentation: Remove suspended solid.

ii) Sedimentation with coagulation: Remove colloidal solid

Main Principle: Reduce velocity by increasing length.

d) Filtration:

Remove microorganism, fine suspended particle colloidal particle.

i) Slow sand filter: Slow filter

ii) Rapid sand filter: Fast filter, Use in melamchi water supply project.

iii) Pressure filter: Suitable for small quantity.

e) Disinfection

to remove pathogenic bacteria.

Chemical: Chlorine, Bromin, Iodine.

Other method: Boiling /SODIS.

F) Water softening Remove hardness of water.

1. Which department in Nepal is responsible for planning, implementing, and maintaining water supply and sanitation systems?
   a. Department of Roads
   b. Department of Irrigation
   c. Department of Water Supply & Sewerage Management (DoWSSM)
   d. Ministry of Physical Infrastructure

2. What is the primary objective of a water supply system?
   a. Wastewater treatment
   b. Rainwater harvesting
   c. Supplying safe & adequate water
   d. Building dams

3. Which is NOT a specific objective of a water supply system?
   a. Supply water for firefighting
   b. Prevent epidemic spread
   c. Promote industrial growth
   d. Irrigation of crops

4. Which is considered a negative impact of water supply systems?
   a. Improved public health   b. Saves time
   c. Reduced downstream flow d. Boosts hygiene

5. The most important source of water for public water supply is
   a. Lake   b. River
   c. Pond   d. Sea

6. The water of a river has an important property called
   a. Turbidity
   b. Self-purification
   c. Permeability
   d. Infiltration capacity

7. Water supply system includes
   a. Digging a well for water
   b. Construction of dams
   c. Construction of canals
   d. Entire arrangement from source to distribution

8. Surface water is obtained from
   a. Spring
   b. Well
   c. Rain
   d. Artesian well

9. Water having PH value as 6, is
   a. Alkaline   b. Acidic
   c. Neutral   d. None

10. Safe water supply coverage of Nepal is
    a. 80%
    b. 85%
    c. 87%
    d. 90%

11. Responsible authority for operation and maintenance of community water supply system is
    a. DWSS
    b. MOWSS
    c. User committee
    d. Government

12. While selecting water sources, it should be considered that,
    a. Quantity of water in source is sufficient to meet consumer's demand.

b. Quality of water is good
c. Water sources should be at higher elevation as possible
d. All of the above

13. Demand of water depends upon
    a. Temperature and rainfall
    b. Economic standard of people
    c. Water quality and price
    d. All of the above

14. Explaining potable water means it is:
    a. Free from minerals
    b. Safe to drink
    c. Completely pure
    d. Salty

15. Which factor is considered when selecting a water source?
    a. Quantity available
    b. Elevation of source
    c. Distance (source to distribution)
    d. All of the above

16. Why is rainwater considered "soft water"?
    a. It contains dissolved calcium and magnesium from the atmosphere.
    b. It has low levels of calcium and magnesium ions, making it naturally soft.
    c. It undergoes ion-exchange in the clouds, replacing hardness ions with sodium.
    d. It's treated with sodium salts before falling to earth.

17. what are the factor affecting selection of water sources.Explain in brief.

18. What do you mean by wholesome and portable water? Write dowm the objectives of water supply system.

19. write down the surface source of water and explain brief.

Answer Sheet

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
c	c	d	c	b	b	d	c	b	c	c	d	d	b	d	b

1. The continuous flow of water may be expected from
   a. Surface spring   b. artesian spring
   c. gravity spring   d. all of the above

2. An artesian spring is formed
   a. when an aquifer gets exposed in a valley against a vertical cut
   b. due to continuous fault in a rock through which water under pressure comes out
   c. when a porous strata gets enclosed between two impervious strata
   d. none of the above

3. The open wells or dug wells
   a. act as a small storage reservoir
   b. are suitable for a small discharge
   c. are cheap in construction
   d. all of these

4. Run off is the water which flows
   a. in infiltration galleries
   b. in sewer pipes

c. due to leakage of pipes

d. in rivers

5. The yield of a surface stream may be obtained by
   a. cross section velocity method
   b. stream gauging
   c. chemical method
   d. all of these

6. The yield the well is measured in
   a. cum / h   b. litres / h
   c. both a and b   d. none of these

7. The ground water is generally free from
   a. suspended solids   b. dissolved solids
   c. colloidal solids   d. none of these

8. Sub surface source of water is
   a. springs and wells
   b. under ground water
   c. ocean
   d. all of these

9. The yield of well depends upon the
   a. permeability of the soil
   b. position of water table
   c. depth of well in impervious layers
   d. all of these

10. What type of spring occurs when groundwater under
    pressure emerges at the surface without pumping?
    a. Gravity spring
    b. Artesian spring
    c. Surface spring
    d. Contact spring

11. Which spring type is formed where an impermeable layer
    forces groundwater laterally until it intersects the ground
    surface?
    a. Depression spring
    b. Fissure spring
    c. Contact spring
    d. Volcanic spring

12. Fracture or fissure springs are formed when groundwater
    emerges through:
    a. Contact zones of rock layers
    b. Volcanic lava tubes
    c. Impervious clay layers
    d. Joints or cracks in rock

13. Depression springs are typically formed
    a. where magma heats the groundwater
    b. along joints in confined aquifers
    c. at topographic lows where the water table meets the
    ground
    d. where carbonated water bubbles from underground

14. A shallow well is defined as one that:
    a. has a depth less than its width
    b. has a depth less than 20 feet
    c. does not rest on impervious layer
    d. rests on a rest on impervious layer

15. Open wells (or shallow wells) are most suitable for:
    a. shallow, high-yield aquifers
    b. deep, high-yield aquifers

c. shallow, low-yield aquifers

d. deep, low-yield aquifers

16. Which of the following factors primarily affect the yield
    of an open well?
    a. Permeability of soil
    b. Area of aquifer opening into the well
    c. Actual flow velocity
    d. Both permeability and flow velocity

17. Write down source of water and differentiate between
    surface and ground/sub-surface water.

1	2	3	4	5	6	7	8	9	10
b	c	d	d	d	c	a	a	d	b
11	12	13	14	15	16				
c	d	c	c	c	d				

1. The Quantity of water available from an infiltration gallery
   depends upon the
   a.   Size of gallery
   b.   Nature of soil
   c.   Yield of source
   d.   All of these

2. Suspended impurities consist of
   a. iron   b. fungi
   c. bacteria   d. all of these

3. The quality of tube well water is
   a. good   b. poor   c. not bad   d. just poor

4. The water bearing strata i.e. layers of sand, gravel etc is called
   a. an acquifer   b. an aquiclude
   c. an aquifuge   d. zone of saturation

5. The strainer type tube well is unsuitable for
   a. coarse gravel
   b. fine sandy strata
   c. clean gravels
   d. none of these

6. Factor to be considered on selection of source of water is
   a. quantity and quality of water
   b. land stability and topography of people
   c. distance from treatment plant
   d. all of these

7. A vertical well provided along the banks of a river to draw
   ground water in dry season are called
   a. open wells
   b. infiltration wells
   c. tube wells
   d. infiltration galleries

8. A horizontal tunnels constructed at shallow depths along the
   banks of a river to intercept the ground water table are called
   a. canals
   b. infiltration galleries
   c. infiltration well
   d. storage reservoir

9. A shallow well typically differs from a deep well in that it:
   a. Is always less deep in meters than a deep well
   b. Draws from the upper unconfined aquifer
   c. Passes through an impervious "mota" layer into deeper aquifers
   d. Taps artesian pressure conditions

10. Deep tube wells generally have higher discharge than shallow tube wells because they:
    a. Always are drilled deeper
    b. Tap multiple aquifers and greater saturated thickness
    c. Rely solely on artesian head
    d. Are only hand-dug

11. Which of the following is *not* a type of tube well?
    a. Slotted type tube well
    b. Strainer type tube well
    c. Artesian tube well
    d. Cavity-type tube well

12. Discuss the key factors that need to be considered while selection of water sources.

13. Write down the sources of water and differentiate between shallow open well and deep open well.

14. Write short notes
    a. Infiltration galleries
    b. Infiltration wells

1	2	3	4	5	6	7	8	9	10
d	d	a	a	b	d	b	b	b	b
11									
c									

1. Which of the following is a waterborne disease?
   e. Malaria
   f. Cholera
   g. Tuberculosis
   h. Dengue

2. Typhoid is mainly spread through
   a. Air   b. Direct contact
   c. contaminated water drink   d. all of these

3. Which of the following is NOT a water related disease ?
   a. Hepatitis A   b. Dengue   c. Malaria   d. Cholera

4. Which of the following helps in preventing water-related disease?
   a. Drinking untreated water
   b. Washing hands with dirty water
   c. Drinking filtered or boiled water
   d. Bathing in stagnant ponds

5. Which of the following is the first component of a gravity water supply system?
   a. Reservoir
   b. Intake
   c. Treatment plant
   d. Distribution chamber

6. In gravity water supply , the eater flows due to:
   a. Electric pump
   b. Solar pressure

   c. Gravity head (altitude difference)
   d. Suction pipe

7. What is the function of the break pressure tank in gravity system?
   a. Store water
   b. Reduce excessive pressure
   c. Remove impurities
   d. Supply to house

8. The pipe that carries water from source to reservoir in gravity flow is called
   a. Distribution pipe
   b. Suction pipe
   c. Transmission pipe
   d. Sedimentation tank

9. Which component stores water before it is distributed to consumers?
   a. Intake
   b. Reservoir tank
   c. Sedimentation tank
   d. Collection chamber

10. The unit generally used for domestic water demand is:
    a. Liter per capita per day (LPCD)
    b. Liter per minute
    c. Liter per second
    d. cubic meter per day

11. Fire demand is considered in water supply design for
    a. Washing clothes
    b. Domestic usage
    c. Emergency situations
    d. Cooking

12. Which of the following demand type is NOT derectly related to population ?
    a. Domestic demand
    b. Fire demand
    c. Institutional demand
    d. Livestock demand

13. Design Period for water demand in urban areas is usually
    a. 5 years
    b. 10 years
    c. 15 years
    d. 20 years

14. Water demand in fully plumed houses is
    a. 45 lpcd   b. 65 lpcd
    c. 112 lpcd   d. 120 lpcd

15. Water required for birds such as hen, duck parrots is
    a. 20 liters per 100 birds
    b. 100 liters per 20 birds
    c. 1 liters 20 birds
    d. 20 liters per birds

16. Water demand taken for industries in urban area is
    a. 10-15% of total demand
    b. 10-15 % of domestic demand
    c. 20-25 % of total demand
    d. 20-25 % of domestic demand

17. Water losses in water supply system, is assumed as
    a. 5%   b. 10%
    c.15%   d. 20%
18. Air valves are generally provided in pressure pipes of water supply
    a. at pipe junction   b. At summit
    c. At low points   d. near service pipes
19. Drain valves are generally provided in pressure pipes of water supply
    a. at pipe junction   b. At summit
    c. At low points   d. near service pipes
20. Write down the different component of gravity water supply system with sketch.
21. Describe per capita and the types of water demand.

1	2	3	4	5	6	7	8	9	10
b	c	b	c	b	c	b	c	b	a
11	12	13	14	15	16	17	18	19	
C	b	d	c	a	c	c	b	C	

5). The disposal of sewage from the septic tank is done by:
 a) Clarifier
b) Soak pit
c) Areated lagoon
c) Lamp holes
6). Per capita demand of water is calculated in liters:
a) Per person per day
b) Per person per month
 c) Per person per year
d) None of the above
7). ……………… is used to measure flow to domestics building:
 a) Rain gauge
 b) Water tank
c) Drain pipe
d) Water meter
 8). Most important method for calculating discharge for planning a water supply project is:
a) Velocity area method
b) Weir or spillway method
c) Use of venturi meter
d) Using power plant consumption
9). The most ideal disinfectant used for drinking wqter throughout the world is:
a) Alum
 b) Lime
c) Chlorine
d) Nitrogen
10). Which reservoir is helpful in permitting the pumps or the water treatment plants to work at a uniform rate:
a) Storage reservoir
 b) Detention reservoir
c) Multipurpose reservoir
d) Distribution reservoir
11). Septic tank is provided for:
a) Collection of incoming sewage
b) Digestion of sewage & settle down

c) Storage of digested sludge
 d) All of the above
12). Water supply system includes:
a) Digging of well for water
b) Construction of dams
c) Construction of canals
 d) Entire arrangements from source to distributions
13). The devices installed for drawing water from the sources are called:
 a) Filters
b) Intakes
c) Aquifers
d) None of the above
14). Factors considered in selection of site for intake point is that it should be:
     a) Near to the treatment plant
     b) In pure Zone of the water sources
     c) Upstream of the point of disposal of
        waste water
     d) All of the above
15). Gravity water supply system starts from:
 a) Intake
b) Collection chamber
 c) BPT
d) Faucet
16). Most common source of water in hill & terai in our country are ….. respectively:
    a) Surface & Ground
b) Ground & Surface
c) Surface & Surface
d) Ground & Ground
17). A good source of water requiring practically least treatment is:
    a) Perennial river
 b) Impounded reservoir
 c) Deep well
d) Elevated lake
18). Source of water in the mountains is:
    a) Tube well   b) Well
c) Stream   d) None of the above
19). "Puits develope" is generally provided in case of:
    a) Well   b) Tube well
 c) Reservoir   d) All of the above

1. What is the typical self-cleansing velocity recommended for normal sewage in sewers of 30–60 cm diameter?
   A. 60cm/s   B. 75cm/s
   C. 90cm/s   D. 100cm/s
2. Self-cleansing velocity is
   A. Maximum velocity preventing scouring
   B. Minimum velocity to avoid deposition of solids

C. Velocity to flush flow rate

D. Velocity at peak flow

3. The non-scouring velocity is the

A. Velocity to keep solids in suspension

B. Maximum velocity at which no scouring action occurs

C. Velocity at full flow design

D. Peak stormwater velocity

4. Non-scouring velocity for cement concrete sewers lies between:

A) 2.5–3.0 m/s   B) 3.0–4.0 m/s

C) 3.5–4.5 m/s   D) 4.5–5.5 m/s

5. What is the typical depth and diameter for a pit latrine?

A. 1 m deep, 0.5 m diameter

B. 3 m deep, 1 m diameter

C. 5 m deep, 2 m diameter

D. 7 m deep, 1.5 m diameter

6. When the pit fills to within 0.5 m of the top, what should be done?

A. Cover with soil and relocate superstructure

B. Reduce usage

C. Deepen the pit

D. Add more users

7. Ventilated Improved Pit (VIP) latrine adds a:

A. Composting chamber

B. Chemical tank

C. Vent pipe above pit

D. Pump

8. What should the bottom of the pit be relative to the groundwater table?

A. 0.5 m below

B. At groundwater level

C. At least 2 m above

D. On a slope

9. What is the typical depth and diameter for a VIP latrine?

A. 1.5 m deep, 1.2 m diameter

B. 3 m deep, 1 m diameter

C. 5 m deep, 2 m diameter

D. 0.9 m deep, 1.5 m diameter

10. Improvement over pit latrine by adding ventilation pipe and superstructure slightly offset is called

A. Septic Tank   B. Soak pit

C. VIP latrine   D. Pit Latrine

11. Diameter of Vent pipe in VIP latrine is

A. 75mm   B. 90mm

C. 100 mm   D. 110mm

12. Height of ventilation Pipe is

A. 1.5m   B. 2.5m

C. 2m   D. 3m

13. Which of the following is known as Shut off valve?

a. Air relief valve

b. Sluice valve

c. Pressure relief valve

d. Altitude valve

14. The spacing between the Sluice valves is………….

a. 10m   B. 30m   C. 80m   D. 180m

15. Which of the following is used to stop the water supplies when required?

a. Air relief valve   C. Sluice valve

b. Pressure relief valve   D. Altitude valve

16. The Gate valves are made of _____ with brass mountings.

a. Cement concrete   C. Reinforced concrete

b. Cast iron   D. Galvanized iron

17. _____ valves are used to discharge air from the water pipelines.

a. Air relief valve   C. Sluice valve

b. Pressure relief valve   D. Altitude valve

18. . _____ valve allows water to flow in one direction only.

a. Air relief valve   C. Sluice valve

b. Reflux valve   D. Altitude valve

19. Which of the following is known as washout valve?

a. Scour valve   C. Sluice valve

b. Reflux valve   D. Altitude valve

20. Which of the following valve is known as a safety valve?

a. Scour valve   C. Pressure relief valve

b. Reflux valve   D. Altitude valve

21. Which of the following is also known as a check valve?

a. Scour valve   C. Pressure relief valve

b. Altitude valve   D. Reflux valve

Explanation: Reflux valve is known as non-return valve or check valve. They are placed in water pipes which obtain water directly from the pumps.

22. The valve which is preferred in elevated tanks and stand pipes is

a. Altitude valve   C. Pressure relief valve

b. Reflux valve   D. Air relief valve

23. ……….valves are used to remove sand and silt from the pipelines.

a. Air relief valve   C. Sluice valve

b. Scour valve   D. Altitude valve

Explanation: Scour valves are provided to blow off the sand and silt deposited in the pipeline. This operation is done manually.

24. Gate valves are

a. Directional control valves   C. Pressure control valves

b. Flow control valves   D. None of the above

25. A relief valve

a. Provides back pressure for a cylinder   C. Unloads a pump

b. Is a directional control valve   D. None of these

26. In which of the following distribution system, the clean water flows entirely under gravity?

a. Gravity system   C. Pressure system

b. Combined gravity and pumping system   D. Pumping system

27. The pressure in distribution mains in a residential building up to three storeys is _____

a. 2kg/cm2   B. 5kg/cm2   C. 7kg/cm2   D. 10kg/cm2

28. The velocity of water in a 10 cm diameter pipe should be ____

a. 0.2m/s   B. 0.5m/s   C. 0.9m/s   D. 1.2m/s

Hints: Velocity For 15cm Dia. Pipe is 1.2m/s

29. In which system of water supply, water is available for 24 hours but uneconomically used?

a. Continuous supply   C. Fixed supply

b. Intermittent supply   D. Low supply

30. In which system of water supply, water is supplied only during fixed hours of the day?

a. Continuous supply   C. Fixed supply

b.   Intermittent supply   D. Low supply

31. The velocity of water in the pipe is 1.8m/Sec. What is the diameter of pipe used?

a.   10cm   B. 15cm   C. 25cm   D. 40cm

32. Pipe corrosion can be minimized by…………

a.   Removal of copper sulfate   C. Addition of calcium carbonate

b.   Addition of carbon dioxide   D. Removal of dissolved oxygen

33. Deep vertical movement of water in the ground is called as……..

a.   infiltration   B. percolation   c) runoff   D. seepage

34. The geological formation which yields only insignificant quantity of groundwater is

a.   aquifer   B. aquifuse   C. aquiclude   D. aquitard

35. The geological formation which may contain water but does not contain any yield is

a.   aquifer   B. aquifuse   C. aquiclude   D. aquitard

36. Which of the following geological formation contains and readily yields water to our tube wells?

a.   Aquifer   B. Aquifuse   C. Aquiclude   D. Aquitard

37. Which of the following geological formation does not contain any amount of groundwater?

a.   Aquitard   B. Aquifer   C. Aquiclude   D. Aquifuge

38. Water wells excavated through confined aquifers are known as

a.   artesian wells   C. non-artesian wells

b.   gravity wells   D. water table wells

39. Septic tank is usually consists of brick wall in cement not less than

a.   20 cm   B. 100 cm   C. 80 cm   D. 200 cm

40. Soak pit shall not be less than………..

a.   45 cm   B. 90 cm   C. 50 cm   D. 100 cm

Hints: Dia. = 90cm and Depth is not less than 1.5m

41. The detention period of a septic tank is

a.   2 hours   B. 12-36 hours   C. 4 hours   D. 1 week

42. What is the maximum design flow of sewage in a septic tank?

a.   70 liters per person per day

b.   100 liters per person per day

c.   30 liters per person per day

d.   40 liters per person per day

Hints: Design Flow 40 to70 liter/person/day

43. The minimum depth of septic tank as per design consideration is

a.   1.8m   B. 1m   C. 1.2m   D. 1.5m

44. The minimum width of a septic tank is taken

a.   70 cm   B. 75 cm   C. 80 cm   D. 90 cm

45. The effluent of a septic tank is

a.   Fit for discharge into any open drain

b.   Foul and contains dissolved and suspended solids

c.   As good as that from a complete treatment

d.   None of these

46. The bottom of the sewage inlet chamber of septic tanks, is provided an outward slope

a.   1 in 5   B. 1 in 10   C. 1 in 15   D. 1 in 20

47. What is the minimum velocity required in sewers to keep the foreign particles from settling?

a.   3 ft/s   B. 5 ft/s   C. 10 ft/s   D. 12 ft/s

48. What is the maximum allowable velocity in public water mains?

a.   3 ft/s   B. 8 ft/s   C. 10 ft/sec   D. 12 ft/sec

49. The quantity of sanitary sewage directly depends on

a.   Rate of water supply   C. Area

b.   Population   D. Precipitation

50. In R.C. sewer pipes, the percentage longitudinal reinforcement to the cross-sectional area of concrete is kept

a.   10.0   B. 5.0   C. 2.0   D. 0.25

51. Most commonly used pump for lifting water in water supply mains, is

a.   Axial flow pump   C. Reciprocating pump

b.   Rotary type pump   D. Centrifugal pumps

52. Distribution mains of any water supply, is normally designed for its average daily requirement

a.   100%   B. 150%   C. 200%   D. 225%

53. The yield of a rapid gravity filter as compared to that of slow sand filter, is

a.   10 times   C. 15 times

b.   20 times   D. 30 times

54. During treatment of water, sedimentation is done

a.   before filtration   C. after filtration

b.   simultaneously with filtration   D. along with chlorination

55. Check valves are installed

a.   on the delivery side of the pumping set

b.   at the interconnections between polluted water system and a potable water system

c.   both (a) and (b)

d.   neither (a) nor (b)

56. A water channel supported above the ground over trestles, is generally called

a.   flume   C. canal

b.   adueduct   D. All of the above

57. For centrifugal pumps

a.   initial cost is low

b.   limited space is required

c.   the discharge obtained is steady and non-pulsating

d.   all the above

58. The detention period for plain sedimentation water tanks, is usually

a.   4 to 8 hours   C. 8 to 16 hours

b.   16 to 24 hours   D. 24 to 36 hours

59. The efficiency of sedimentation tank does not depend upon

a.   depth of tank   C. length of tank

b.   detention period   D. velocity of water

60. Most commonly used section in grade aqueducts, is

a.   circular   C. rectangular

b.   parabolic   D. horse shoe section

61. Aqueducts are generally designed

a.   circular   C. rectangular

b.   horse shoe section   D. all the above

62. The type of pipe commonly used in water supply distribution schemes, is

a.   R.C.C. pipes   C. Hume pipes

b.   Cast iron pipes   D. G.I. pipes

63. Recuperation test is carried out to determine

a.   turbidity of water   C. pH value of water

b.   yield of well   D. discharge from a well

64. Alum is chemically

a.   Copper sulphate   C. Aluminium sulphate

b.   Ferrous sulphate   D. Ferric sulphate

65. Manholes are less common in

a.   cast iron pipes   C. steel pipes

b.   hume steel pipes   D. R.C.C. pipes

66. To remove very fine suspended particles from water, the method adopted is

a.   screening   C. sedimentation

b.   boiling   D. filtration

67. In a well planned city, the layout of distribution pipes generally adopted, is

a.   grid-iron system   C. interlaced system

b.   reticulation system   D. all the above

68. Pressure relief valves are provided in water mains

a.   to reduce the pressure   C. at low points

b.   upstream of sluice   D. all the above

69. Higher yield may be expected from

a.   gravity springs   C. surface springs

b.   artesian springs   D. all the above

70.   Capacity of soil to absorb moisture, is generally known as

a.   permeability   C. porosity

b.   infiltration capacity   D. perviousness

71.   A pressure conduit carrying water beneath a stream or a canal, is known as

a.   sag   C. depressed pipe

b.   inverted syphon   D. all the above

72.   Which one of the following pairs is not correctly matched?

A.   Air valve : To release the accumulated air

B.   Sluice valve : To control flow of water through pipelines

C.   Checked valve : To check water flow in all directions

D.   Scour value : The remove silt in a pipeline

73.

*Topic wise MCQ discussion in physical and online class.

9. Irrigation Engineering

9.1 General

Irrigation may be defined as an application of controlled amounts of water to crops at needed intervals. Irrigation helps grow agricultural crops, re-vegetate distributed soils in dry areas during period of inadequate rainfall.

9.1.1   Advantages and disadvantage of irrigation

*Advantages of irrigation:-

A. **An increase in food production**
   Irrigation dramatically increases food production by supplying a reliable water source, enabling higher and more consistent crop yields.

B. **Optimum benefits of crops**
   Irrigation ensures the optimum benefits of crops by maximizing yields, enhancing quality, and enabling efficient use of water and nutrients.

C. **General Prosperity of the nation and community**
   Irrigation fosters general prosperity by boosting agricultural productivity, strengthening rural incomes, and driving broader economic and social development.

D. **Domestic Water supply**
   Irrigation provides reliable domestic water supply, particularly in areas where treated tap water may not be available.

E. **Afforestation**
   Irrigation enhances afforestation success by providing consistent water supply, ensuring tree survival and growth in arid or degraded areas.

F. **Protection from Famine**
   Irrigation ensure in any region provided safety of people from famine.

G. **Generation of hydroelectricity**
   If the same of the head is available for the production of hydropower, electricity can also be generated.

H. **Inland navigation**
   The larger irrigation canal can be used for Inland navigation offers a cost-effective, fuel-efficient, and environmentally friendly mode of transporting bulk goods over long distances.

*Disadvantage of irrigation:-

A. **Waterlogging**
   Excessive irrigation can raise the water table, suffocating plant roots and reducing crop yields.

B. **Soil Salinization**
   Poor drainage and over-irrigation can lead to salt accumulation in the soil, harming plant growth.

C. **Health Risks**
   Stagnant irrigation water can breed mosquitoes, increasing the spread of diseases like malaria and dengue.

D. **High Initial Costs**
   Setting up irrigation systems requires significant investment in infrastructure and equipment.

E. **Maintenance Challenges**
   Irrigation systems demand regular upkeep to prevent clogs and ensure efficient water distribution.

F. **Water Waste**
   Inefficient irrigation methods can lead to overwatering, wasting valuable water resources.

G. **Soil Erosion**
   Improper irrigation can increase surface runoff, leading to soil erosion and loss of topsoil.

H. **Energy Consumption**

Pumping water for irrigation requires energy, contributing to increased operational costs and environmental impact.

***Types of irrigation**

Irrigation is primarily classified into two types:
A.   Surface irrigation
B.   Sub-surface irrigation

A.   Surface irrigation

Surface irrigation may be further divided into two types:
i. **Flow irrigation:-** when a source of water is available at a higher level and water is supplied to lower level, under gravity, it is called flow irrigation.
ii. **Lift irrigation:-** when a water is lifted up by mechanical or manual means, such as pumps, the water supplied for irrigation is called lift irrigation.

B.   Sub-surface irrigation

i. **Natural sub-surface irrigaton:-** water is stored in root zone of plant by seepage system.
ii. **Artificial sub-surface irrigation:-** water directly in root zone of plant by using perforated pipe network.

***Water distribution in fields /Methods of irrigation**

A. free flooding

In this method, ditches are excavated aling the contours or up-qown slope, water from these ditches flow across the field. Such as free flooding irrigation is sometimes called wild flooding.

B. Border flooding

In this method, the field is divided into a number of strips separated by two leaves called borders.

C. Check flooding

This method is similar to ordinary flooding except that the water is controlled by surrounding the check area with low and flat leaves.

D. Furrow irrigation method

In this method , furrow narrow field ditches are excavated between rows of plants to carry irrigation water through them. Furrows are 8 to 30 cm deep and about 400 metres long.

E. Sprinkler irrigation method

In this method, water is applied to the soil in the form of a spray through a network of pipes an pumps. It can be used for all types of crops and desert type terrain.

F. Drop irrigation method

In this method, water is slowly and directly applied to the root zone of the plants so that the losses by evaporation and percolation is minimized.

9.2 Crop Water Requirement

Crop Water Requirement is the total amount of water needed by a crop to meet its evapotranspiration needs from planting to harvest, under optimal conditions.

9.2.1 Major Crop Seasons in Nepal

A. Summer (Monsoon) Season
➢ **Timeframe**: June to September
➢ **Characteristics**: Characterized by the monsoon rains, this season is crucial for cultivating crops that require abundant water.
➢ **Common Crops**: Rice, maize, millet, and pulses.

> **Cultural Significance**: The paddy planting festival, known as "Asar Pandra," is celebrated during this time, marking the traditional rice planting day.

B. Winter Season
> **Timeframe**: October to February
> **Characteristics**: Cooler temperatures prevail, and irrigation becomes essential due to reduced rainfall.
> **Common Crops**: Wheat, barley, mustard, and vegetables.

C. Spring (Pre-Monsoon) Season
> **Timeframe**: March to May
> **Characteristics**: Transitional period with increasing temperatures and preparation for the upcoming monsoon.
> **Common Crops**: Vegetables like tomatoes, cucumbers, and beans.

*Crop water requirement for principal crops

The term water requirement of a crop is defined as the total quantity and the way in which a crop requires water from the tome crop is sown to the time it is harvested. It may be noted that the same crop may have different water requirements at different places of the country depending upon the types of soil, method of cultivation the climate and amount of rainfall.

9.2.2 Duty delta and base period

A. Delta (Δ)

The total depth of water (in cm) required by a crop in the desired intervals of time for its full fledged nourishment upto maturity is called its delta (Δ).

> Every crops requires certain amount of water at certain intervals throughout its growth. This time interval between consecutive watering is called as **frequency of irrigation** or **rotation period**.
> It's generally measured in meters or centimeters.
> Delta for some important crops are:
1. Sugar cane   120cm
2. Rice   120cm
3. Tabacco   75cm
4. Garden fruits   60cm
5. Cotton   50cm
6. Vegetable   45cm
7. Wheat   40cm
8. Barley   25cm
9. Fodder   22.5cm
10. Peas   15cm

B. Duty (D)

The area of land in hectares that can be irrigated by constant supplying 1m^3/sec of water throughout the base period of the crop is called Duty (D).

> Unit of duty is hectars/cumes and the relation of duty with area and discharge is:

Dischagre (D)=$\frac{area\ (A)}{DUty(D)}$

a. Factors affecting the duty
> Types of crop
> Climate and season
> Useful rainfall

> ➤ Types of soil
> ➤ Efficiency of cultivation method.

C. Base period (B)
The time between first watering to (after sowing) to last watering before harvesting is called base period. It's measured in days.

*Relation between Duty(D) , Delta (Δ) and base period
Let 1m3/sec of water is applied in a field having area of D hectare and having a crop of base period B days.

Area (A) = D ha. = $D*10^4 m^2$

Volume of water applied in B days (V)=Q * time

$$= Q*B \text{ days}$$
$$= 1m^3/sec*B \text{ days}$$
$$= 1m^3/sec * 86400 \text{ sec. B}$$
$$= 86400B \text{ m}^3$$

Depth of water applied in B days

$$D=\frac{volume}{area} = \frac{86400B}{D*10000} \text{ m}$$

D = 8.64B/D m or 1.985B/D Ft.

*Crop period: time period between sowing and it's harvesting as called crop period.

*Paleo irrigation: irrigation done before sowing for land preparation is called as paleo irrigation.

*Kor watering/ first watering: first watering after sowing when crop has growth few cm is called kor watering.

*Kor period: time period between sowing to it's kor watering is called kor period.

9.3 irrigation canal
Irrigation canal is an artificial waterway constructed open conduit either lined or unlined for the different purpose like, irrigation, hydropower , water supply etc.

9.3.1 Canal losses and their minimization
A. canal losses
Types of Canal Losses
    a. **Seepage (Percolation)**
        This is typically the major form of loss in irrigation canals. It occurs when water infiltrates through the canal bed and walls into the surrounding soil or groundwater.
        In many cases, seepage accounts for as much as 30% of diverted water
        Conveyance losses—including seepage and evaporation—can reach up to 45%, as reported regionally (e.g., India)
    b. **Evaporation**
        ➤ Water is lost from the canal surface due to atmospheric exposure. Although always present, evaporation generally represents a small portion of total losses.
        ➤ Estimates range from 2–3% of total diverted water lost by evaporation, and during hot seasons can rise to up to 7%
    c. **Transpiration (Vegetation Losses)**
        ➤ Water uptake and release by vegetation growing along the canal banks—for instance, weeds or grasses—can contribute to losses, though this is usually minor compared to seepage and evaporation
    d. **Operational Losses (Leakage & Spills)**

> These include water lost due to leaks from gates or structures, uncontrolled spillways, or poor management practices.
> A recent modeling study found that operational losses often account for a much larger share than seepage—up to 90%, with seepage making up only around 10%—largely depending on infrastructure and operation quality.

B. Minimization of losses in canals
a. Canal Lining
> Concrete lining helps prevent water from seeping through the bed or walls, dramatically reducing percolation.
> Geomembrane or plastic liners offer flexible, cost-effective alternatives, particularly for uneven terrain.
> Compacted clay or cement–bentonite lining provides a lower-cost, impermeable layer in earth canals.

b. Canal Covering or Shading
> Floating covers **or** shade cloths reduce sunlight exposure on the water surface, cutting evaporation losses.
> Planting riparian vegetation strategically (while controlling excessive growth) also provides shade and reduces evaporation.

c. Efficient Water Delivery Scheduling
> Implement on-demand water delivery rather than continuous flow to limit standing water.
> Use smarter flow control systems (like gates and sensors) to match supply closely to crop demand.

d. Modernization of Infrastructure
> Replace outdated or leaky canal structures (e.g., gates, siphons, regulators).
> Install automation and monitoring tools (flow meters, remote sensors) to detect leaks or inefficient water delivery.

e. Regular Maintenance and Inspection
> Conduct frequent checks and repairs for cracks, animal burrows, erosion, or vegetation intrusion**.**
> Keep canals clean of debris to maintain smooth flow and reduce risk of structural damage.

f. Alternative Conveyance Systems
> Pressurized pipelines or piping systems can completely eliminate seepage and significantly reduce evaporation—especially practical in certain terrains or distances.
> Piped "last-mile" delivery systems (e.g., pipe distribution near fields) convey only necessary water over vulnerable stretches.

g. Capacity Right-Sizing
> Designing canals to carry only the necessary volume (instead of oversizing) cuts down on the surface area exposed—and therefore evaporation and seepage.

h. Water Accounting and Education
> Employ a water balance approach: monitor inflow, outflow, and actual use to spot unexplained losses.
> Train operators and farmers in water management best practices to cultivate a conservation mindset.

9.3.2 Maximum and minimum velocities

A. Maximum Velocities in canal sections

The maximum velocity depends on the types of lining material provided. The maximum velocities in certain sections are given below:

Lining Type	Maximum velocities
1. Light loose sand to average sandy soil	0.3-0.6
2. Sandy loam, BC soil, ordinary soil	0.6-0.9
3. Mooram. Hard soil etc.	1-1.1
4. Rock and gravel	1.5
5. Boulder lining	1.5
6. Stone masonry lining	1
7. Burnt clay tile lining	1.8
8. Cement concrete lining	2-1.5

9.3.3 Design of irrigation canal section using manning's formula

*Manning's Formula

This is most commonly used formula for canal design;

The discharge is given by $Q = A/n * R^{2/3} * S^{1/2}$

Where, Q= discharge, A=flow area, R= area/wetted perimeter= hydraulic mean radius,

S=longitudinal slope or bed slope, n=manning's roughness constant=manning's rugosity coefficient.

Also,

Velocity can be calculated by $V = 1/n * R^{2/3} * s^{1/2}$

Where,

V= Velocity and other symbols have usual meanings.

Value of manning's roughness coefficient,

Types of materials	manning's coefficient (n)
1. fine sand	0.02
2. fine gravel	0.025
3. coarse fravel	0.025
4. clay	0.025
5. loam	0.02

9.3.4 Need and location of weir/barrage

*Need of Weir/Barrage

- **Flow Regulation:** Weirs raise the water level upstream to regulate flow, facilitating water diversion into canals for irrigation or other uses.
- **Flow Measurement:** They are instrumental in measuring river discharge by allowing water to flow over the crest, enabling flow rate calculations.
- **Flood Control:** By controlling the flow rate, weirs help in mitigating flooding risks.
- **Navigation:** They can make rivers more navigable by controlling flow characteristics.
- **Water Storage:** Some weirs function as storage weirs, temporarily holding surplus water for use during dry periods.
- **Irrigation Support:** They ensure a stable water supply for irrigation by maintaining desired water levels.
- **Hydropower Generation:** Some barrages are equipped to generate power using tidal energy.
- **Transportation:** The top of barrage can be used as bridge to cross the river.

*Location of weir/barrage

➢ **Hydraulic Conditions**

Straight river reach, adequate width, stable flow

➢ **Geotechnical Factors**

Stable foundation, minimal scour potential, suitable soil conditions

➢ **Environmental Impact**

Sediment transport, ecological effects, floodplain dynamics

➢ **Structural Design**

Afflux limits, flood frequency, alignment with river axis

➢ **Construction Feasibility**

Land access, material availability, diversion feasibility

➢ **Regulatory Compliance**

Land ownership, community impact, necessary approvals

9.3.5 Head Work for small canals
A. Weir or Barrage
➢ A raised barrier across the river that elevates the water level, allowing gravity-fed flow into the canal.
➢ For small canals, a masonry or concrete weir is often used due to cost-effectiveness and simplicity.
B. Under Sluices
➢ Openings beneath the weir that allow sediment-laden water to pass without entering the canal.
➢ They help in flushing out silt and debris, maintaining water quality.
C. **Canal Head Regulator**
➢ A gate structure that controls the flow of water into the canal, ensuring a consistent supply.
➢ It can be manually operated or automated, depending on the system's complexity.
D. **Divide Wall**
➢ A partition wall that separates the canal intake from other parts of the headworks.
➢ It directs the flow into the canal and reduces turbulence, aiding in sediment management.
E. **Fish Ladder**
➢ A series of steps or channels that allow fish to bypass the weir, maintaining ecological balance.
➢ While more common in larger systems, they can be included in small canals if biodiversity is a concern.
F. **Silt Excluder or Ejector**
➢ Devices that prevent or remove sediment from the canal intake, ensuring clean water delivery.
➢ They are particularly important in rivers with high sediment loads.
G. **River Training Works**
➢ Structures like guide banks or marginal bunds that direct the river flow towards the weir, preventing erosion and scouring.
➢ Essential in maintaining the stability of the headworks.

*Numerical and remaining part discuss in physical and online class.

1. **The irrigation engineering may be defined as**
   (a) the process of artificially supplying water to soil for raising crops
   (b) a science of planning and designing an efficient and economic irrigation system
   (c) the engineering of controlling and harnessing the various natural sources of water, by the construction of dams, canals and finally distributing the water to the agricultural fields
   (d) all of the above

2. Silt is a
   (a) fertilizing agent
   (b) non-fertilizing
   (c) type of crop
   (d) type of rock

3. **The irrigation is necessary in an area**
   (a) where there is a scanty rainfall
   (b) where the rainfall is non-uniform
   (c) where commercial crops require more water
   (d) all of the above

4. The necessity of irrigation in required due to
   (a) less rainfall
   (b) non-uniform rainfall
   c) commercial crops
   (d) all of the above

5. **The irrigation water is said to be unsatisfactory, if it contains**
   (a) chemicals toxic to plants or to persons using plants as food
   (b) chemicals which react with the soil to produce unsatisfactory moisture characteristics
   (c) bacteria injurious to persons or animals eating plants irrigated with water
   (d) all of the above

6. Which of the following is also called inundation irrigation?
   (a) Diversion irrigation
   (b) Storage irrigation
   (c) Flow irrigation
   (d) Combined scheme

7. Intensity of irrigation
   (a) Percentage of culturable commanded area to be irrigated annually
   (b) is always more than 100%
   (c) is the percentage tha could be ideally irrigated
   (d) all of the above

8. The operation during the infiltration of water below the ground surface is
   (a) adsorption
   (b) absorption
   (c) ozonization
   (d) sedimentation

9. The water utilized by plants is available in soils mainly in the form of
   (a) capillary water
   (b) gravity water
   (c) hygroscopic water
   (d) pore water

10. Which type of irrigation is practiced when the water supply is at too low a level to run by gravitation of the land?
    (a) Lift irrigation
    (b) River canal irrigation
    (c) Flow irrigation
    (d) Inundation irrigation

11. Sandy soils with good drainage become impermeable after prolonged use, if it is irrigated with a water containing sodium:
    (a) 25%
    (b) 50%
    (c) 5%
    (d) 85%

12. For irrigation purposes, the pH value of water should be:
    (a) between 3 and 6
    (b) between 6 and 8.5
    (c) between 8.5 and 11
    (d) more than 11

13. Which of the salts present in water is harmful for cultivation purposes:
    (a) Potassium sulphate
    (b) Sodium sulphate
    (c) Potassium chloride
    (d) None of these

14. When an oven-dried sample of soil is kept open in the atmosphere, it absorbs some amount of water. This water is known as:
    (a) Capillary water
    (b) Gravitational water
    (c) Hygroscopic water
    (d) All of these

15. A part of water which exists in the porous space of the soil by molecular attraction, is known as:
    (a) Capillary water
    (b) Gravitational water
    (c) Hygroscopic water
    (d) All of these

16. A part of water which will move out of the soil, if proper drainage is provided, is known as gravitational water:
    (a) True
    (b) False
    (c) both
    (d) none

17. Superfluous water is also called:
    (a) Capillary water
    (b) Gravitational water
    (c) Hygroscopic water
    (d) All of these

18. Irrigation is supplementary to rainfall.
    (a) Agree
    (b) Disagree
    (c) both
    (d) none

19. Irrigation………….the chances of water logging:
    (a) Increases
    (b) Decreases
    (c) same
    (d) all of these

20. A useful soil moisture for plant growth is:
    (a) Capillary water
    (b) Gravitational water
    (c) Hygroscopic water
    (d) All of these

21. The amount of water required to fill up the pore spaces in soil particles by replacing all air held in pore spaces, is known as:
    (a) Field capacity
    (b) Saturation capacity
    (c) Available moisture
    (d) All of these

22. The moisture content of the soil, after free drainage has removed most of the gravity water, is known as:
    (a) Field capacity
    (b) Saturation capacity
    (c) Wilting coefficient
    (d) Available moisture

23. The water content at which plants can no longer extract sufficient water from the soil for its growth, is called:
    (a) Field capacity
    (b) Saturation capacity
    (c) Permanent wilting point
    (d) Available moisture

24. The saturation capacity, field capacity and the permanent wilting point of a soil are 47%, 27% and 14% respectively. The available moisture for the crops grown in the soil is:
    (a) 13%
    (b) 20%
    (c) 27%
    (d) 33%

25. The types of irrigation is during low quantity of water
    (a) sprinkler irrigation
    (b) drip irrigation
    (c) free flooding
    (d) furrow method

26. Check flooding method of irrigation is used for:
    (a) closed growing crops
    (b) tracts with flat gradients
    (c) crops which can stand inundation of water for some time
    (d) crops such as sugarcane, potatoes etc.

27. Which of the following statement is correct?
    (a) In free flooding, the field is divided into a number of small sized plots which

    are practically level.
    (b) In border strip method, the strips are separate by low levels.
    (c) In furrow irrigation, the water is admitted between the rows of plants in the field.
    (d) all of the above

28. The method of irrigation, in which land surrounded by natural or artificial banks is flooded
    (a) broad irrigation
    (b) natural irrigation
    (c) basin irrigation
    (d) none of the above

29. The kharif crop is sawn
    (a) at the end of summer
    (b) at the end of north-east mansoon
    (c) the beginning of south-west monsoon
    (d) in mind summer

30. Crop water is proportional to
    (a) evapo-transpiration
    (b) effective rainfall
    (c) seepage of water
    (d) all of the above

31. The area in which crop is grown at a particular time or crop season is called
    (a) gross commanded area
    (b) culturable commanded area
    (c) cultivable cultivated area
    (d) none of the above

32. The first watering before sowing the crop is known as
    (a) kor watering
    (b) paleo
    (c) none of these
    (d) none of the above

33. For any crop base period is measured in
    (a) day
    (b) week
    (c) month
    (d) year

34. The numerical value of base period is
    (a) less than crop period
    (b) more than crop period
    (c) equal to crop period
    (d) all of the above

35. The duty is largest
    (a) at the head of main canal
    (b) at the head of water course
    (c) on the field
    (d) same at all place

36. The average delta of rice crop is nearly
    (a) 30cm
    (b) 60cm
    (c) 120cm
    (d) 150cm

37. The operation, which washes out salts from the upper zone of the soil, is called
    (a) reclamation
    (b) leaching
    (c) efflorescence
    (d) salinity

*All topic wise MCQ discuss in physical and online class

Answers

1	D	**21**	B
2	A	**22**	A
3	D	**23**	C
4	D	**24**	A
5	D	**25**	B
6	C	**26**	C
7	A	**27**	D
8	B	**28**	C
9	A	**29**	C
10	A	**30**	B
11	D	**31**	B
12	B	**32**	B
13	D	**33**	A
14	C	**34**	A
15	A	**35**	C
16	A	**36**	B
17	B	**37**	B
18	A		
19	A		
20	B		

10. Highway engineering

10.1 General

Highway engineering is a branch of civil engineering that deals with the planning, design, construction, operation, and maintenance of roads, streets, and highways to ensure safe and efficient movement of people and goods.

10.1.1 Introduction to transportation system

A transportation system is the organized network of facilities, infrastructure, vehicles, and operations used to move people, goods, and services from one place to another efficiently, safely, and economically.

*Importance of transportation system
- ➢ Reduces travel time and cost.
- ➢ Boosts industrial and agricultural activities by connecting markets.
- ➢ Supports emergency services and disaster response.
- ➢ Facilitates tourism and cultural exchange.

*Primary modes of transportation
There are four types of primary mode of transportation:
- **A. Land ways**
  - ➢ **Road** (highways, streets, expressways)
  - ➢ **Rail** (passenger and freight trains)
- **B. Waterways** (ships, ferries, canals)
- **C. Airways** (airplanes, helicopters)
- **D. Space ways** (satellite, rocket)

*Secondary modes of transportation
There are four types of secondary mode of transportation:
- **A. Ropeway** (cable car, cabin, chair, gondala.
- **B. Pipelines** (oil, gas, water transport)
- **C. Belt-conveyor** (aggregate in crusher plant)

* Characteristics of a Good Transportation System
- ➢ **Safety**: minimizes accidents and hazards.
- ➢ **Reliability**: consistent and predictable travel times.
- ➢ **Capacity**: handles expected traffic efficiently.
- ➢ **Economy**: cost-effective for users and government.
- ➢ **Sustainability**: minimizes environmental impact.

10.1.2 Historic development of roads

The history of roads can be traced back thousands of years, evolving from simple dirt tracks to today's modern highways.
- ➢ Development of roads given below in sequential order:
  1. Roman roads (roman)
  2. Tresaguet construction (France)
  3. Metcalf construction (enland)
  4. Telford construction (united kingdom)
  5. Macadam construction (England)

➢ **The development of road in Nepal is by following agency:**
1. Naya bato kaj goswara (est- 1948AD)- for construction of new road
2. Purano bato koj goswara (est-1948AD)- for maintenance of old road
3. Public work development (est-1950AD)- merging naya and purano bato koj gowsara
4. In 1956 AD Tribhuvan highway was constructed *(oldest and the first highway of Nepal, first Nepal connecting to foreign country, total length is 155Km)*
5. In 1963 AD Araniko highway was constructed *(first highway of Nepal connecting with china)*
6. In 1964 AD sidhartha highway was constructed
7. Department of roads (Est-1970AD) -after splitting the PDW
8. Department of building (Est- 1970AD) -after splitting the PWD 2027 BS

10.1.3 Classification of road in Nepal
   A. classification of road according to NRS, 2070

   a. **Administrative Classification**
   Based on which agency is responsible for the road:
   i. **National Highways**
      ➢ Connect the capital with provincial capitals, major cities, and border points.
      ➢ Managed by the Department of Roads (DoR).
      ➢ They are designated by letter "NH" followed by a two-digit number.
      ➢ Example: East–West Highway (Mahendra Highway 1027Km).
   ii. **Feeder Roads**
      ➢ Link national highways to district headquarters or important towns.
      ➢ Also under DoR.
      ➢ They are designated by letter "F" followed by 3 digit number.
   iii. **District Roads**
      ➢ Connect village areas to district headquarters or feeder roads.
      ➢ Maintained by Department of Local Infrastructure (DoLI) and local bodies.
   iv. **Urban Roads**
      ➢ Streets and roads within municipalities.
      ➢ Managed by municipal offices.
   v. **Rural Roads**
      ➢ Connect rural settlements and agricultural areas.
      ➢ Constructed and maintained by rural municipalities or DoLI.

   b. **Functional /technical classification**
   Based on purpose and traffic importance:
   i. **Class I:**
      Class I roads are the highest standard roads with divided carriageway and access control (Expressways) with **ADT** of **20,000 PCU or more** in a 20 years perspective period.**Design speed** for plain terrain: **120 km/h**
   ii. **Class II:**
      Class II roads are those with **ADT** of **5,000–20,000 PCU** in a 20 years perspective period. **Design speed** for plain terrain: **100 km/h**
   iii. **Class III:**
      Class III roads are those with **ADT** of **2,000–5,000 PCU** in a 20 years perspective period. Design speed for plain terrain: 80 km/h
   iv. **Class IV:**
      Class IV roads are those with ADT of less than 2,000 PCU in a 20 years perspective period. Design speed for plain terrain: 60 km/h

C. Classification of urban roads
i. **Arterial Roads (Class-I)**
   ➢ Carry large volumes of traffic over long distances at high speed.
   ➢ Example: National Highways.
ii. **Sub-arterial Roads (Class-II)**
   ➢ Connect arterial roads to collector roads; medium traffic volume.
iii. **Collector Roads (Class-III)**
   ➢ Collect and distribute traffic between local roads and arterial/sub-arterial roads.
iv. **Local Roads (Class-IV)**
   ➢ Provide access to individual properties, farms, or small settlements.

B. Based on uses in different weather
i. all weather road
ii. fair weather road

C. Based on pavement / carriage way
i. paved road: WBM, bituminous, concrete road
ii. unpaved road: earthen road, gravel road

D. Based on types of pavement surfacing
i. surfaced road: the roads which are provided with bituminous or cement concrete surfacing.
ii. Unsurfaced road: the roads which are not provided with bituminous cement concrete surfacing.

10.1.4 Basic requirements of road alignment
A. Purpose & Guiding Principles/best route location/ideal alignment
➢ **Shortest, straight, economical, safe, and easy to construct**: The alignment should ideally follow a direct path to minimize cost and vehicle operating expenses, while ensuring safety and constructability.
➢ Known collectively as the **SESE rule**: *Short, Easy, Safe, Economical*.

2. Horizontal Alignment (Plan view)
➢ Consists of **tangents (straight sections)** and **horizontal curves**, with curve radius determined by design speed and superelevation
➢ **Sight distance** must be sufficient for stopping safely; tight curves require greater banking (superelevation) to maintain safety.
➢ Avoid obstacles: alignment should bypass natural or cultural constraints and cross infrastructures (railways, rivers) at optimal locations.

3. Vertical Alignment (Profile view)
➢ Includes **gradients** and **vertical curves** for smooth transitions between grades.
➢ Avoid abrupt changes—maintain a minimum curve length (e.g., ~200 m for trunk roads) to prevent a "roller coaster" profile.
➢ Ensure **adequate sight distance** along crests and sags, balancing driver visibility with comfort and safety.

4. Cross-Sectional Elements & Drainage
➢ **Lane and shoulder widths**, **formation width**, **right-of-way** dimensions are driven by design speed, terrain, traffic volume, and future expansion needs.

> **Drainage**: Cross slope (camber) and longitudinal slope must be sufficient (typically ≥0.5–1%) to prevent water accumulation and hydroplaning.

5. Terrain, Environmental & Social Constraints
> Terrain classification (plain, rolling, mountainous, steep) dictates design speed, slope, and right-of-way requirements.
> Avoid sensitive areas: cultural/historical sites, forests, marshes, or unstable slopes. Also, design should respect environmental impact and aesthetics.

6. Alignment Selection Process
> Involves a structured survey process: **map study → reconnaissance → preliminary → detailed (location)** to evaluate options and costs.
> Optimizes the balance between cut and fill, cost, and safety

10.2 Geometric Design
Geometric design of highways is the branch of highway engineering that arranges the road's visible physical features, such as alignment, profile, and cross-sectional elements, to achieve optimal safety, traffic efficiency, cost-effectiveness, and livability while minimizing environmental impact.

10.2.1 Basic design control and criteria for design
* Design Controls
A. Functional Classification
Dictates design parameters by defining a road's role—whether a national highway, collector road, or local feeder road.
B. Topography (Terrain Type)
Road design standards adjust significantly depending on terrain—categories include plain, rolling, mountainous, and steep—with each influencing alignment, gradient, and cost.
C. Design Speed
The baseline parameter from which many geometric elements, curvature, sight distance, grades are derived. Terrain and budget constraints may warrant using a "minimum design speed" in challenging sections.
D. Design Vehicle Characteristics
Highways are designed to accommodate standard "design vehicles" whose dimensions, weights, and turning characteristics shape lane widths, curve radii, and clearances.
E. Traffic Volume & User Behavior
Includes vehicle mix, traffic flow, and driver behavior, essential for determining capacity, sight distance needs, and safety design.
F. Sight Distance
Ensuring drivers can see far enough to react safely, covering stopping, decision-making, and intersection maneuvers is foundational to safe geometric design.
G. Land Use & Environmental/Economic Factors
Includes the character of adjacent areas, aesthetics, environmental limitations, and construction/maintenance cost constraints that inform route alignment and design standards.

* Controlling Criteria
> Design speed
> Lane width
> Shoulder width
> Horizontal & vertical alignment
> Super-elevation

  - ➢ Grade (longitudinal slope)
  - ➢ Stopping sight distance
  - ➢ Cross slope
  - ➢ Vertical and horizontal clearances
  - ➢ Structural capacity (e.g., for bridges)

10.2.2 Elements of cross section, typical cross-section for all roads in filling and cutting
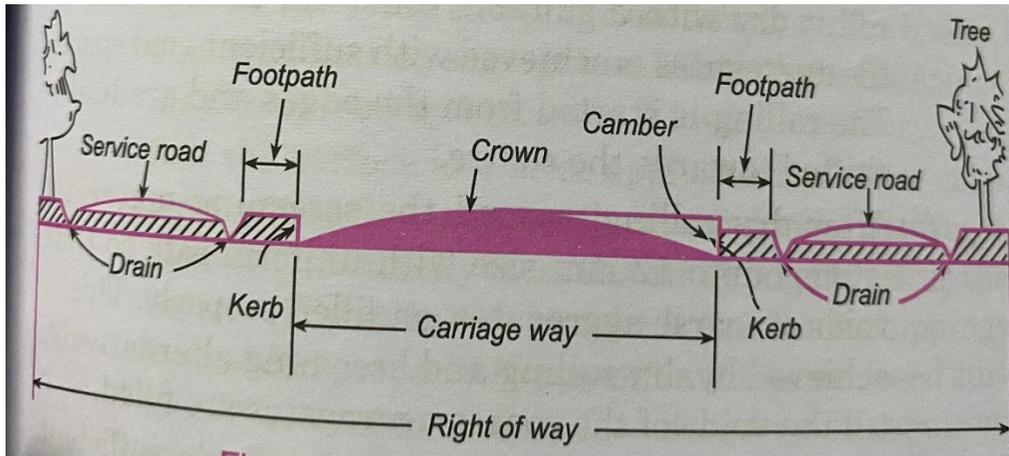***Element of cross-section**

Fig: cross-section of road

A. Right-of-Way (ROW)
The total land acquired for the road, including space for future expansion, drainage, and landscaping. It must accommodate all cross-sectional elements along with control/building lines.
As per NRS 2070 BS

Types of road	Row or total row	Row from center line of road
highway	50m	25m
Feeder road	30m	15m
District road	20m	10m
City road	20m	10m
4-lane	50m	25m
2-lane	30m	15m
Village road/agriculture road (ROW)		15m

B. Carriageway or Pavement Width
The width of the roadway constructed for the movement of vehicular traffic is called carriage way or pavement.
As per NRS 2070 BS

Width of single lane road	3.75m
Multi-lane pavement width	3.5m
Intermediate lane	5.5m

C. Shoulders

Provided on either side of the carriageway to serve as emergency lanes, parking areas, and to support structural integrity. They also improve sight distance and drainage. In Nepal, typical widths range from 0.5 m to 1.5 m.

As per NRS 2070 BS

Road class	Class-I	Class-II	Class-III	Class-IV
Minimum shoulder width (bothside)	3.75m	2.5m	2m	1.5m

D. Traffic Lanes

Defined areas used by vehicles. Lane width depends on vehicle dimensions and safety clearances, with ideal widths ranging between 3.0 and 3.6 m, balancing safety, capacity, and cost considerations.

E. Shoulders

Provided on either side of the carriageway to serve as emergency lanes, parking areas, and to support structural integrity. They also improve sight distance and drainage. In Nepal, typical widths range from 0.5 m to 1.5 m.

F. Footpath

A footpath road for pedestrian only is known as footpath

As per NR 2070 BS.

S.N.	Design hourly flow (both ways) of 15 minute peak period survey	Minimum footpath width each side
1	Up to 500	1.5m
2	500-1500	2m
3	1500-2500	2.5m
4	2500-3500	3m

G. Control lines

In addition to building line, it is desirable to exercise control on the nature of building activity for a further distance beyond the building up to what are known as control lines.

H. Bus bays

It is provided by raising the kerb to avoid conflict with moving traffic. It should be located at least 75m away from the intersection.

I. Camber

It is the convexity provided to the cross-section of the surface of carriageway and is the difference of level between the highest point (crown) and the edge. It is also known as cross fall.

J. Formation width

It is the top width if road embankment or bottom width id road cutting excluding the side drains. It includes carriageway and the shoulders.

K. Kerb
It indicates the boundary between pavement and shoulders or island or footpath.

L. Road way width
It's width of roadway including carriage way plus shoulders on either side and separators or bottom width of cutting. i.e. (roadway=carriage way + 2 * shoulder separators)

M. Super elevation at curve
Super elevation is the banking of a roadway on a horizontal curve.
raising the outer edge of the pavement above the inner edge
to counteract centrifugal force and improve vehicle stability.
It helps vehicles navigate curves safely and comfortably at higher speeds.

N. Widening of curve
is the intentional increase in pavement width on horizontal curves. This widening ensures that vehicles, especially larger ones, can navigate curves safely and comfortably, similar to how they operate on straight sections of the road.

10.2.3. Camber
Camber is the Transverse slope of road surface from center to edges (crown shape).
➢ Also known as cross slope or cross fall.
➢ Purpose of camber are Drainage, safety, structural protection.
➢ It depend on surface of road, amount of rainfall, types of road, impermeability of surfacing materials.
➢ Camber should never be less than 50% of the gradient.

*Types of camber
A. Straight or Sloped Camber
Two straight, uniform slopes meet at the center (crown). Simple to construct, used often in rigid or concrete pavements.
B. Two Straight Line Camber
Slope is steeper near the edges and gentler near the center, offering a balance between drainage efficiency and comfort.
C. Barrel (Parabolic) Camber
Curved shape (parabolic or elliptical), steeper near the edges and flatter at the crown. Ideal for high-speed roads, but more complex to build.
D. Composite Camber
Combines parabolic center with straight-line edges. providing smooth transition, good drainage, and easier construction. It's the best camber.
E. **Negative camber**
When the slope (lateral) of the road is provided towards the center of road then it is called negative camber.

10.2.4 Determination of radius of horizontal curves
Radius of horizontal curves is decided in such a way that the centrifugal force acting on the vehicle is balanced by supereelevation and side friction. Basic equation for finding the radius of horizontal curve from the condition of equilibrium of centrifugal force, super elevation and friction is given below;

$$R = (V^2)/127(e+f) = 0.0079V^2/(e+f) = \sqrt{127(e+f)}$$

Where,

R=radius of curve, metres
V=design speed, Kmph
e= super elevation metres/metres
f = coefficient of friction α roughness/dry

$$\alpha \frac{1}{smooth/wet}$$

From the consideration of passengers comfort, the radius of curve is given by R=V$^{2/20}$

10.2.5. Super elevation

- ➤ Super elevation is the banking of a roadway on a horizontal curve.
- ➤ raising the outer edge of the pavement above the inner edge
- ➤ to counteract centrifugal force and improve vehicle stability.
- ➤ It helps vehicles navigate curves safely and comfortably at higher speeds.
- ➤ It should not be more than 75 in plain and rolling terrain.
- ➤ It should not be more than 10% in hill road with no snow.

10.2.6 sight distance

Sight distance is the length of road ahead that a driver can see clearly. It directly impacts safety and determines how quickly a driver must see, react to, and manage hazards.

It depends upon the following factors:

- Features of the road ahead
- Height of the driver's eye above the road surface (IRC/NS- 1.2m)
- Height of the object the road surface (IRC/NS-0,15m)
- Speed of vehicle

*Types of sight distances:

A. Stopping Sight Distance (SSD):
Required for a driver to identify an obstruction, react, and stop safely before hitting it.
It includes both perception-reaction distance and braking distance.

B. Passing Sight Distance (PSD)/Overtaking sight distance (OSD) :
Applies on two-way, two-lane roads to allow overtaking while returning to your lane safely, factoring in oncoming traffic.

- ➤ Minimum length of overtaking zone=3*OSD
- ➤ Desirable length of overtaking zone=5*OSD

C. Intermediate Sight Distance (ISD):
A compromise when overtaking sight distance isn't feasible—typically set as twice the SSD.
Intermediate sight distance = 2* SSD

D. Decision Sight Distance (DSD):
Supports more complex driving decisions, requiring additional distance for perception, decision-making, and maneuvering.

10.2.7 Gradient

Gradients the rate of rise or fall along the length of the road with respect to the horizontal.

- ➤ Ruling gradient (1 in 20m hill and 1 in 30m plains)
- ➤ Limiting/maximum gradient (1 in 15 hill and 1 in 20 plain)
- ➤ Exceptional gradient (1 in 12 hill and 1 in 15 in plain)

➢ Minimum gradient (1 in 100 katcha drain , 1 in 200 inferior surface of drain, 1 in 500 concrete)

➢ The provision of exceptional gradient should not be greater than 60m per km.

➢ The gradient of road at which no fuel is required to move the vehicle even in neutral condition is known as floating gradient. Floating gradient is generally provided at summit curves.

10.2.8 Use of Nepal road standard 2027 (first revision 2045) and sussequent revision in road design.

➢ The Nepal Road Standard—NRS 2027 was first introduced in Bikram Sambat (B.S.) 2027, corresponding to 1970 CE, by the Ministry of Works and Transport's Department of Roads (DoR) as a baseline guideline for road construction across the country.

➢ The first official revision occurred in B.S. 2045 (1988 CE), which refined design elements and improved context-specific suitability.

➢ Subsequent minor revisions in 2051 (1994 CE) and 1997 CE were isolated updates; however, the more comprehensive second edition, NRS-2070 (2027 CE), now governs strategic rural roads.

*Scope and application

➢ NRS 2027 (First Revision 2045) applies to all roads constructed in Nepal, particularly non-urban roads outside built-up areas. Urban roads may follow additional or modified standards.

➢ The NRS-2070 update specifically covers strategic roads in rural areas (e.g., national highways, feeder roads). It's more tailored to the country's expanding road network and modern planning needs.

*Practival Guidelines

    A. **Structures**:

• Structures are classified by span length:

➢ Culverts: ≤ 6 m

➢ Minor bridges: up to 20 m

➢ Medium bridges: spans above 20 m but total span < 20 m

➢ Major bridges: spans > 20 m

• **Vertical clearance**: ≥ 4.75 m for traffic, with overhead utilities at ≥ 7 m

    B. **Camber (Cross-Slope)**:

Camber is tailored by surface type:

➢ Earthen: 5%

➢ Gravel: 4%

➢ Bitumen (rural): 3%

➢ Bitumen (urban): 2.5%

10.3 Drainage system

    Highway drainage systems are essential for maintaining road safety, longevity, and infrastructure integrity. These systems keep the pavement dry, reduce erosion, and prevent structural damage due to water accumulation.

*Types of drainage

    A. surface drainage

    B. Sub-surface drainage

* Importance of drainage system

> Prevents water-induced structural damage
> Enhances safety by keeping the surface dry
> Controls erosion and stabilizes road slopes
> Extends road lifespan and lowers maintenance costs
> Manages runoff and safeguards road usability
> Protects environment and improves water quality

*Requirement of a good highway drainage system

S.N.	Requirement	Purpose/Benefit
	Rapid removal of surface water	Prevents ponding, infiltration, and pavement damage
	Protection from runoff from adjacent land	Safeguards road structure and prevents erosion
	Sufficient drain capacity & slope	Ensures effective water conveyance
	Groundwater & seepage control	Maintains pavement stability and strength
	Prevention of erosion and rutting	Preserves structural integrity of road
	Adaptation in moist or challenging sites	Prevents waterlogging and structural failure
	Adequate camber on pavement	Aids quick drainage, reducing skid risks
	Sustainable, eco-friendly features	Enhances environmental resilience and water reuse
	Regular maintenance and standards compliance	Ensures long-term function and safety

10.4 Road Pavement
  A. Subgrade (Formation Level)
  > This is the compacted natural soil or fill that forms the foundation for all pavement layers above. Its strength directly impacts the pavement's performance.
  > Proper compaction and drainage are essential to prevent failures like rutting or moisture-related weakening.
  B. Sub-base Course
  > Typically made of granular material like gravel, slag, or clinker, this layer improves load distribution and drainage, especially when the subgrade is weak.
  > It also helps prevent capillary rise of water and provides insulation against frost.
  C. Base Course
  > Often the most crucial structural layer, it supports traffic loads and transfers them evenly to lower layers.
  > Constructed from high-quality crushed aggregates, sometimes stabilized with cement or asphalt.
  D. Binder Course (Intermediate Layer)
  > A bituminous layer sandwiched between the base course and surface layer in flexible pavements.
  > It strengthens structure, aids load distribution, and ensures good bonding between layers.

E. Surface or Wearing Course
➢ The topmost layer exposed to traffic, providing a smooth, skid-resistant surface with weather protection.
➢ In flexible pavements, it's asphalt concrete; in rigid pavements, it's a concrete slab

10.5 Road machineries

*Road Moving machineries
A. Excavators
➢ **Function:** Used for digging trenches, foundations, and lifting heavy materials.
➢ **Features:** Equipped with a bucket, boom, and arm mounted on a rotating platform.
➢ **Applications:** Excavation, demolition, and material handling.
B. Bulldozers
➢ **Function:** Designed for pushing large quantities of soil, sand, rubble, or other materials.
➢ **Features:** Equipped with a large metal blade at the front and often a ripper at the rear.
➢ **Applications:** Clearing land, grading, and road construction.
C. Motor Graders
➢ **Function:** Used to create a flat surface during the grading process.
➢ **Features:** Long adjustable blade for fine grading and leveling.
➢ **Applications:** Road maintenance and preparation of subgrade surfaces.
D. Wheel Loaders
➢ **Function:** Used for loading materials into trucks or moving them around a site.
➢ **Features:** Front-mounted bucket for scooping and lifting.
➢ **Applications:** Material handling and stockpiling.
E. Backhoe Loaders
➢ **Function:** Versatile machines with a loader bucket at the front and a backhoe at the rear.
➢ **Features:** Compact size suitable for urban and small-scale projects.
➢ **Applications:** Digging, trenching, and material handling.
F. Skid-Steer Loaders
➢ **Function:** Compact machines with lift arms for attaching various labor-saving tools or attachments.
➢ **Features:** Maneuverable in tight spaces with a rigid frame.
➢ **Applications:** Landscaping, demolition, and material handling.
G.   Dump Trucks
➢ **Function:** Transport materials such as sand, gravel, or debris to and from construction sites.
➢ **Features:** Open-top bed that can be raised to dump contents.
➢ **Applications:** Material transport and disposal.
H. Rollers (Compactors)
➢ **Function:** Used to compact soil, gravel, concrete, or asphalt in the construction of roads.
➢ **Features:** Heavy cylindrical drums that apply pressure to the surface.

> **Applications:** Surface compaction and preparation.

*Road compacting machineries

A. **Plate Compactors (Vibratory Plate Compactors)**
> **Use:** Ideal for compacting granular soils, sand, and asphalt in confined spaces.
> **Features:** Hand-guided, portable, and effective for small-scale projects.

B. **Rammers (Jumping Jacks)**
> **Use:** Designed for compacting cohesive soils like clay and silt.
> **Features:** Self-propelled with a high impact force, suitable for trench work and confined areas.

C. **Smooth Drum Rollers**
> **Use:** Effective for compacting granular materials and asphalt.
> **Features:** Heavy, steel drums provide static compaction; suitable for large, flat areas.

D. **Vibratory Rollers**
> **Use:** Suitable for compacting granular soils, aggregates, and asphalt.
> **Features:** Equipped with vibrating drums to increase compaction efficiency.

E. **Pneumatic-Tired Rollers**
> **Use:** Ideal for compacting asphalt layers.
> **Features:** Multiple rubber tires provide uniform pressure distribution, reducing surface damage.

F. Sheepsfoot Rollers
> **Use:** Primarily used for compacting cohesive soils like clay.
> **Features:** Drums with protruding feet create kneading action, enhancing compaction in cohesive materials.

G. **Impact Rollers**
> **Use:** Used for deep compaction of granular soils and rock fills.
> **Features:** Heavy, impact-generating drums provide high-energy compaction.

H. **Combination Rollers**
> **Use:** Versatile for compacting both granular and cohesive soils.
> **Features:** Combine smooth drum and pneumatic tires in one machine for efficient compaction.

10.7 Bridge
> A bridge is structure provided to cross-on obstacle.
> A cross drainage structure provided to structure having span length less or equal to 6m (<6m) is known as culvert.
> Having span length more than 6 m is called bridge.

10.7.1 T-Beam bridge
> Bridge having shape of T are called T-beam bridge.
> T-beam bridge are suitable for span upto 25m generally of (10-25)m.

!0.7.2 timber bridge
> Bridge constructed of timber are timber bridge.
> Timber having suitable for span length of (8-12)m and generally for pedestrian.
> Used;where small width.

10.8 Road maintenance and Repair

Road maintenance and repair are essential activities aimed at preserving and enhancing the functionality, safety, and longevity of road infrastructure.

10.8.1 Types of maintenance works

A. **Routine Maintenance**

Routine maintenance involves regular, ongoing tasks to keep roads in good condition and safe for use. These activities are scheduled and performed at regular intervals to address minor issues before they become significant problems. Examples include:

> - Pothole patching
> - Crack sealing
> - Surface cleaning and sweeping
> - Drainage maintenance
> - Vegetation control and brushing
> - Signage and guardrail inspection and repair

B. Preventive Maintenance

Preventive maintenance aims to prolong the life of roadways and prevent major repairs by addressing potential issues before they develop. This approach is proactive and cost-effective, focusing on maintaining the road's structural integrity. Common preventive measures include:

> - Asphalt overlays
> - Surface dressing or sealing
> - Crack filling
> - Joint sealing
> - Resurfacing

C. Emergency Maintenance

Emergency maintenance is reactive and addresses unexpected road failures or hazards that pose immediate risks to safety or traffic flow. This type of maintenance is unplanned and requires swift action to restore road usability. Situations requiring emergency maintenance may include:

> - Flood damage
> - Landslides
> - Accidents involving hazardous materials
> - Structural failures
> - Severe weather-related damage

D. Recurrent maintenance

The works in general need to be dine by the use of minor equipment. Recurrent maintenance may include:

> - Sealing cracks
> - Local surface treatment
> - Repair of depression
> - Holes and ruts
> - Pothole patching
> - Edge repair
> - Local reconstruction

E. Periodic Maintenance

Maintenance operations of large extent required only at intervals of several years. Periodic maintenance may include:

> - Surface treatment
> - Slurry sealing
> - Resurfacing (thin overlay)

10.9 Tracks and Trails
*Track

- ➤ A **track** refers to a pathway designed for the movement of vehicles, typically associated with railroads or specialized transport systems.
- ➤ to temporary or construction access routes used by machinery and vehicles.
- ➤ **Users**: Motorized vehicles, construction equipment, and trains.
- ➤ **Examples**: Railroad tracks, construction access tracks, and temporary haul roads.

*Trail

- ➤ A **trail** is a designated path designed primarily for non-motorized activities such as walking, cycling, horseback riding, or cross-country skiing.
- ➤ Trails are often constructed in natural or rural settings, providing recreational opportunities and connecting communities.
- ➤ **Users**: Pedestrians, cyclists, equestrians, and outdoor enthusiasts
- ➤ **Examples**: Rail-trails, nature trails, and multi-use paths.

*All Numerical and remaining part discuss in physical and online class.

Highway engineering

1. **For transportation purpose in Nepal, the first preference is given to**
   a) air lines
   b) roads
   c) shipping
   d) railways

2. **In telford construction, the side portions were made up of only one layer of broken stones and levelled off to give a camber not greater than**
   a) 1 in 40
   b) 1 in 60
   c) 1 in 80
   d) 1 in 120

3. In water-bound macadam roads
   a) small broken stones are laid in two layers
   b) voids between the stones are filled by stone dust
   c) camber for drainage is given at the formation level it self
   d) all of the above

4. **Which one is correct sequence with respect to four stages of survey in a highway alignment?**
   a) reconnaissance, map study, preliminary survey, final survey
   b) map study, reconnaissance, preliminary survey, final survey
   c) reconnaissance, preliminary survey, map study, final survey
   d) preliminary survey, reconnaissance, map study, final survey

5. **The economic survey of a proposed road project includes a detailed survey of**
   a) origin and destination of traffic
   b) agricultural and industrial products available in the area
   c) resources of income of local bodies as toll tax
   d) characteristics of soil at various level

6. **An undesirable element to be avoided while fixing the alignment of a highway is**
   a) short and straight route
   b) right angled to the bridge, culvert etc.
   c) rising ground and high embankment
   d) proximity to the place of worship

7. **As per NRS 2070 a minimum width of foot path should be**
   a) 60 cm
   b) 120 cm
   c) 150 cm
   d) 300 cm

8. **The city roads which are meant for through traffic usually on a continuous route are known as**
   a) express
   b) arterial/street road
   c) sub-arterial streets
   d) collector streets

9. **Mostly used road in Nepal is**
   a) earthen road
   b) WBM road
   c) bitumen road
   d) cement concrete road

10. **The road connecting head quarter of zone is called**
    a) national highway
    b) local road
    c) zonal road
    d) feeder road

11. **A circumferential road, built around an urban area to enable free flow of traffic is called**
    a) ring road
    b) loop road
    c) mid strip
    d) circular road

12. **A road within a town is called**
    a) truck road
    b) country road
    c) carriage road
    d) street

13. **The portion of the road for high speed vehicles is known as**
    a) motor way
    b) express way
    c) both (a) and (b) of above
    d) carriage way

14. **A junction so designed that traffic streams are divided to enable them to pass over or under each other is called**
    a) sub-way
    b) loop-road

c) fly-over

d) by-pass road

15. **An underground passage used by pedestrians, vehicular traffic etc. is called**

    a) sub-way

    b) service road

    c) drive way

    d) fly-over

16. **A portion of the traffic way that is used by the pedestrians only is called**

    a) foot path

    b) side walk

    c) foot way

    d) all of the above

17. **The alignment of a road should cross the series of hills through**

    a) ride

    b) saddle

    c) valley

    d) none of the above

18. **A dividing strip in the middle of the road way is called**

    a) central strip

    b) median strip

    c) mid strip

    d) road center

19. **The length of ring road around Kathmandu valley is**

    a) 27 km

    b) 29 km

    c) 29.5 km

    d) 30 km

20. **The length of Arniko Highway connecting Kathmandu to Kodari is**

    a) 82 km

    b) 93 km

    c) 112 km

    d) 123 km

21. **Number of National highway in Nepal (According to decision of Ministries of council dated 2076/02/06)**

    a) 35

    b) 92

    c) 80

    d) 115

22. **Siddhartha highway connect**

    a) Belahiya–Pokhara

    b) Kathmandu–Pokhara

    c) Birgunj–Pokhara

    d) none of the above

23. **The types of transition curves generally used in hill road is**

    a) spiral

    b) circular

    c) parabolic

    d) lemniscate

24. **Mahendra Rajmarg of Nepal does not touch the boarder of .... Terai district.**

    a) Sarlahi

    b) Rautahat

    c) Bara

    d) Parsa

25. **The concrete pavement is provided when the daily traffic load per lane exceeds**

    a) 100 ton

    b) 1000 ton

    c) 500 ton

    d) 10,000 ton

26. The basic requirement of road alignment should be

    a) Short

    b) Easy

    c) Safe

    d) Short, easy, safe and economical

27. The changes in gradient and vertical curves fall under

    a) Horizontal alignment

    b) Vertical alignment

    c) Geometric design

    d) Highway specifications

28. The most economical option when constructing a road around a hill is to

    a) Cut the hill

    b) Provide a tunnel

    c) Provide a road around the hill

    d) Look for alternative approaches

29. Obligatory points in alignment refer to locations that alignment should

    a) Pass through

    b) Not pass through

    c) Both pass through and avoid

    d) None

30. The maximum number of cities and towns are connected by which type of highway?

    a) State highway   b) National highway

    c) Village road   d) Major district road

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31. What is the first step in highway construction after paperwork?
a) Evaluation   b) Surveying
c) Bill of quantities   d) Estimation

32. The economical highway can be achieved by
a) More transport cost and less quality aggregate
b) Cheap aggregate
c) Good quality aggregate
d) Good aggregate and less transport cost

33. The vertical alignment of a highway includes?
a) Highway lighting
b) Design of valley curves and gradients
c) Sight distance and traffic intersection
d) Widening of pavements

34. Which of the following pavement is better for highway lighting?
a) Gravel roads
b) WBM
c) Black top surface
d) Cement concrete

35. The skid number for highways should not be less than
a) 25   b) 35
c) 45   d) 55

36. The roads passing through hilly terrain and leading to the villages and towns near hills are called
a) Hill road
b) Village road
c) State highway
d) National highway

37. What is the minimum setback?
a) 0.4 m   b) 0.2 m
c) 3.0 m   d) 5.0 m

38. What is the desirable setback?
a) 0.4 m   b) 0.2 m
c) 3.0 m   d) 5.0 m

39. The length of valley curve depends on
a) Speed limit
b) deviation angle

c) Centrifugal acceleration
d) Speed limit and deviation angle

40. What is the total resistance length of a road?
a) Effective length
b) Effective length after friction
c) Effective length after skid
d) Effective length after all resistance

41. What is the most important structure in a hill road?
a) Retaining wall
b) Pavement
c) Drainage
d) Security force

42. The rollers that uses both tamping and kneading is
a) Plain roller
b) Vibratory roller
c) Sheep foot roller
d) Pneumatic roller

43. The breaking efficiency mainly depends on
a) Sight distance
b) PIEV theory
c) Friction
d) Length of the curve

44. The unevenness index for a good pavement surface of high speed should be
a) 1500mm/km
b) 2500mm/km
c) 3500mm/km
d) 4500mm/km

45. The camber required depends on
a) Type of pavement
b) Rainfall
c) Type of pavement and rainfall
d) Rainfall characteristics

46. In scant rainfall regions, the camber provided is
a) Nill
b) Flatter
c) Steeper
d) normal

47. The minimum camber required in heavy rainfall area for bituminous roads as per IRC is
a)1%   b)2.5%
c)2.7%   d)3%
48. The camber of shoulders in water bound macadam roads is
a)equal to the cross slope of pavement
b)less than the cross slope of pavement
c)greater than the cross slope of pavement
d)zero
49. Camber is provided on
   a) Straight road
   b) Curved road
   c) Super elevation
   d) All of the above
50. The fundamental factor in the selection of pavement type is
a)climatic condition
b)type and intensity of traffic
c)subgrade soil and drainage conditions
d)availability of funds for the construction project
51. As per IRC recommendations, the maximum limit of super elevation for mixed traffic in plain terrain is
a)1 in 15
b) 1 in 12.5
c)1 in 10
d) equal to camber
52. Excessive camber camber on pavement may cause
   a) Erosion of the berms
   b) Deterioration of center position
   c) Slip of the speedy vehicle
   d) All of the above
53. Reaction time of a driver
a)increases with increase in speed
b)decreases with increase in speed
c)is same for all speeds
d)none of the above

54. For water bound macadam roads in localities of heavy rainfall, the recommended value of camber is
a)1 in 30
b) 1 in 36
c)1 in 48
d) 1 in 60
55. Which of the following represents a carpet of sand-bitumen mix without coarse aggregates?
a)mastic asphalt
b)sheet asphalt
c)bituminous carpet
d) bituminous concrete
56. When two equally important roads cross roughly at right angles, the suitable shape of central island is
a)circular
b)elliptical
c)tangent
d) turbine
57. Set back distance is the distance between
   a) The centerline of a horizontal curve and an obstruction on the inner side of the curve
   b) The outer edge of the road and the design vehicle's track
   c) The centerline of a horizontal curve and the outer shoulder
   d) The centerline of a vertical curve and the crest point
58. Which of the following is considered to be the highest quality construction in the group of black top pavements?
a)Mastic asphalt
b) Sheet asphalt
c)Bituminous carpet
d) Bituminous concrete
59. The function of an expansion joint in rigid pavements is to
   a) Relieve warping stresses
   b) Relieve shrinkage stresses
   c) Resist stresses due to expansion
   d) Allow free expansion

60. Which of the following premix methods is used for base course?
   a) bituminous carpet
   b) mastic asphalt
   c) sheet asphalt
   d) bituminous bound macadam

61. In case of summit curves, the deviation angle will be maximum when
   a) an ascending gradient meets with another ascending gradient
   b) an ascending gradient meets with a descending gradient
   c) a descending gradient meets with another descending gradient
   d) an ascending gradient meets with a level surface

62. In the penetration macadam construction, the bitumen is
   a) Sprayed after the aggregates are spread and compacted
   b) Premixed with aggregates and then spread
   c) Sprayed before the aggregates are spread and compacted
   d) None of the above

63. Maximum daily traffic capacity of bituminous pavements is
   a) 500 tonnes per day
   b) 1000 tonnes per day
   c) 1500 tonnes per day
   d) 2000 tonnes per day

64. Psychological extra widening depends on the
   a) Speed of vehicle
   b) No of traffic lanes
   c) Length of wheel base
   d) Both B and C

65. Penetration test on bitumen is used for determining its
   a) Grade
   b) Viscosity
   c) Temperature susceptibility
   d) Ductility

66. Bitumen of grade 80/100 means
   a) its penetration value is 8 mm
   b) its penetration value is 10 mm
   c) its penetration value is 8 to 10 mm
   d) its penetration value is 8 to 10 cm

67. When the bituminous surfacing is done on already existing black top road or over existing cement concrete road, the type of treatment given is
   a) Seal coat
   b) Tack coat
   c) Prime coat
   d) Spray of emulsion

68. The binder normally used in flexible pavement construction is
   a) cement
   b) lime
   c) bitumen
   d) none of the above

69. On a single lane road with two way traffic, the minimum stopping sight distance is equal to
   a) stopping distance
   b) two times the stopping distance
   c) half the stopping distance
   d) three times the stopping distance

70. Which of the following shapes is preferred in a valley curve?
   a) Square parabola
   b) Cubic parabola
   c) Spiral
   d) Lemniscate

71. Which of the following shapes is preferred in a summit curve?
   a) Square parabola
   b) Cubic parabola
   c) Spiral
   d) Lemniscate

72. Design of horizontal and vertical alignments, super-elevation, sight distance and grades, is worst affected by

a) width of the vehicle
b) length of the vehicle
c) height of the vehicle
d) speed of the vehicle

73. Pick up the incorrect statement from the following. The super-elevation on roads is
    a) directly proportional to width of pavement
    b) directly proportional to velocity of vehicles
    c) inversely proportional to acceleration due to gravity
    d) inversely proportional to the radius of curvature

74. Increase in traffic volume, due to increase in transport vehicles, is known as
    a) development traffic
    b) normal traffic growth
    c) generated traffic growth
    d) current traffic

75. Volume of traffic which would immediately use a new road or an improved one when opened to traffic, is known
    a) Development traffic
    b) Current traffic
    c) General traffic
    d) Normal traffic growth

76. During reconnaissance, the general route of the alignment is selected then
    a) A trace is cut for the alignment
    b) The detailed surveys for desired geometric of the highway
    c) Both A and B of the above
    d) Neither A nor B

77. Reinforcement in cement concrete slab of road pavements, is placed
    a) in the form of welded wire mesh
    b) transversely
    c) longitudinally and transversely
    d) longitudinally

78. Driving vehicles on wet surfaced roads, is dangerous because it may
    a) skid
    b) slip
    c) overturn
    d) all the above

79. The main advantage of providing super-elevation is
    a) to decrease the intensity of stresses on the foundation
    b) to increase the stability of the fast moving vehicles, when they negotiate a horizontal curve
    c) to achieve higher speed of vehicles
    d) all of the above

80. In the absence of super-elevation on road along curves, pot holes are likely to occur at the
    a) centre
    b) outer edge
    c) inner edge
    d) Both outer and inner edge

81. The wearing course in the case of flexible pavements consist of
    a) hard well burnt clinker
    b) broken stone and granular material mixed with tar
    c) a mixture of bituminous material and aggregate
    d) all of the above

82. The main advantage of concrete pavements is that
    a) it offers less resistance to traffic
    b) it is not slippery when clean
    c) it has low maintenance cost
    d) all of these

83. The length visible to the driver at any moment is called _____.
a) Sight distance
b) Visibility limit
c) Headlight distance
d) Overtaking sight distance

84. The stopping sight distance does not depend on _____.

a) Driver reaction time
b) Vehicle speed
c) Vehicle length
d) Coefficient of friction

85. **The SSD is based on _____.**
   a) Speed of vehicle
   b) PIEV theory
   c) Voluntary action of brain
   d) Reflex action of brain

86. **Stopping sight distance is always _____.**
   a) Less than overtaking sight distance
   b) Equal to overtaking sight distance
   c) More than overtaking sight distance
   d) None of the above

87. **What does the term 'sight distance' refer to in highway design?**
   a) Distance a driver can see to appreciate scenery
   b) Maximum distance visible for safe driving decisions
   c) Distance between two road signs
   d) Length of vehicle's headlight beam

88. **The steepest gradient permitted on roads, used when ruling gradient is not feasible, is called:**
   a) Ruling gradient
   b) Limiting gradient
   c) Exceptional gradient
   d) Floating gradient

a) **The maximum design gradient for the vertical profile of a road is referred to as:**
   a) Ruling gradient
   b) Limiting gradient
   c) Exceptional gradient
   d) Minimum gradient

89. **A gradient along which a vehicle does not require any tractive effort to maintain a specified speed is called:**
   a) Ruling gradient
   b) Pushing gradient
   c) Floating gradient
   d) Minimum gradient

90. **In steep terrain, the ruling gradient is limited to (select the closest):**
   a) 1 in 25
   b) 1 in 20
   c) 1 in 17
   d) 1 in 12.5

91. **The branch of civil engineering concerned with removing excess surface and subsurface water within the roadway is called:**
   a) Highway engineering
   b) Highway maintenance
   c) Highway drainage
   d) Highway financing

92. **What are the two primary classifications of highway drainage systems?**
   a) Gradient and cross slope
   b) Surface and sub-surface drainage
   c) Curbs and gutters
   d) Side ditches and culverts

93. **Which component intercepts water flowing toward the road and reduces erosion and landslide risks?**
   a) Culvert
   b) Underdrain
   c) Catch water drain
   d) Soakaway

94. **The minimum recommended drainage gradient to prevent water pooling on a road is:**
   a) 0.1%
   b) 0.5%
   c) 5%
   d) 10%

95. **Flexible pavement consists of _____ course after subgrade course.**
   a) Grade course
   b) Base course
   c) Sub-base course
   d) Binder course

96. **Which of the below is not a purpose of providing a prime coat?**
   a) Bonding
   b) Cohesion
   c) Toughness
   d) Waterproofing

97. **It is important to ensure that the subgrade is not _____ at any time.**
   a) Flooded
   b) Overstressed

c) Over compacted
d) Cleaned

98. Frost protection layer is provided in between which layers?
a) Surface and base course
b) Sub-base and base course
c) Subgrade and sub-base course
d) Surface and sub-base course

99. What is the thickness of the binder course that is provided in the pavement?
a) 50 – 100 mm
b) 100 – 200 mm
c) 25 – 50 mm
d) 100 – 150 mm

100. What type of surface course is provided in a semi-rigid pavement?
a) None
b) Flexible
c) Rigid
d) Pozzolanic

101. Acrylic sealer is preferred to fast dry sealers.
a) True
b) False

102. Which of the below doesn't represent the purpose of providing a base course in the rigid pavement?
a) Prevent pumping
b) Carry load
c) Resist frost
d) Slab settlement

103. Within what temperature range should the tack coat be applied?
a) 30 – 40°C
b) 20 – 50°C
c) 34 – 44°C
d) 24 – 54°C

104. Which of the following machines is primarily used for compacting soil in road construction?
a) Bulldozer
b) Excavator
c) Road Roller
d) Grader

105. Which type of roller is best suited for compacting granular soils like sand and gravel?

a) Sheep Foot Roller
b) Smooth-Wheel Roller
c) Pneumatic Tyre Roller
d) Vibratory Roller

106. What is the primary purpose of compaction equipment on construction sites?
a) Concrete Finishing
b) Soil Stabilization
c) Material Transport
d) Excavation

107. Which type of compaction equipment roller consists of a hollow cylindrical steel drum on which projecting feet are mounted?
a) Smooth Wheel Roller
b) Pneumatic Tyre Roller
c) Sheep Foot Roller
d) Vibratory Roller

108. Which of the following is commonly used for compacting soil and aggregates during road construction?
a) Bulldozer
b) Excavator
c) Roller
d) Grader

109. Which compaction method involves applying stress by dropping a large mass onto the surface of the soil?
a) Static Compaction
b) Impact Compaction
c) Vibratory Compaction
d) Kneading Compaction

110. Which of the following machines is used for compaction in road construction?
a) Bulldozer
b) Excavator
c) Road Roller
d) Grader

111. Which equipment is commonly used for compacting soil and aggregates during road construction?
a) Bulldozer
b) Excavator
c) Roller
d) Grader

112. Which type of roller is effective for compacting cohesive soils such as clays?
a) Smooth Wheel Roller
b) Pneumatic Tyre Roller
c) Sheep Foot Roller
d) Vibratory Roller

113. What is the primary function of the flange in a T-beam bridge?
a) To resist shear stress
b) To resist compressive stress
c) To resist tensile stress
d) To act as a decorative element

114. In a T-beam, what does the web primarily resist?
a) Compressive stress
b) Shear stress
c) Tensile stress
d) Bending stress

115. Which of the following is a common span range for RCC T-beam and slab bridges?
a) 5–19 m
b) 10–15 m
c) 15–20 m
d) 20–25 m

116. What is the typical material used for the flange and web in T-beam bridges?
a) Steel
b) Wood
c) Reinforced concrete
d) Aluminum

117. What is the main advantage of using T-beam bridges in construction?
a) High aesthetic value
b) Efficient use of materials
c) Easy to dismantle
d) Requires minimal maintenance

118. In the context of T-beam bridges, what does 'bw' represent?
a) Width of the flange
b) Width of the web
c) Beam weight
d) Beam width

119. Which of the following is a disadvantage of T-beam bridges?
a) High construction cost
b) Limited span length

c) Complex design calculations
d) Requires specialized materials

120. In a T-beam bridge, what is the purpose of the slab?
a) To provide aesthetic appeal
b) To distribute loads to the beams
c) To act as a support for the web
d) To resist tensile stress

121. Which of the following is a typical application of T-beam bridges?
a) Pedestrian walkways
b) Small residential bridges
c) Highway overpasses
d) Decorative garden features

122. What is the primary advantage of using timber in bridge construction?
a) High tensile strength
b) Lightweight and easy to transport
c) High cost
d) Requires minimal maintenance

123. Which type of timber bridge is commonly used for short spans and is supported by rigid frames?
a) Arch bridge
b) Beam bridge
c) Trestle bridge
d) Suspension bridge

124. What is the main disadvantage of timber bridges compared to concrete or steel bridges?
a) Higher cost
b) Susceptibility to decay and pests
c) Limited span length
d) Complex construction process

125. Which of the following is a common treatment applied to timber used in bridge construction to enhance durability?
a) Galvanization
b) Pressure treatment with preservatives
c) Painting with epoxy
d) Coating with asphalt

126. Which of the following is a typical application of timber bridges?
a) Pedestrian walkways
b) Heavy vehicular traffic routes

c) High-speed rail lines
d) Large-scale industrial areas

127. What is a common method for enhancing the fire resistance of timber used in bridge construction?
a) Applying fire-retardant coatings
b) Using naturally fire-resistant timber species
c) Incorporating fire-resistant additives during manufacturing
d) All of the above

128. Which of the following is a characteristic feature of a timber trestle bridge?
a) Use of steel cables for support
b) Multiple short spans supported by closely spaced frames
c) Single long span with a central support
d) Elevated deck supported by piers

129. Which timber species is commonly used in the construction of timber bridges due to its strength and durability?
a) Pine
b) Oak
c) Sal wood
d) Redwood

130. What is the primary purpose of using timber in bridge construction in rural or forested areas?
a) Aesthetic appeal
b) Availability of local materials
c) High load-bearing capacity
d) Resistance to environmental factors

131. Which of the following is a characteristic of a "circuit trail"?
a) It starts and ends at different points
b) It is a loop, returning to the starting point
c) It is a one-way trail
d) It is primarily used for cycling

132. In graph theory, what defines a "trail"?
a) A walk that repeats vertices
b) A walk that repeats edges
c) A walk that does not repeat vertices or edges
d) A closed walk

133. Which type of trail is specifically designed for equestrian use?
a) Bridle trail
b) Hiking trail
c) Ski trail
d) Biking trail

134. What is the primary purpose of a "service trail"?
a) To provide access for emergency vehicles
b) To offer scenic views for tourists
c) To serve as a recreational path
d) To connect different hiking trails

135. Which of the following is true about a "closed walk" in graph theory?
a) It starts and ends at the same vertex and does not repeat edges
b) It starts and ends at the same vertex and may repeat edges
c) It starts and ends at different vertices
d) It is a path that does not repeat vertices

136. Which type of trail is primarily used for cross-country skiing?
a) Ski trail
b) Hiking trail
c) Equestrian trail
d) Biking trail

137. In graph theory, what is a "path"?
a) A walk that repeats vertices
b) A walk that does not repeat vertices or edges
c) A closed walk
d) A walk that repeats edges

138. Which of the following is a characteristic of a "multi-use trail"?
a) It is designated for a single type of activity
b) It is designed for multiple types of activities, such as hiking, biking, and horseback riding
c) It is restricted to motorized vehicles only
d) It is a private trail for landowners

139. Which of the following is a common feature of "interpretive trails"?
a) They are designed for competitive races

b) They provide educational information about the environment or history
c) They are only accessible by permit
d) They are primarily used for motorized vehicles

140. What is the main difference between a "trail" and a "path" in outdoor settings?
a) A trail is wider than a path
b) A path is a type of trail
c) A trail is a type of path
d) There is no difference; they are synonymous

141. Which of the following is a characteristic of a "multi-use trail"?
a) It is designated for a single type of activity
b) It is designed for multiple types of activities, such as hiking, biking, and horseback riding
c) It is restricted to motorized vehicles only
d) It is a private trail for landowners

*Topics Wise MCQ discussion in physical and online class.

Answers

1	B	21	C	41	A	61	B	81	D	101	A	121	C	141	B
2	B	22	A	42	C	62	A	82	D	102	B	122	B		
3	D	23	A	43	C	63	C	83	A	103	D	123	C		
4	B	24	D	44	A	64	A	84	C	104	C	124	B		
5	B	25	B	45	C	65	A	85	B	105	B	125	B		
6	D	26	D	46	B	66	C	86	A	106	B	126	A		
7	C	27	B	47	B	67	B	87	B	107	C	127	D		
8	B	28	C	48	A	68	C	88	B	108	C	128	B		
9	A	29	B	49	A	69	B	89	C	109	B	129	C		
10	D	30	B	50	B	70	B	90	C	110	C	130	B		
11	A	31	B	51	A	71	A	91	C	111	C	131	B		
12	D	32	D	52	D	72	D	92	B	112	C	132	B		
13	C	33	B	53	B	73	B	93	C	113	B	133	A		
14	D	34	D	54	B	74	B	94	B	114	B	134	A		
15	A	35	D	55	B	75	D	95	C	115	A	135	B		
16	D	36	A	56	A	76	C	96	B	116	C	136	A		
17	B	37	C	57	A	77	A	97	B	117	B	137	B		
18	B	38	D	58	D	78	B	98	C	118	B	138	B		
19	A	39	D	59	D	79	D	99	A	119	B	139	B		
20	C	40	D	60	D	80	B	100	B	120	B	140	C		

11. Estimating and Costing

11.1 General

*Estimating and Costing

Estimating is the process of calculating the probable cost of a project before work begins and costing is the process of calculating the overall cost of any project before or after the work complete is called costing.

*Purpose of estimating

- ➢ To find the probable cost of any project.
- ➢ To have an idea about the time of work complete.
- ➢ To arrange the required labor with required work.
- ➢ To find the benefit cost ratio.
- ➢ To control the extra expenditure of the work.
- ➢ For tender invites.
- ➢ For valuation.

11.1.1 Main items of work

- A. Clearing the site
- B. Soil excavation for foundation trenches
- C. Earthwork filling (foundation & plinth)
- D. Damp-proof courses (DPC)
- E. Plain Cement Concrete (PCC) for foundations and slabs
- F. Reinforced Cement Concrete (RCC) for structural elements, plus steel reinforcement and formwork
- G. Steel work for reinforcement
- H. Wood work
- I. Painting

11.1.2 Units of Measurement
A. Earthwork & Site Preparation

1. **Excavation** – Cubic Meter (m³)
2. **Filling** – Cubic Meter (m³)
3. **Dressing** – Square Meter (m²)
4. **Compaction** – Cubic Meter (m³)
5. **Trenching** – Cubic Meter (m³)
6. **Soil Stabilization** – Cubic Meter (m³)
7. **Grading** – Square Meter (m²)
8. **Slope Protection** – Square Meter (m²)
9. **Clearing Vegetation** – Hectare (ha)
10. **Tree Cutting** – Each (Nos.)
11. **Stump Removal** – Each (Nos.)
12. **Debris Disposal** – Cubic Meter (m³)
13. **Soil Testing** – Each (Nos.)
14. **Surveying** – Meter (m)
15. **Boundary Marking** – Meter (m)

16. **Landscaping** – Square Meter (m²)
17. **Erosion Control** – Square Meter (m²)
18. **Drainage Excavation** – Cubic Meter (m³)
19. **Dewatering** – Cubic Meter (m³)
20. **Shoring** – Square Meter (m²)
21. **Sheet Piling** – Meter (m)
22. **Rock Blasting** – Cubic Meter (m³)
23. **Boulder Removal** – Cubic Meter (m³)
24. **Soil Replacement** – Cubic Meter (m³)
25. **Backfilling** – Cubic Meter (m³)
26. **Consolidation** – Cubic Meter (m³)
27. **Subgrade Preparation** – Square Meter (m²)
28. **Subbase Installation** – Cubic Meter (m³)
29. **Base Course Installation** – Cubic Meter (m³)
30. **Pavement Preparation** – Square Meter (m²)
31. **Asphalt Milling** – Square Meter (m²)
32. **Soil Cement Stabilization** – Cubic Meter (m³)
33. **Geotextile Installation** – Square Meter (m²)
34. **Geogrid Installation** – Square Meter (m²)
35. **Curb & Gutter Construction** – Meter (m)
36. **Sidewalk Construction** – Square Meter (m²)
37. **Driveway Construction** – Square Meter (m²)
38. **Pavement Marking** – Meter (m)
39. **Traffic Sign Installation** – Each (Nos.)
40. **Guardrail Installation** – Meter (m)
41. **Fencing** – Meter (m)
42. **Gate Installation** – Each (Nos.)
43. **Retaining Wall Construction** – Cubic Meter (m³)
44. **Slope Stabilization** – Square Meter (m²)
45. **Noise Barrier Installation** – Meter (m)
46. **Lighting Installation** – Each (Nos.)
47. **Signage Installation** – Each (Nos.)
48. **Utility Relocation** – Meter (m)
49. **Pavement Rehabilitation** – Square Meter (m²)
50. **Bridge Deck Preparation** – Square Meter (m²)

B. Masonry & Concrete Works

51. **Brickwork** – Cubic Meter (m³)
52. **Blockwork** – Cubic Meter (m³)
53. **Stone Masonry** – Cubic Meter (m³)
54. **Reinforced Concrete** – Cubic Meter (m³)
55. **Plain Concrete** – Cubic Meter (m³)
56. **Precast Concrete** – Each (Nos.)
57. **Concrete Slab** – Square Meter (m²)
58. **Concrete Beam** – Cubic Meter (m³)
59. **Concrete Column** – Cubic Meter (m³)
60. **Concrete Footing** – Cubic Meter (m³)
61. **Concrete Staircase** – Cubic Meter (m³)
62. **Concrete Ramp** – Cubic Meter (m³)

63. **Concrete Plinth** – Cubic Meter (m³)
64. **Concrete Slab Formwork** – Square Meter (m²)
65. **Beam Formwork** – Square Meter (m²)
66. **Column Formwork** – Square Meter (m²)
67. **Shuttering** – Square Meter (m²)
68. **Scaffolding** – Square Meter (m²)
69. **Concrete Curing** – Square Meter (m²)
70. **Concrete Cutting** – Meter (m)
71. **Concrete Grinding** – Square Meter (m²)
72. **Concrete Polishing** – Square Meter (m²)
73. **Concrete Sealing** – Square Meter (m²)
74. **Concrete Waterproofing** – Square Meter (m²)
75. **Concrete Painting** – Square Meter (m²)
76. **Concrete Repair** – Square Meter (m²)
77. **Concrete Demolition** – Cubic Meter (m³)
78. **Concrete Disposal** – Cubic Meter (m³)
79. **Concrete Recycling** – Cubic Meter (m³)
80. **Concrete Testing** – Each (Nos.)
81. **Concrete Mix Design** – Each (Nos.)
82. **Concrete Pumping** – Cubic Meter (m³)
83. **Painting**: Measured in Square Meters (m²)
84. **Distempering**: Measured in Square Meters (m²)
85. **Polishing**: Measured in Square Meters (m²)
86. **Waterproofing**: Measured in Square Meters (m²)
87. **Wiring**: Measured in Meters (m)
88. **Conduit Installation**: Measured in Meters (m)
89. **Switches/Sockets**: Measured in Each (Nos.)
90. **Plumbing Pipes**: Measured in Meters (m)
91. **Sanitary Fixtures**: Measured in Each (Nos.)
92. **Boundary Wall**: Measured in Linear Meters (m)
93. **Paving**: Measured in Square Meters (m²)
94. **Landscaping**: Measured in Square Meters (m²)
95. **Drainage**: Measured in Meters (m)
96. **Fencing**: Measured in Meters (m)

*Types of estimate

a) Preliminary estimate:
The main function of preliminary estimate is to find the financial position for approval which is prepared on the basis of cost of similar works. The detail drawing is not necessary for rough estimate.

b) Plinth area estimate:
It is also known as square method. It is prepared on the basis of plinth area of a building multiplied by plinth area rate relevant in the region. It is less accurate.

c) Cube rate estimate:
It is prepared on the basis of the cubical contents of the purposed building to be constructed. It is more accurate than plinth area estimate.

d) Detailed or Item rate estimate:
It is prepared on the basis of plan and sections of structures. It is most accurate estimate and is mostly used.

e) Revised estimate:

It is a detailed estimate and is prepared afresh, when the original sanctioned detailed estimate exceeds by 5% more or expenditure exceeds by 10% either due to the rates being found insufficient or due to some other reasons.

f) Supplementary estimate:

This is fresh a detailed estimate in addition of original one and is prepared when additional work is required to supplement the original work.

g) Annual repair and maintenance estimate:

The estimate prepared to keep the structure in proper condition with the provision of repair and maintenance, is known as annual repair and maintenance estimate. It should not be more than 1.5% of the capital cost of work.

h) Approximate quantity method estimate:

It is very rough estimate.

11.1.3 Standard estimate formats of government offices

A. Quantities calculation and measurement sheet

S.N.	Description of work	No.	Length	Breadth	Height	Quantity	Units	Remarks

B. Abstract of cost

S.N.	Description of work	Unit	Quantity	Rate	Amount	Remarks
1						
2						
3						
4						
				Total cost	**1+2+3+4**	

Estimate cost is increased by 4% for any unforeseen expenditure is called contingency work and VAT 13% as per government rule.

C. Bill Of Quantities (BOQ)

S.N.	Description of work	Unit	Quantity	Rate in Figure	Rate in Words	Amount	Remarks
1	E/W excavation	M3	10	200	Two hundred	2000	

11.2 Rate Analysis

Rate analysis is a technique of determining unit cost of any item of work including cost of materials, cost of labour, cost of hire charge tools, equipment and plants and contractor over head.

*Government procedure of rate analysis:
    A. Material cost (65-79)% of total cost = Rs. X
    B. labour cost (30-35)% of total = Rs. Y
    C. Hire charge tools, equipment and plant (3% of unskilled labour cost)=Rs. Z
    D. Total cost = Rs. (X+Y+Z) (A+B+C)
    E. Contractor overhead is (15% of total cost) = 15% of (X+Y+Z)
$$= 0.15*(X+Y+Z)$$
    F. Grand total cost = D+E
$$=Rs.(X+Y+Z)+0.1*(X+Y+Z)$$

Note:
Contractor profit= 10%
Contractor overhead = 15% (Acc to IS)
Contractor overhead =15%(Acc to norms of nepal)

1.5 Basic general knowledge on the use of rate analysis norms of government of Nepal and approved district rates
*Purpose of rate analysis
    a) Accurate Cost Estimation & Budgeting
    They provide a consistent method to break down work items into cost components, enabling precise budgeting and financial planning.
    b) Transparent Tendering & Bid Comparison
    Since norms standardize costs, they help both public and private agencies compare bids objectively.
    c) Cost Control Throughout the Project
    By offering a baseline rate for each activity, these norms aid in monitoring expenses and identifying cost deviations as projects progress.
    d) Updating with Market Changes
    Norms allow for the revision of rates due to inflation, changes in tax policy, or updated material/labor costs.
    e) Dispute Resolution
    Standardized norms help resolve disagreements between contractors and clients by providing an objective cost reference.

Norms for Rate Analysis of Road and Bridge Works, 2075

S.N.	Description of works	Manpower		Unit	Remarks
		S	Us		
1	**Cutting of trees all complete (201)**				
	Girth from 300 to 600 mm		25	30 nos.	
	Girth from 600 to 900 mm		25	10 nos.	
	Girth from 900 to 1800 mm		35	5 nos.	
	Girth from 1800 to 2500 mm		32	2 nos.	
	Girth above 2500 mm		50	1 no.	
2	**Dismantling of existing structures means (202)**				
A	Concrete graded M10 & below	1	24	20 cum.	
B	Concrete graded M15 & M20	1	30	20 cum.	
C	RCC concrete graded M20 & above (Technical-1)	1, 3	30	10 cum.	

Prep

3	Roadway Excavation in All types of Soil (905, 9.1 I A & B))				
A	Manual means	1	8	12 cum.	
B	Mechanical means	1	3	360 cum.	
4	Roadway Excavation in ordinary rock (905, 9.1 II A & B)				
A	Manual means	3	50	60 cum.	
B	Mechanical means	1	3	120 cum.	
5	**Excavation for Structures Foundation (907)**				
	A) Manual means				
A	Depth utpo 3 m	1	8	10 cum.	
B	Depth 3 to 6 m	1	12	10 cum.	
C	Depth above 6 m	2	18	10 cum.	
	B) Mechanical means				
A	Depth utpo 3 m	1	3	240 cum.	
B	Depth 3 to 6 m	1	3	210 cum.	
C	Depth above 6 m	2	4	180 cum.	
6	**Providing and laying sub-base all complete (1201)**				
A	**Manual means**	2	60	200 cum.	
B	**Mechanical means**	2	12	300 cum.	
7	**Providing, laying, spreading and compacting Water bound macadam all complete(1203)**				
A	Manual means	10	375	360 cum.	
B	Mechanical means	3	15	360 cum.	
8	**Providing, laying Telford base (Block pitching) all complete (1206)**	60	120	50 cum.	
9	**Providing and applying prime coat all complete (1302)**				
A	Manual means	3	100	1000 ltr.	
B	Mechanical means	3	50	5000 ltr.	
10	**Providing and applying tack coat with hot all complete(1302)**				
A	Manual means	3	40	1000 ltr.	
B	Mechanical means	3	20	5000 ltr.	

11	Providing and laying surface dressing all complete(1303)			
A	Manual means	3	12	600 m2
B	Mechanical means	3	12	6000 m2
12	Providing and laying Bituminous concrete/ Asphalt concrete all complete(1309)	5	15	95.5 cum.
13	Providing and laying seal coat sealing all complete (1310)	1	6	7858 sqm.Or 47.16 cum.
14	Providing and laying brick on edge over 60 mm thick sand bed all complete. (1403) (Brick-725)	1	3	10 Sqm.
15	Providing and laying flat brick over 60 mm thick sand bed all complete. (1403) (Brick-750)	1.5	4	20 Sqm.
16	Providing and laying of Plain/RCC in Foundation all complete (2000)			
A	PCC M10	2	22	15 cum.
B	PCC M15	3	30	15 cum.
C	PCC M20	3	30	15 cum.
D	RCC M20	3	30	15 cum.
E	PCC M25	3	30	15 cum.
F	RCC M25	3	30	15 cum.
17	Providing and laying , fitting and placing un-coated Mild steel / HYSD reinforcement all complete (SS: 2104) (MS bar= 1.1 Ton, Binding wire=8 kg)	4	9	1 Ton
18	Providing and laying Brick Masonry Work in Cement mortar in Foundation / structure complete all complete (2500) (Brick-2800)			
A	Cement mortar (1:2)	6	12	5 cum.
B	Cement mortar (1:3)	6	12	5 cum.
C	Cement mortar (1:4)	6	12	5 cum.
D	Cement mortar (1:6)	6	12	5 cum.
19	Providing and laying Brick masonry work in superstructure/ sub-structure all complete (2500) (Brick-2800)			
A	Cement mortar (1:2)	6	12	5 cum.
B	Cement mortar (1:3)	7	14	5 cum.

C	Cement mortar (1:4)	7	14	5 cum.	
D	Cement mortar (1:6)	7	14	5 cum.	
20	Providing, and applying Pointing with cement mortar (1:3) on brick work in structure all complete (2500)				
A	Cement mortar (1:2)	10	12	100 sqm.	
21	Providing and applying 12.5 mm thick Plasterall complete (2500)				
A	Cement mortar (1:2)	10	12	10 sqm.	
B	Cement mortar (1:3)	10	12	10 sqm.	
C	Cement mortar (1:4)	10	12	10 sqm.	
22	Providing and laying of dry Stone Masonry Work all complete (2602, 2603, 2608)	4	8	5 cum.	
23	Providing and laying of RRM in mud Mortar all complete (2602, 2603, 2608)	6	12	5 cum.	
24	Providing and laying of SM in Cement Mortar in Foundation complete all complete (2602, 2603, 2608)				
A	Cement mortar (1:3)	7	14	5 cum.	
B	Cement mortar (1:4)	7	14	5 cum.	
C	Cement mortar (1:6)	7	14	5 cum.	

➢ As per the norms prepared by the Ministry of Physical Infrastructure and Transport labour, materials and equipments are included in the analysis of rate.

*Component of Rate analysis

A. **Material Costs**
   ➢ Includes quantities and unit prices of materials required, along with transport, storage, and wastage.
B. **Labour Costs**
   ➢ Covers wages for skilled, semi-skilled, and unskilled workers, including allowances and benefits.
C. **Equipment (Tools & Plant) Costs**
   ➢ Account for hiring, operating, depreciation, fuel, and maintenance of machinery and tools.
D. **Overhead Costs**
   ➢ Indirect expenses like site supervision, office rent, utilities, insurance, and administrative costs, generally calculated as a percentage of direct costs (often 2–5%).
E. **Contingencies**
   ➢ A buffer allowance for unforeseen issues or cost fluctuations, typically a small percentage of total costs.

F. **Contractor's Profit**
  ➤ A margin added by the contractor, commonly around 10% for larger jobs, and possibly up to 15–20% on smaller projects.

11.3 Specification
  It's a statement giving the clear and concise description of materials, labours and tools and plants to be employed in the execution of any project and methods, precautions etc required before.

*Purpose of specification

A. **Defining Quality & Scope**:
  ➤ Specifications clarify material standards, workmanship, and project requirements
  ➤ Ensuring estimators understand exactly what's needed.
B. **Enabling Detailed and Reliable Estimates**:
  ➤ Well-defined specs paired with drawings make it possible to produce highly accurate, itemized cost estimates.
C. **Consistency and Fair Tendering**:
  ➤ Ensuring all bidders work from the same detailed specifications, estimators can produce fair, comparable bids
  ➤ Especially important when using a Bill of Quantities.
D. **Organization and Standardization**:
  ➤ Using structured frameworks like MasterFormat (divisions by trade) and UniFormat (by building components) keeps specifications well-organized and consistent across estimates.
E. **Supporting Accuracy and Avoiding Cost Variability**:
  ➤ Clear specifications reduce misunderstandings, curb change orders, and improve cost predictability.
F. **Foundation for Cost Control and Updates**:
  ➤ Specifications serve as a baseline, allowing cost changes to be tracked and adjusted systematically.
G. **Client Trust and Effective Tendering**:
  ➤ Detailed specifications foster confidence and transparency among stakeholders, laying the groundwork for smooth, competitive bidding

*Importance of specification
  ➤ Cost of unit quantity of work governed by specification.
  ➤ In arbitration process: specification is a part of contract document.
  ➤ If conflict arises between specification and drawing specification shall given priority.
  ➤ Any contract without specification is incomplete.
  ➤ Any change in specification will changes the rate of material.
  ➤ It specifies quality of materials strength, hence helps to check , superstructure work.

*Types of Specification
  A. General specification
  ➤ In general specifications, nature and class of works and names of materials that should be used are described.
  ➤ Only a brief description of each and every item is given. It's useful for estimating the project.
  ➤ The general specification do not form a part of contract document.
  B. Detailed specification
  ➤ The detailed specification form a part of a contract document.

➢ The specify the qualities, quantitites and proportions of materials and the method of preparation and execution for a particular item of works in a project.
➢ The detailed specifications of the different item of the work are prepared separately and they describe what the work should be and how they shall be executed.
➢ While writing the detailed specifications, the same order sequences as the work is to be carried out is to be maintained.

11.4 Valuation

It is the process of calculating or determining the current rate of any existing property such as land, building, vehicle etc is called valuation.the valur of property mainly depends on it's :
➢ Structure
➢ Life
➢ Location
➢ Supply and demand
➢ Bank interest rate

*Purpose of valuation

➢ To find the current rate of any property.
➢ For buying and selling the property.
➢ Auction of bid property.
➢ Acquisition of the property.
➢ Insurance of property.
➢ Tax fixation.

11.4.1 Method of valuation

A. Direct rental method

➢ This method is adopted when the rental value of the property is known or identified.
➢ The net income is calculate by desuctiign all outgoings from gross income.(net income=gross income-out goining expenditure)
➢ The rate of interest is assumed form open market i.e. 3 to 5 %(generally 3%).
➢ The year of purchase is calculate from

Yp=100/rate of interest

➢ The Yp is multiplied with net income to get the valuaton of the property.

B. **Direct comparison of capitalized value**

➢ This method is adopted when the rental valur isnot identified but some evidence is available or known.
➢ This valuation of property is calculated by direct by direct, comparison with similar property which is located in our locality.

C. **Valuation based on cast**

➢ This method is adopted, based on original/actual co in the construction work and required depreciation is deducted and get the valuation of the property.

D. **Valuation based on profit**

➢ This method is adopted which is based on net profit such as hotels, hospitals, cinema hall, theater etc.
➢ The ent income is calculate by deduction are out-going from gross income.
Net income=gross income-outgoings
➢ The next points should be same as direct rental method.

E. **Under developed method od valuation**

➢ This method is adopted when the property is in underdeveloping stage.
➢ If the property should be renewed, modification, maintenance, security of loan etc.

F. **Depreciation method od valuation**
   - ➢ The building is classified into four party i.e.
     *floor
     *wall
     *doors and windows
     *slab and beams
   - ➢ The quantity should be calculate from detailed measurements and multiplying with specified current rates to get the valuation of the property.
   - ➢ The cost of canal, water supply system, sanitary and electrification is added in valuation of property to get the total valuation of property.

*some terms in estimating and costing

A

1. **Allowance** – A provisional sum included in an estimate to cover the cost of work that is not yet fully defined.
2. **Assembly** – A collection of materials, labor, and equipment grouped together for estimating purposes.
3. **As-Sold Estimate** – The final estimate that matches the agreed items and price for the project scope.
4. **Audit Trail** – A detailed record of all changes made to an estimate, ensuring transparency.

B

5. **Back Charges** – Deductions made from a contractor's payment for costs incurred due to their actions.
6. **Base Estimate** – The most likely project cost estimate, excluding contingency.
7. **Basis of Estimate (BOE)** – A document describing the scope, pricing methods, assumptions, and exclusions.
8. **Bid** – A contractor's offer to perform work at a specified price.
9. **Bid Bond** – A guarantee that a bidder will enter into a contract if awarded.
10. **Bid Item** – A specific item or service included in a bid.
11. **Bill of Materials (BOM)** – An itemized list of materials needed for a project.
12. **Bill of Quantities (BOQ)** – A document listing materials, parts, and labor with their costs.
13. **Break-Even Point** – The point where total costs equal total revenue, resulting in no profit or loss.
14. **Budget Estimate** – An approximate cost estimate used for securing funding.

C

15. **Change Order** – A document that modifies the original contract scope or price.
16. **Class of Estimate** – A categorization of estimates based on their level of detail and accuracy.
17. **Contingency** – An allowance for unforeseen costs during a project.
18. **Cost Allocation** – The process of assigning costs to specific project components.
19. **Cost Control** – The process of monitoring and managing project costs to stay within budget.
20. **Cost Estimate** – An approximation of the costs required to complete a project.
21. **Cost Index** – A numerical measure of cost changes over time.
22. **Cost Risk** – The potential for cost overruns due to uncertainties.
23. **Cost Schedule** – A timeline detailing when costs are expected to occur.
24. **Cost-to-Complete Estimate** – An estimate of the remaining costs to finish a project.
25. **Critical Path Method (CPM)** – A scheduling technique to determine the longest path of planned activities.
26. **Cubic Feet Per Minute (CFM)** – A unit of measurement for airflow volume.
27. **Current Cost Estimate** – An up-to-date estimate reflecting the latest project information.

D

28. **Data Sheet** – A document providing detailed information about materials or equipment.
29. **Definitive Estimate** – A detailed estimate prepared when construction documents are available.

30. **Design Build** – A project delivery method where design and construction services are contracted by a single entity.
31. **Design Development Estimate** – An estimate prepared during the design development phase, incorporating more detailed information.
32. **Direct Costs** – Costs that can be directly attributed to a specific project activity.
33. **Direct Labor** – Labor costs directly involved in the construction process.
34. **Direct Materials** – Materials directly used in the construction process.
35. **Disbursement** – The payment of funds for project expenses.
36. **Diversity Factor** – A factor used to adjust costs based on varying conditions.
37. **Duration** – The total time required to complete a project or task.

E

38. **Earned Value** – A measure of work performed expressed in terms of the budget authorized for that work.
39. **Economic Life** – The period during which an asset is expected to be useful.
40. **Escalation** – The adjustment of costs to account for inflation or market changes.
41. **Estimate at Completion (EAC)** – The expected total cost of a project when all work is completed.
42. **Estimate to Complete (ETC)** – The expected cost needed to complete all remaining work for a project.
43. **Estimate Type** – The classification of an estimate based on its purpose and timing.
44. **Exclusion** – Items or services that are not included in the scope of work.
45. **Expenditure** – The outflow of funds for project costs.

F

46. **Feasibility Study** – An analysis to determine the viability of a project.
47. **Final Account** – The final statement of account between the contractor and client.
48. **Fixed Costs** – Costs that do not change with the level of production or activity.
49. **Floating** – The amount of time that a task can be delayed without affecting the project completion date.
50. **Force Account** – Work performed using the contractor's own forces rather than subcontractors.
51. **Forecast** – An estimate of future project costs based on current data.

G

52. **General Conditions** – The general requirements and provisions of a contract.
53. **General Overhead** – The indirect costs associated with running a business.
54. **Gross Profit** – Revenue minus the cost of goods sold.
55. **Gross Unit Price** – The total price per unit, including all associated costs.
56. **Gross Value** – The total value of work completed before deductions.

H

57. **Hard Costs** – Direct costs associated with physical construction, such as materials and labor.
58. **Headquarters Costs** – Costs incurred at the contractor's main office, not directly attributable to a specific project.
59. **Hourly Rate** – The cost per hour for labor or equipment usage.

I

60. **Indirect Costs** – Costs not directly attributable to a specific project activity.
61. **Indirect Labor** – Labor costs not directly involved in the construction process.
62. **Indirect Materials** – Materials used for general purposes, not directly in the construction process.
63. **Inflation Factor** – A multiplier used to adjust costs for inflation.
64. **Initial Estimate** – The first estimate prepared at the beginning of a project.
65. **Installation Costs** – Costs associated with setting up equipment or systems.
66. **Interim Payment** – A partial payment made during the course of a project.
67. **Item Rate** – The cost per unit of a specific item of work.

J

68. **Job Costing** – The process of tracking costs associated with a specific project.
69. **Job Order** – A work order specifying tasks to be completed.

K

70. **Key Performance Indicator (KPI)** – A metric used to evaluate the success of a project.
71. **Kickoff Meeting** – The initial meeting to discuss project objectives and plans.

L

72. **Labor Burden** – The additional costs associated with employing labor, such as taxes and benefits.
73. **Labor Cost** – The total cost of labor, including wages and benefits.
74. **Labor Productivity** – The amount of work completed per unit of labor input.
75. **Lump Sum Estimate** – An estimate where the total cost is agreed upon before the project begins.
76. **Line Item** – An individual entry in a list, such as a bill of quantities.

M

77. **Man-Hour** – The amount of work one person can complete in one hour.
78. **Markup** – An amount added to the cost to determine the selling price.
79. **Material Cost** – The total cost of materials required for a project.
80. **Material Takeoff (MTO)** – The process of measuring and listing materials needed for a project.
81. **Master Format** – A standard for classifying construction specifications.
82. **Mobilization** – The process of preparing and equipping a construction site.
83. **Modeling** – Creating a digital representation of a project.
84. **Market Conditions** – The economic factors affecting the cost of materials and labor.

*All numerical and remaining part discuss in physical and online class.

1. **What is the primary purpose of estimating in civil engineering?**
   A) To calculate load
   B) To know the probable cost
   C) To design the structure
   D) To ensure quality

2. **Which of the following is a detailed estimate?**
   A) Preliminary estimate
   B) Quantity estimate with cost
   C) Plinth area estimate
   D) Rough estimate

3. **The unit of measurement for brickwork in cement mortar is:**
   A) Square meter
   B) Cubic foot
   C) Cubic meter
   D) Running meter

4. **Measurement of steel reinforcement is done in:**
   A) Cubic meter
   B) Kilograms
   C) Square meter
   D) Tons

5. **The main purpose of estimating is to:**
   A) Calculate load
   B) Know the probable cost
   C) Design the structure
   D) Ensure quality

6. **The deduction for one door of area 2 square meters in plastering is:**
   A) 1 m²
   B) 2 m²
   C) 2.5 m²
   D) 1.5 m²

7. **The most reliable estimate is:**
   A) Detailed estimate
   B) Preliminary estimate
   C) Plinth area estimate
   D) Cube rate estimate

8. **The expected outturn of 12 mm plastering with cement mortar is:**
   A) 2.5 sq m
   B) 4.0 sq m
   C) 6.0 sq m
   D) 8.0 sq m

9. **The unit of measurement for cement concrete work is:**
   A) Cubic meter
   B) Square meter
   C) Running meter
   D) Kilogram

10. **The area is measured correct to the nearest:**
    A) 0.01 sqm
    B) 0.02 sqm
    C) 0.03 sqm
    D) 0.04 sqm

11. **Which of the following is typically included in the main items of work for building construction?**
    A) Site clearance
    B) Excavation
    C) Concrete work
    D) All of the above

12. **What is the unit of measurement for brickwork in cement mortar?**
    A) Cubic meter
    B) Square meter
    C) Running meter
    D) Kilogram

13. **Which item is not typically included in the main items of work for a building estimate?**
    A) Plastering
    B) Flooring
    C) Landscaping
    D) Electrical wiring

14. **The measurement of steel reinforcement in a structure is typically done in:**
    A) Cubic meters
    B) Kilograms
    C) Square meters
    D) Running meters

15. **In estimating the cost of excavation work, which of the following factors is crucial?**
    A) Depth of excavation
    B) Type of soil
    C) Area to be excavated
    D) All of the above

16. **The expected outturn for plastering with cement mortar (12 mm thick) is:**
    A) 2.5 sq.m per mason per day
    B) 4.0 sq.m per mason per day
    C) 6.0 sq.m per mason per day
    D) 8.0 sq.m per mason per day

17. **Which of the following is not a main item of work in estimating the cost of a building?**
    A) Roof truss fabrication
    B) Water supply installation
    C) Electrical wiring
    D) Site landscaping

18. **The unit of measurement for flooring work is typically:**
    A) Cubic meter
    B) Square meter
    C) Running meter
    D) Kilogram

19. **Which of the following is included in the main items of work for estimating the cost of a building?**
    A) Foundation work
    B) Wall construction
    C) Roofing
    D) All of the above

20. **In estimating the cost of electrical wiring, which of the following factors is important?**
    A) Length of wiring
    B) Type of wiring material
    C) Complexity of installation
    D) All of the above

21. What is the standard unit of measurement for earthwork in excavation?
    A) Cubic meter
    B) Square meter
    C) Running meter
    D) Kilogram

22. The unit of measurement for brickwork in cement mortar is:
    A) Square meter
    B) Cubic meter
    C) Running meter
    D) Kilogram

23. Which unit is used for measuring steel reinforcement in reinforced cement concrete (RCC) work?
    A) Cubic meter
    B) Kilogram
    C) Square meter
    D) Running meter

24. The unit of measurement for plastering work is:
    A) Cubic meter
    B) Square meter
    C) Running meter
    D) Kilogram

25. Which unit is used for measuring the quantity of cement required in concrete work?
    A) Kilogram
    B) Cubic meter
    C) Quintal
    D) Square meter

26. The unit of measurement for stone masonry work is:
    A) Cubic meter
    B) Square meter
    C) Running meter
    D) Kilogram

27. The unit of measurement for damp proof course (DPC) is:
    A) Cubic meter
    B) Square meter
    C) Running meter
    D) Kilogram

28. The unit of measurement for woodwork in doors and windows is:
    A) Cubic meter
    B) Square meter
    C) Running meter
    D) Number

29. The unit of measurement for collapsible gates with rails is:
    A) Cubic meter
    B) Square meter
    C) Running meter
    D) Quintal

30. The standard estimate formats used by the Government of Nepal are designed to:
    A) Ensure uniformity and consistency across civil engineering projects
    B) Facilitate transparency in project costing and resource allocation
    C) Improve project quality and cost control
    D) All of the above

31. Which of the following is NOT typically included in the standard estimate formats of the Government of Nepal?
    A) Preliminary Information
    B) Bill of Quantities (BOQ)
    C) Schedule of Rates (SOR)
    D) Contractor's Profit Margin

32. The Schedule of Rates (SOR) in the standard estimate formats provides:
A) Rates for various items of work and materials
B) Detailed drawings and specifications
C) Tendering information and bid evaluation criteria
D) Project timeline and milestones

33. The Bill of Quantities (BOQ) in the standard estimate formats lists:
A) All the materials, labor, and equipment required for the project
B) The quality and standards that must be maintained during the project
C) Details about the tendering process and bid submission
D) The project timeline and completion schedule

34. In the standard estimate formats, the Specifications section outlines:
A) The rates for various items of work and materials
B) The quality and standards that must be maintained during the project
C) Details about the tendering process and bid submission
D) The project timeline and completion schedule

35. Rate analysis is a process of deriving the rate of a unit item from the cost of its:
A) Material Cost
B) Equipment Cost
C) Labour Cost
D) All of the above

36. Which of the following costs is not typically included in rate analysis?
A) Petrol, Oil & Lubricant Cost
B) Contractor's Profit
C) Land Cost
D) Overhead Cost

37. Usually, the contractor's profit is taken as what percentage for rate analysis of an item?
A) 10%
B) 15%
C) 8%
D) 20%

38. Water charges are usually taken as what percentage for rate analysis of an item?
A) 3%
B) 1%

C) 1.5%
D) 5%

39. The purpose of rate analysis is to:
A) Determine the profit margin of the contractor
B) Calculate the taxes applicable to the project
C) Estimate the cost of materials and labor for various tasks
D) Evaluate the environmental impact of construction projects

40. Which of the following factors can influence the rate of an item in construction?
A) Market demand
B) Weather conditions
C) Political stability
D) Historical significance

41. What does C.S.R. stand for in construction?
A) Construction Schedule of Resources
B) Current Schedule of Rates
C) Costly Supply Requirements
D) Comprehensive Service Report

42. Why is it important to prepare rates for important items of work in construction projects?
A) To create confusion among workers
B) To ensure uniformity and transparency in pricing
C) To discourage competition among contractors
D) To increase project delays

43. Which of the following is NOT a component of rate analysis in construction?
A) Material requirement
B) Labor requirement
C) Equipment maintenance
D) Overhead costs

44. How does labor requirement influence the rate of an item in construction?
A) Higher labor requirement leads to lower rates
B) Lower labor requirement leads to higher rates
C) Labor requirement has no impact on rates
D) Labor requirement is determined independently of rates

45. Specifications in construction estimating serve to:
    A) Define the quality and standards of materials and workmanship
    B) Determine the project timeline
    C) Specify the project's financial budget
    D) Outline the project's environmental impact
46. In the context of specifications, the term "IS Code" refers to:
    A) International Standard Code
    B) Indian Standard Code
    C) Industrial Standard Code
    D) Internal Standard Code
47. Which of the following is typically included in the specifications for a building project?
    A) List of materials to be used
    B) Quality standards for materials and workmanship
    C) Method of measurement for various works
    D) All of the above
48. The purpose of including specifications in construction estimating is to:
    A) Increase the project's cost
    B) Ensure uniformity and quality in construction
    C) Reduce the project's duration
    D) Limit the scope of work
49. Specifications in estimating help in:
    A) Determining the project's aesthetic appeal
    B) Ensuring compliance with legal and regulatory requirements
    C) Selecting the project's location
    D) Choosing the project's financing options
50. Which of the following is an example of a specification related to concrete work?
    A) "Use M20 grade concrete for all foundations."
    B) "The building shall have a modern design."
    C) "Install energy-efficient lighting fixtures."
    D) "Ensure the project is completed within 12 months."
51. The difference between the cost of a property and its accumulated depreciation is known as:

A) Market value
B) Salvage value
C) Book value
D) Capital value
52. Which of the following methods is commonly used for property valuation?
    A) Market approach
    B) Income approach
    C) Cost approach
    D) All of the above
53. In the context of property valuation, depreciation refers to:
    A) Increase in property value over time
    B) Decrease in property value due to wear and tear
    C) Cost of improvements made to the property
    D) Initial cost of the property
54. Which of the following is NOT a factor considered in property valuation?
    A) Location of the property
    B) Condition and age of the property
    C) Personal preferences of the property owner
    D) Market trends and comparable sales
55. The term used to describe the estimated cost of construction based on the area of the building is:
    A) Plinth Area Rate
    B) Detailed Estimate
    C) Cube Rate Estimate
    D) Preliminary Estimate
56. In the long and short wall method of estimation, the length of the long wall is:
    A) Measured along the center line
    B) Measured along the face of the wall
    C) Measured along the top of the wall
    D) Measured along the bottom of the wall
57. The method of estimating the cost of work based on the quantity of materials required is known as:
    A) Detailed Estimate
    B) Material Estimate
    C) Rate Analysis
    D) Preliminary Estimate
58. The document that itemizes materials, parts, and labor (and their costs) in tendering for construction work is known as:

A) Bill of Materials
B) Bill of Quantities
C) Rate Analysis
D) Cost Estimate

59. The amount of currency per unit of time required to employ people in the execution of construction work activity is termed as:
A) Labor Rate
B) Unit Cost
C) Markup
D) Profit Margin

60. The cost of a structure in the cubical contents method is determined by:
A) Multiplying total cubic contents with the local cubic rate
B) Multiplying total area with the local area rate
C) Multiplying total length with the local length rate

D) Multiplying total weight with the local weight rate

61. The process of applying appropriate costs to the line items after the take off is known as:
A) Costing
B) Take Off
C) Rate Analysis
D) Contingency

62. The cost incurred to employ people (workers, crafts, trades, etc.) in the execution of construction work activity is categorized as:
A) Labor
B) Material
C) Overhead
D) Profit

*Topics wise MCQ discussion in physical and online class.

1	B	21	A	41	B	61	A
2	B	22	A	42	B	62	A
3	C	23	B	43	C	63	
4	B	24	B	44	B		
5	B	25	A	45	A		
6	A	26	A	46	B		
7	A	27	B	47	D		
8	D	28	D	48	B		
9	A	29	D	49	B		
10	A	30	D	50	A		
11	D	31	D	51	C		
12	B	32	A	52	D		
13	C	33	A	53	B		
14	B	34	B	54	C		
15	D	35	D	55	A		
16	D	36	C	56	A		
17	D	37	A	57	B		
18	B	38	C	58	B		
19	D	39	C	59	A		
20	D	40	A	60	A		

12. Construction Management

Construction management is a professional service that provides a project's owner(s) with effective management of the project's schedule, cost, quality, safety, scope, and function.

It involves the planning, coordination, and control of a project from inception to completion, aiming to meet client requirements and ensure the project is completed on time, within budget, and to the required quality standards.

12.1 Organization

An organization refers to the structured arrangement of roles, responsibilities, and relationships within a construction company or project team. This structure ensures efficient planning, coordination, and execution of construction projects.

12.1.1 Need for organization

A. **Clear Roles and Responsibilities**
Defining specific roles ensures that each team member understands their tasks and reporting lines, minimizing confusion and enhancing efficiency.

B. **Effective Communication and Coordination**
A structured framework facilitates seamless communication among stakeholders, enabling prompt issue resolution and alignment with project objectives.

C. **Resource Management and Allocation**
Proper organization allows for efficient allocation of resources like labor, materials, and equipment, reducing wastage and preventing delays.

D. **Enhanced Accountability and Performance Monitoring**
A clear hierarchy aids in monitoring performance and holding individuals accountable, driving productivity and ensuring timely milestone achievement.

E. **Risk Management and Problem-Solving**
An organized approach enables proactive identification and mitigation of risks, allowing for swift decision-making and minimizing disruptions.

F. **Compliance and Safety Standards**
A well-organized site ensures adherence to safety protocols and regulatory requirements, maintaining a safe working environment and reducing legal complications.

12.1.2 Responsibilities of a civil engineer

➢ To understand his/her own duties.
➢ To divide and assets the work among the labours.
➢ To execute the work.
➢ To fulfill the measurement book.
➢ To take attendance on master roll.
➢ To make quality control in work/materials.
➢ To supervise the site.
➢ To maintain quality in the work.

12.1.3 Relation between owner, contractor and engineer

A. Owner

➢ The project's funder and client, responsible for defining objectives, scope, budget, and selecting both designer and builder.
➢ Contracts separately with the designer (often an engineer or architect) for design services and with the contractor for construction.

B. Engineer (or Architect / Design Professional)

➢ Engaged by the owner for the design phase, creating plans and specifications.
➢ During construction, acts as the owner's representative to:

- o Administer the construction contract,
- o Review shop drawings and payment requests,
- o Clarify specifications,
- o Monitor work quality,
- o Process changes, and
- o Advise on project completion and value delivery.
- ➢ Crucially, engineers must not interfere in the contractor's domain such as means, methods, sequencing, safety, or daily site supervision as it can lead to disputes.

C. Contractor (General Contractor)
- ➢ Hired by the owner to execute the construction work per the design documents.
- ➢ Responsible for daily site operations, including:
    - o Managing labor, materials, and equipment,
    - o Ensuring safe execution,
    - o Coordinating trades, and
    - o Implementing the specified design.

Interaction Dynamics
A. Engineer ↔ Owner
- ➢ The engineer provides technical oversight and constructive advice, essentially safeguarding the owner's interests throughout construction.
- ➢ They interpret contract documents, evaluate contractor submissions, process payments, manage change, and assess project completion.

B. Contractor ↔ Owner
- ➢ The contractor delivers the project according to the agreed design, timeline, and budget.
- ➢ Effective communication, transparent bidding, and realistic expectations are essential for a successful relationship.

C. Engineer ↔ Contractor
- ➢ The engineer oversees contract compliance but should not step into contractor-specific processes like how they build something or their scheduling.
- ➢ Collaboration and constructability are improved when engineers understand and respect the contractor's workflow—keeping instructions clear and practical is key.

12.2 Site Management

Construction Site Management is the comprehensive process of overseeing and coordinating all activities, resources, and personnel involved in a construction project at a specific location.
- ➢ It encompasses planning, execution, monitoring, and completion phases to ensure that projects are delivered safely, on time, within budget, and to the required quality standards.

12.2.1 Preparation of site plan

A. Access to the site
- ➢ There should be entrance and exit the site.
- ➢ There should be a track on the site for easy and efficient movement.
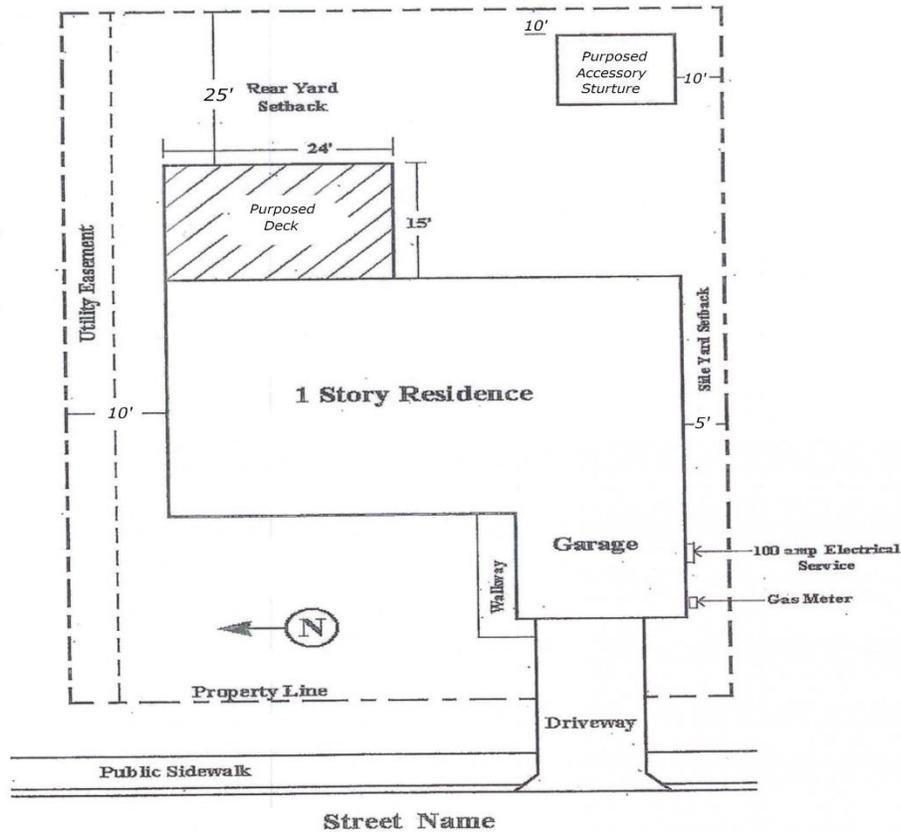
B. Stronge of materials
- ➢ Cement bag should be prevent from moisture and stacked on a raised platform should be kept 30cm apart from the walls.

C. Plants
- ➢ Mishanding, misuse and over use of plant is avoided.

D. Temporary building
  ➢ Such as site office, accommodation for site manage, engineers, guards and labours.

Sample Site Plan

12.2.2 Organizing labor and accidental prevention
*Measure to improve labour efficiency
  ➢ By reward and punishment system.
  ➢ Skills
  ➢ Education
  ➢ By giving training
*Accident prevention
  ➢ Use of construction safety.
  ➢ Use personal protective seats. (helmet, shoes, globs etc, colour of helmet white: engineer,sub-engineer,project manager ; Yellow:labour and Red: fire fighter)
  ➢ Use of single

12.3 Contract Procedure
12.3.1 Contract

A contract is an agreement which will be valid in law or enforceable by law, between or among two or more parties, for provision of supplies and services against a consideration of monetary value.

The elements of contracts are:

- Offer and acceptance
- Consideration
- Capacity to contract
- Lawful purpose
- Possibility of performance
- Free consent
- Certainty/uncertainty
- Legal relationship
- Written agreement
- Competent party

12.3.3 Types of contract

Based on payment method of contract

A. Unit rate / item rate contract
   This kinds of contract is based in estimated quantities of items included in the project and their unit prices.
   Government of Nepal generally used this type of contract.

B. Lumpsum contract
   This types of method also named as "fixed fee contract" In order to be carried out a construction work difficult to measure a lumo sum contract may be concluded with this kinds of contract the engineer and contractor agrees to do the described and specified project for a fixed price.
   This types of contract is suitable, if the scope and schedule of the project are sufficiently defined to allow the consulting engineer to estimate project costs.

C. Design and build contract
   A design and build contract to be concluded to have a design and construction by the same contractor.

D. EPC contract
   The EPC contracts stands for engineering procurement and construction contract. The contractor designs, [rocures the necessary materials and builds the project, either directly or by sub-contracting part of the work.

E. Turnkey contract
   A turnkey contract may be concluded by maintaining the performance capacity of an industrial plant of high technology. In Nepal this type of contract is generally used in housing industries.

F. Build own operate transfer (BOOT) contract
   Build own operate transfer (BOOT) or Build-Operate transfer (BOT) or Build own operate (BOO) is a form of project financial, where in a private entity receivers a concession from the

private or public sector to finance, design, construct and operate a facility stated in the concession contract. Some advantage of BOOT projects are:

> ➢ Encourage private investment.
> ➢ Inject new foreign capital to the country.
> ➢ Transfer of technology and know-how.
> ➢ Completing project within time frame and planned budget.
> ➢ Providing addition financial source for other priority projects.
> ➢ Releasing the burden on public budget for infra-structure development.

In the BOT framework a third party, for example the public administration, delegates to a private sector entity to design and build infrastructure and to operate and maintain these facilities for a certain period. In a BOO project ownership of the project remain usually with the project company for example a mobile phone network. Therefore the private company gets the benefits of any residual value of the project.

G. Cost plus contract

It's also called cost reimbursement contract. A contract agreement where in the purchaser agrees to pay the cost of all labour and materials plus an amount for contractor overhead and profit [usually as a percentage of the labour and material cost]. The contracts may be specified as :

> ➢ Cost + fixed percentage contract
> ➢ Cost + fixed fee contract
> ➢ Cost + fixed fee with guaranteed maximum price contract.
> ➢ Cost + fixed fee with bonus contract.

12.3.4 Tender and tender Notice

*Tender

Tender is defined as an offer, usually in writing, to execute work or supply of goods or services at a stated price and under stated conditions.

> ➢ It's a first step of formulation of a contract.
> ➢ It's also known as a Bid.

*Purpose of tendering

> ➢ Ensuring fairness and transparency.
> ➢ Ensuring quality and capability
> ➢ Promoting healthy competition
> ➢ Managing costs and budgeting.
> ➢ Enhancing accountability
> ➢ Facilitating legal and regulatory compliance

*Preparation before inviting tender

> ➢ Project preparation
> ➢ Prepare Cost estimate
> ➢ Approval of estimate
> ➢ BOQ preparation
> ➢ Tender document preparation

*Procedure for inviting tender

    A. **Preparation of Tender Documents**
- Project specifications and drawings
- Bill of Quantities (BoQ)
- Contract terms and conditions
- Evaluation criteria
- Instructions to bidders

    B. **Tender Invitation**

    C. **Bidder Queries and Clarifications**

    D. **Bid Submission**
- Technical proposals
- Financial proposals
- Compliance documents (e.g., licenses, insurance)

    E. **Bid Opening**

    F. **Bid Evaluation**
- Compliance with technical specifications
- Cost-effectiveness
- Contractor's experience and qualifications
- Proposed timeline and methodology

    G. **Contract Award**

    H. **Project Delivery**

*Procurement Method

    A. International competitive bidding
- When the public entity has certified that the goods or construction works, being of complex and special nature.
- A notice on invitation shall be published in english language and all bidding or prequalification documents shall have to be made available in the English language.
- It's used for construction work <1- 5 arab.(Need Joint venture JV with nepali form compulsory)
- It's used for construction work exceeding 5 arab and consulting services exceeding 15 crores. (JV not required)

    B. National competitive bidding
- It's used for construction work exceeding 20 lakhs to 5 arab and consulting services exceeding 20 lakhs and upto 15 crores.

    C. Seal Quotation
- It's used for construction work, goods procurement and other services upto 20 lakhs. But x-ray, ECG, medicine upto 50 lakhs.
- The validity period of a seal quotation shall be forty five days.
- A notice published in local and national newspaper by giving a period at least of 15 days.

    D. Direct purchase
- Expendable or capital goods, or construction work valuing up to 10 lakhs may and consulting works upto 5 lakhs rupees may be directly procured.

    E. work through user's committee or beneficiary community
- Construction work upto 1 crore.
- Payment shall be made only after deducting value added tax, overhead, contingency, and portion of people's participation from the cost estimate.

F. Lump sum price rate
> Upto 2 crore.

G. catalogues shopping
> Upto 60 lakhs

*Information to be included in Tender Notice

A. Name and address of public entity (Office)
B. Brief description of work
C. Contract identification number
D. First date of publication
E. Minimum qualification criteria/eligibility criteria
F. Earnest money deposited amount (bid security)
G. Priced of bid/tender document
H. Date time place for purchasing bid document
I. Last date of submission of bid
J. Bid opening date/time/place
   - Immediately after last date of submission of bid
K. Estimate amount
L. Prebid meeting date/time/place)
   - Before 10 days last date of submission of bid
M. Bank account number
N. Contact person (Name and address or post)

12.3.5 Bid security / earnest money deposit (EDM)

The amount deposited by contracted at the time of tender deposit is known as earnest money.

> Also known as bid bond/bid security.
> Earnest money is (2-3)% of estimated amount.
> Earnest money (Cash or bank guarantee)
> The validity period of the bid security shall exceed to the validity period of bid at least by thirty days.
> Bid security of contractors whose tenders are not accepted will be refunded.

*Security Deposit / performance security

> The amount deposited by contractor at the time before awarding a work, after his tender is accepted.
> Performance security is 5 % of estimated cost of the project and is inclusive of the EDM already deposited by the contractor along with the tender.
> Security - 5% for national contract)
>   -10% for international
> If contract amount is greater than 85% (>85%) of estimate amount (E.A.)
> If contract amount is less than 85% (<85%) of estimate amount security deposit will change by S.D. = 5% _1/2*decrease%
> Example,

> Estimate amount = 1 crore
> Contract amount = 80 lakh (less than 85% of E.A.).

$$S.D> = 5\%+1/2*(85-80)$$
$$=7.5\%$$

➢ This will be refunded to the contractor after the completion of the project.
➢ The validity period of the performance security shall have to exceed at least more than one month's period to the last period for supply or delivery of the goods or warranty period or defects liability period of construction works as referred to in such contract.

*Mobilization

➢ The amount of money that is given to the contractor by client after the agreement and before the start of work is known as mobilization.
➢ Mobilization-20% of contract amount (maximum).

*Retention maney

➢ Amount of money that is hold by client from contractor or bill.
➢ Retention money= 5% of running bill (intention payment certificate) - IPC
➢ Retention money is give back to contractor after defect liability period.

*Notice for proceed

➢ The letter given by the client to the contractor for the start of work in site is known as notice to proceed.

*Liquidity damage/penalty

➢ Does not related to real damage.
➢ Deals with fixed term of condition.
➢ Liquidity damage = (0.05%* contract amount) upto 200 days.
$$= 30 \% \text{ of contract amount}$$
➢ If days greater than 200 days, project is terminated.

*DLP (Defect liability period)

➢ It stands for defect liability period.
➢ DLP counts after projection end upto 365 days (or 1 year)
➢ DLP is maintenance period.
➢ After DLP contractor get it's full payment

*Price Adjustment

➢ It's applicable when project duration is greater than 12 months. (15 moths old data)
➢ Applicable to material, labour and fuel.
➢ Price adjustment = 25%.

*Contingency

➢ Contingency= 4 % (3%-5% old data)
➢ But according to PIR , contingency can be classified into two group.
  i. Physical contingency: 10 %
  ii. Price contingency : 10%
➢ Total contingency according to PPR : (10+10)%
$$= 20\%$$

12.3.6 Preparation before inviting tender

➢ Define risks, scope, objectives
➢ Build procurement strategy & plan
➢ Pre-qualify bidders via PQQ
➢ Draft and structure tender documents
➢ Communicate clear timelines & details

➢ Set up project team and tracking tools
➢ Ensure compliance & thorough documentation

12.3.7 Agreement

12.3.8 Condition of contract

Example Structure of a Contract Conditions Section
A. Scope & Definitions
B. Payment Terms
C. Delivery & Acceptance
D. Performance Standards (KPIs, Bond, Guarantees)
E. Inspection & Quality Assurance
F. Force Majeure & Suspension
G. Termination (Default, Convenience)
H. Dispute Resolution
I. Liability & Indemnity
J. Compliance & ESG Clauses
K. Implied Terms & Governing Law

12.3.9 Construction supervision

Construction supervision refers to the continuous oversight and management of construction activities to ensure quality, safety, compliance, and effective project delivery. It serves as the critical link between design intent and actual execution.

*Responsibilities of Construction site supervisor are:
➢ Project Coordination & Planning
➢ Quality Control
➢ Safety Management
➢ Monitoring Progress & Timelines
➢ Documentation & Reporting
➢ Problem-Solving & Communication

12.4 Accounts
12.4.1 Administrative approval and technical sanction
*Administrative approval

➢ For every work, it is necessary to obtain, in the first instances the concurrence of the competent authority of the administrative department requiring the work.
➢ The formal acceptance of the proposals by the authority is termed as administrative approval of the work.
➢ It's duty if the engineering department requiring the work by the administration to obtain the requisite approval to it.
➢ An approximate estimate and such preliminary plans are necessary to explain the proposals are submitted by an engineering department to the administration to obtain administrative approval to take up the work within the sanctioned amount.

> ➢ After receiving the administrative approval, detailed drawings, design and estimated cost etc. are prepared by the engineering department and submitted to the administrative department for sanction.

*<u>**Technical sanction**</u>

After receipt of administrative approval and expenditure sanction, a detailed estimate is further sanctioned by a competent technical authority of the engineering department empowered by the government, which ensures that the proposals are structurally sound and the estimate is accurately calculated based on adequate data such sanction is known as technical sanction and should be taken before inviting tenders to execute the work.

12.4.2 Familiarity with standard account keeping formats used in governmental organizations

12.4.3 Muster roll
Parts of muster roll are:
   A. **Nominal Roll**: Lists personal details of each worker, such as name, designation, and father's name.
   B. **Attendance Record**: Tracks daily attendance, including hours worked and any leave taken.
   C. **Wage Register**: Details the wages paid, including any arrears or deductions.
   D. **Work Measurement**: Records the quantity and type of work completed by each laborer.

12.4.4 Completion report
Completion report is a statement prepared after the completion of the work. Completion report enables to know the estimated cost and the actual cost of work. If expenditure is higher than the approved cost, then the payment is made only after approval of completion of report by the authorized person. The completion report should include following information:
   ➢ Description of the contract
   ➢ Design revisions, construction highlights, problem and solutions
   ➢ Financial summary
   ➢ Copies of taking over and defect liability certificate.
   ➢ Recommendations for operation and maintenance of the completed works
   ➢ Description of consulting services and costs.

12.5 Planning and Control
*<u>**Planning**</u>

Planning is the process of setting objectives and determining the most effective course of action to achieve them. It involves anticipating future needs, allocating resources, and establishing procedures to guide activities toward desired outcomes.
Planning is a fundamental aspect of management and is essential for ensuring that goals are met efficiently and effectively.

*<u>**Control**</u>

Control is a process of taking necessary action for maintaining the pre-determined schedule budget and quality of project. Control helps in following the plan for successful execution of the

project. Control in a project means control of schedule of control, cost control and quality control.

12.5.1 Construction schedule

It's a mechanical process for setting up the sequential order of the various operations in a construction project of fixing the dates of starting and copleting each operation of the work in such a manner so that the whole work should be dine in an orderly and systematic way. In order to prepare a construction schedule, the following date is required:

- ➢ Number of operations
- ➢ Number of activities
- ➢ Output of labour
- ➢ Number of field workers

12.5.2 Equipment and materials schedule

*Equipment schedule

An equipment schedule in construction is a comprehensive document that organizes and communicates the details of equipment use across the project's timeline. It tracks what equipment is needed, when, where, for how long, and often includes maintenance aspects too.

*Materials schedule

Materials schedule in construction is a comprehensive planning tool that outlines all the materials required for a project, including details such as specifications, quantities, delivery timelines, costs, and supplier information. It acts like a highly detailed "shopping list," synchronized with project phases to ensure smooth execution.

*Labour schedule

A labour schedule in construction management is a planning tool that details how, when, and where labor resources are allocated across project tasks. It ensures that the right number of workers, with appropriate skills, are deployed efficiently across different phases of the project.

*Financial schedule

A financial schedule is a structured timeline detailing how and when costs are incurred, payments are made, and revenue or funding is received throughout a project. It ensures that cash flows align with project milestones, helping maintain financial health and transparency during execution.

12.5.3 Construction stages and operations

The following are the various stages in every construction work:

- A. Conception
- B. Study and evaluation
- C. Design, drawing and estimates
- D. Specifications
- E. Contractor realization
- F. Procurement of materials
- G. Construction and supervision
- H. Utilization and maintenance

12.5.4 Bar chart
- Bar chart is the pictorial representation of project activities by horizontal bars in time axis.
- It's develope by henry Gantt in 1900 AD.
- It's also called Gantt Chart.
- Left part of the bar shows :start time.
- Right part of the bar shows finish time
- Length of the bar shows duration.
- Length bar is directly proportional to activity duration.
- Bar chart also shows;
  o Project start date
  o Project duration
  o Project finish time

*linked bar chart
- If the relation between activities are shown by arrow, in gantt chart or bar chart is called linked bar chart.

*Mile stone chart
- If important event are shown by special indication in bar chart it's called mile stoen charts. It was developed in 1940s (1931-1940).

*Critical path method (CPM)
- It's NETWORK based method of scheduling project developed by R marfon for scheduling repair and maintenance of dupont of chemical factory in 1957 AD.
- It uses ARROW (➔) to represent activity/job/task.
- Rules in CPM network
  o Only one starting event
  o One activity on arrow
  o Only one ending events

*Program evaluation and review technique (PERT)
It's also network based technique for scheduling project developed by us novy for polaries messile project (launching nuclear messile by sub marine in 1956 AD. It's used for novel projects like research and development.

CPM ➔ experience project like engineering

PERT ➔ new experience project.

PERT uses three estimates
A. **Optimistic line (to) -** minimum time required to complete the activity in idea;/favorable condition.
B. **Pessimistic time (tp)** maximum time required to complete the activity in worst condition.
C. **Most likely time (tm) :** time required to complete the activity in normal situation.

Average time (μ) or expected time (te)

μ(te) = (to +4tm +tp)/6

where, probability of to 1/6 , tm = 4/6 or 2/3, tp = 1/6

*Difference between CPM and PERT

Characteristic	PERT	CPM
Model Type	Probabilistic (uncertain durations)	Deterministic (fixed durations)
Time Estimates	Three-point (O, M, P)	Single estimate
Diagram Type	Activity-on-Arrow (milestones/events as nodes)	Activity-on-Node (activities as nodes)
Focus	Time accuracy under uncertainty (event-oriented)	Time–cost optimization (activity-oriented)
Suitable For	R&D, unique/one-off, uncertain-duration projects	Repetitive/clear-scope projects like construction
Cost Consideration	No direct cost modeling	Built-in time–cost trade-offs; supports crashing
Critical Path & Slack	Yes, but more focused on time variance	Yes, precise analysis of float, slack, and task prioritization

1. **What is the correct sequential order of managerial functions according to classical theory?**
   A. Organizing → Planning → Controlling → Leading
   B. Planning → Organizing → Leading → Controlling
   C. Planning → Controlling → Organizing → Leading
   D. Leading → Organizing → Planning → Controlling

2. **The principle stating that each subordinate should report to only one superior is known as:**
   A. Chain of Command
   B. Unity of Direction
   C. Unity of Command
   D. Centralization

3. **Which managerial function involves setting goals, developing strategies, and devising ways to implement them?**
   A. Leading
   B. Controlling
   C. Planning
   D. Organizing

4. **Which of these is a critical need addressed by organizational management related to documentation and governance?**
   A. Motivation
   B. Compliance and policy alignment
   C. Technical training
   D. Team building

5. **According to strategic management principles, organizations need to:**
   A. Ignore external environment
   B. Allocate resources without analysis
   C. Reorganize resources and continuously monitor strategies
   D. Focus solely on internal processes

6. **Departmentalization in an organization refers to:**
   A. Assigning work to machines
   B. Grouping activities into departments (functional, divisional, matrix, etc.)
   C. Planning budgets
   D. Marketing strategies

7. **Which task is a primary responsibility of a civil engineer during the planning phase of a construction project?**
   A) Conducting surgeries
   B) Feasibility studies and creating project plans using CAD
   C) Operating heavy machinery on site
   D) Publishing marketing materials

8. **During the construction phase, what is a key oversight duty of a civil engineer?**
   A) Marketing the project to the public
   B) Supervising construction, ensuring quality and safety standards are met
   C) Making cooking plans for the crew
   D) Drafting contracts for external consultants

9. **What responsibility does a civil engineer have regarding environmental and regulatory matters?**
   A) Writing novels
   B) Conducting Environmental Impact Assessments and securing permits
   C) Managing social media accounts
   D) Filing taxes

10. **Which of the following best describes a civil engineer's role in cost control for a construction project?**
    A) Hiring landscaping staff
    B) Conducting detailed cost estimations and managing budgets
    C) Scheduling catering services
    D) Designing logos for project signage

11. **What responsibility does a civil engineer have in team coordination and communication?**
    A) Creating promotional ads
    B) Coordinating with contractors, suppliers, and stakeholders, and communicating progress
    C) Programming in Python
    D) Managing fitness schedules for the team

12. **How does a civil engineer contribute to the maintenance and sustainability of infrastructure?**
    A) Conducting cultural festivals

B) Scheduling inspections, repairs, and incorporating sustainable practices
C) Writing poems about bridges
D) Painting structures

13. Who defines the project's scope, secures funding, and oversees its overall success?
A) Contractor
B) Engineer
C) Owner
D) Subcontractor

14. Which party is primarily responsible for day-to-day construction site operations and managing subcontractors?
A) Owner
B) Contractor
C) Engineer
D) Architect

15. Which role typically reviews design compliance, inspects the contractor's work, and monitors quality control on behalf of the owner?
A) Owner
B) Contractor
C) Engineer (Owner's Engineer)
D) Subcontractor

16. Who is responsible for reviewing contractor billing, approving progress payments, and managing change requests?
A) Owner
B) Contractor
C) Engineer
D) Architect

17. Which party provides the design basis, technical standards, site data, and resolves specification conflicts?
A) Contractor
B) Engineer
C) Owner
D) Architect

18. In construction, a site manager (or construction manager) is responsible for:
A) Day-to-day site operations including quality, safety, and schedule control
B) Only administrative tasks

C) External marketing of the project
D) Preparing technical designs

19. Which of the following is not a leading hazard at construction sites?
A) Falls
B) Electrocutions
C) Crush injuries
D) Wireless network issues

20. What does organizing labor effectively on a construction site help achieve?
A) Increase in worker accidents
B) Efficient resource allocation and minimized idle time
C) Higher costs and delays
D) Increased scope creep

21. According to accident prevention theory (Heinrich's triangle), reducing minor accidents results in:
A) No change in serious accidents
B) Increase in major accidents
C) Corresponding decrease in serious accidents
D) Unpredictable effects

22. Which hazard is commonly the leading cause of injury on construction sites?
A) Falls
B) Inadequate office lighting
C) Poor communication
D) Excessive documentation

23. What is a critical labor-related accident prevention measure on construction sites?
A) Reducing worker training
B) Improper equipment maintenance
C) Proper use of Personal Protective Equipment (PPE) through training and audits
D) Avoiding safety audits

24. Which organizational failure is a direct contributor to accidents at work?
A) Defective supervision of work
B) Perfect planning
C) Excellent communication
D) Proper training

25. Who is potentially responsible for workplace accidents?

A) Only the worker
B) Only management
C) Only working conditions
D) All of the above

26. **Which safety measure is associated with accident prevention?**
    A) Cluttered passageways
    B) Overloaded equipment
    C) Ensuring sufficient and clear workspace
    D) Ignoring workplace cleanliness

27. **Which of the following is a primary document that outlines the terms agreed upon by the owner and contractor?**
    A) Specifications
    B) Drawings
    C) Agreement
    D) Bill of Quantities

28. **In a construction contract, which document provides detailed technical descriptions of the materials, workmanship, and quality standards required?**
    A) Specifications
    B) Agreement
    C) Drawings
    D) Bill of Quantities

29. **Which of the following is typically included in the contract documents to provide a detailed graphical representation of the project?**
    A) Specifications
    B) Drawings
    C) Agreement
    D) Bill of Quantities

30. **What document in a construction contract outlines the quantities and costs of materials and labor required for the project?**
    A) Specifications
    B) Drawings
    C) Agreement
    D) Bill of Quantities

31. **Which clause in a construction contract typically assigns responsibility for health and safety on a construction site?**
    A) Force majeure clause
    B) Health and safety clause
    C) Indemnity clause
    D) Liquidated damages clause

32. **What type of bond guarantees the contractor will complete the project according to contract terms?**
    A) Payment bond
    B) Performance bond
    C) Bid bond
    D) Warranty bond

33. **Which clause in a construction contract specifies the penalties for delays in project completion?**
    A) Force majeure clause
    B) Health and safety clause
    C) Indemnity clause
    D) Liquidated damages clause

34. **What document in a construction contract outlines the general terms and conditions governing the contract?**
    A) Specifications
    B) Drawings
    C) Agreement
    D) General Conditions

35. **Which type of construction contract sets a fixed total price before work begins?**
    A) Lump-sum contract
    B) Unit price contract
    C) Time and materials contract
    D) Cost-plus contract

36. **hat clause in a construction contract allows for adjustments to the contract price due to unforeseen circumstances?**
    A) Force majeure clause
    B) Health and safety clause
    C) Indemnity clause
    D) Liquidated damages clause

37. **Which of the following is a type of construction contract where the contractor is paid for all construction-related expenses plus an additional payment for profit?**

    A) Lump Sum Contract
    B) Cost-Plus Contract
    C) Unit Price Contract
    D) Time and Materials Contract

38. **What type of construction contract involves a fixed total price for all work to be completed?**

    A) Cost-Plus Contract
    B) Lump Sum Contract
    C) Unit Price Contract
    D) Time and Materials Contract

39. **Which contract type is commonly used when the scope of work cannot be clearly defined at the outset?**

    A) Lump Sum Contract
    B) Cost-Plus Contract
    C) Unit Price Contract
    D) Time and Materials Contract

40. **What type of contract is used when the quantity of work is uncertain and payment is based on unit rates for measured work?**

    A) Lump Sum Contract
    B) Cost-Plus Contract
    C) Unit Price Contract
    D) Time and Materials Contract

41. **Which type of contract involves the contractor completing the design and construction of a project for a fixed total price?**

    A) Design-Bid-Build Contract
    B) Design-Build Contract
    C) Cost-Plus Contract
    D) Lump Sum Contract

42. **What is a characteristic of a cost-plus percentage of cost contract?**

    A) The contractor is paid a fixed price for the entire project.
    B) The contractor is reimbursed for costs plus a percentage of those costs as profit.
    C) Payments are based on unit rates for measured work.
    D) The contractor completes the design and construction for a fixed total price.

43. **Which contract type is often used for large-scale infrastructure projects where the contractor is responsible for all aspects of the project?**

A) Lump Sum Contract
B) Cost-Plus Contract
C) Unit Price Contract
D) Engineering, Procurement, and Construction (EPC) Contract

44. **What is a disadvantage of a cost-plus contract?**

    A) The contractor assumes all financial risk.
    B) The total project cost is fixed.
    C) There is potential for higher total costs due to lack of cost control.
    D) Payments are based on unit rates for measured work.

45. **What is the primary purpose of a tender notice in construction projects?**
    A) To advertise the completion of a project
    B) To invite contractors to submit bids for a project
    C) To announce the project's budget
    D) To finalize the project design

46. **Which of the following is typically included in a tender notice?**
    A) Project completion date
    B) Bid submission deadline
    C) Contractor's previous project list
    D) Project's profit margin

47. **What is the first step in the tendering process?**
    A) Bid evaluation
    B) Issuance of tender notice
    C) Contract award
    D) Project completion

48. **Which of the following is NOT a type of tendering method?**
    A) Open tendering
    B) Selective tendering
    C) Negotiated tendering
    D) Closed tendering

49. **What document is typically issued after the tender notice to provide detailed information about the project?**
    A) Tender document
    B) Contract agreement
    C) Project completion report
    D) Invoice

50. **What is the main advantage of using open tendering?**
    A) Limited competition
    B) Transparency and fairness

C) Faster project completion
D) Reduced documentation requirements

51. In which scenario is selective tendering most appropriate?
A) When the project requires specialized expertise
B) When the project is of low value
C) When the project timeline is flexible
D) When the project is in a remote location

52. What is a key characteristic of negotiated tendering?
A) Bids are submitted publicly
B) The client negotiates directly with a selected contractor
C) Multiple contractors submit bids simultaneously
D) The lowest bid is automatically accepted

53. Which document outlines the terms and conditions under which a contractor will perform the work?
A) Tender notice
B) Tender document
C) Contract agreement
D) Project brief

54. What is the purpose of the bid evaluation process?
A) To select the contractor with the lowest bid
B) To assess the quality and suitability of bids
C) To finalize the project design
D) To determine the project's budget

55. What is the first step in the tendering process for a construction project?
A) Bid submission
B) Tender evaluation
C) Tender invitation
D) Contract award

56. Which document provides detailed information about the project to potential bidders?
A) Invitation to Tender (ITT)
B) Contract agreement
C) Project completion report
D) Invoice

57. What is typically included in a tender invitation?
A) Project scope and specifications
B) Submission guidelines and deadlines
C) Evaluation criteria
D) All of the above

58. What is the purpose of a pre-qualification questionnaire (PQQ) in the tendering process?
A) To assess the financial capability of bidders
B) To evaluate the technical expertise and experience of bidders
C) To determine the bid price
D) To finalize the project design

59. What is the role of a bid security in the tendering process?
A) To guarantee the contractor's performance
B) To ensure the bidder's commitment to the tender
C) To cover project insurance costs
D) To finalize the contract terms

60. Which of the following is NOT a common method of tendering?
A) Open tendering
B) Selective tendering
C) Negotiated tendering
D) Closed tendering

61. What is the purpose of the bid evaluation process?
A) To select the contractor with the lowest bid
B) To assess the quality and suitability of bids
C) To finalize the project design
D) To determine the project's budget

62. What is the primary objective of International Competitive Bidding (ICB)?
A) To promote fair and healthy competition for World Bank-funded projects
B) To limit participation to domestic contractors
C) To expedite the procurement process
D) To reduce the number of bidders

63. Which of the following is a requirement for ICB under World Bank guidelines?
A) Bidding documents must be published in the local language only
B) Bids must be submitted within 2 weeks of advertisement
C) Contracts should be awarded to the lowest evaluated bid
D) Only domestic suppliers are eligible to participate

64. What is the minimum time frame recommended for bid preparation in ICB?

A) 2 weeks
B) 4 weeks
C) 6 weeks
D) 8 weeks

65. **Which document is required to announce ICB procurement opportunities?**
A) Specific Procurement Notice
B) General Procurement Notice
C) Invitation to Tender
D) Request for Proposals

66. **In which publication is the General Procurement Notice for ICB typically published?**
A) Local newspapers
B) UN Development Business
C) Official Gazette of the borrowing country
D) International trade journals

67. **Which procurement method is typically used for construction works with a cost estimate not exceeding NPR 20 million in Nepal?**
A) National Competitive Bidding
B) Sealed Quotation
C) Lump Sum Price Rate Method
D) Catalogue Shopping

68. **What is the minimum notice period required for inviting sealed quotations in Nepal?**
A) 3 days
B) 5 days
C) 7 days
D) 15 days

69. **In which procurement method does a public entity procure goods or services directly from the producer or authorized seller at the specified rate?**
A) Sealed Quotation
B) Direct Purchase
C) Catalogue Shopping
D) Force Account

70. **Which procurement method is used when a public entity needs to procure goods or services from a single source due to urgency or compatibility requirements?**
A) National Competitive Bidding
B) Sealed Quotation
C) Direct Purchase
D) Lump Sum Price Rate Method

71. **What is the primary advantage of involving a user's committee or beneficiary group in the procurement process?**

A) Faster procurement process
B) Increased transparency and accountability
C) Higher quality of goods and services
D) Reduced cost estimates

72. **In which procurement method does a public entity use its own personnel and equipment to carry out construction work?**
A) National Competitive Bidding
B) Sealed Quotation
C) Direct Purchase
D) Force Account

73. **Which procurement method is characterized by submitting a bid offering a lump sum rate that is a certain percentage more or less than the total cost estimate?**
A) National Competitive Bidding
B) Sealed Quotation
C) Lump Sum Price Rate Method
D) Catalogue Shopping

74. **Which of the following is a mandatory requirement in a Tender Notice for construction projects in Nepal?**
A) Cost estimate
B) Bidder's qualifications
C) Project completion time
D) All of the above

75. **What is the minimum notice period required for publishing a Tender Notice for national competitive bidding in Nepal?**
A) 15 days
B) 30 days
C) 45 days
D) 60 days

76. **Which of the following is NOT typically included in a Tender Notice in Nepal?**
A) Bid submission deadline
B) Bid opening date
C) Bidder's company history
D) Contact information for clarification

77. **What is the primary purpose of including a cost estimate in a Tender Notice for construction projects in Nepal?**
A) To set a price ceiling for bids
B) To guide bidders in pricing their proposals
C) To comply with legal requirements
D) All of the above

78. **Which of the following is NOT a commonly accepted form of Bid Security in Nepal?**
    A) Bank Guarantee
    B) Demand Draft
    C) Fixed Deposit Receipt
    D) Property Documents

79. **In Nepal, what is the usual percentage range for Earnest Money Deposit (EMD) in government tenders?**
    A) 2–3% of the estimated contract value
    B) 5–7% of the estimated contract value
    C) 8–10% of the estimated contract value
    D) 10–20% of the estimated contract value

80. **What is the typical validity period for a Bid Security in Nepal?**
    A) 30 days from the bid submission deadline
    B) 60 days from the bid submission deadline
    C) 90 days from the bid submission deadline
    D) 120 days from the bid submission deadline

81. **What is the typical percentage range for Performance Security in Nepal's public procurement?**
    A) 2% of the contract value
    B) 5% of the contract value
    C) 10% of the contract value
    D) 15% of the contract value

82. **In Nepal, what is the usual validity period for a Performance Security?**
    A) 30 days from the contract signing
    B) 60 days from the contract signing
    C) 90 days from the contract signing
    D) Until the completion of all contractual obligations

83. **What is the primary objective of the pre-tender preparation phase?**
    A) To evaluate received bids
    B) To define project scope, budget, and procurement strategy
    C) To award the contract
    D) To execute the contract

84. **Which of the following is a key activity during pre-tender preparation?**
    A) Bid evaluation
    B) Market research and supplier engagement

C) Contract signing
D) Bid submission

85. **What is the purpose of conducting a pre-bid evaluation?**
    A) To assess the feasibility and profitability of the project
    B) To select the winning bidder
    C) To finalize the contract terms
    D) To review submitted bids

86. **Which of the following is NOT typically part of the pre-tender preparation process?**
    A) Defining procurement objectives
    B) Engaging with potential suppliers
    C) Evaluating submitted bids
    D) Preparing tender documents

87. **What role does defining a procurement strategy play in pre-tender preparation?**
    A) It determines the project's timeline
    B) It outlines how the procurement will be conducted, including methods and evaluation criteria
    C) It specifies the project's location
    D) It sets the project's budget

88. **Which of the following is NOT typically a responsibility of a construction supervisor?**
    A) Conducting site inspections
    B) Approving project designs
    C) Coordinating with subcontractors
    D) Managing construction schedules

89. **What is the purpose of maintaining a daily log on a construction site?**
    A) To track employee attendance
    B) To record weather conditions and work progress
    C) To document safety incidents and material usage
    D) All of the above

90. **Which document is essential for a construction supervisor to verify that materials meet project specifications?**
    A) Work order
    B) Material submittal
    C) Purchase order
    D) Safety data sheet

91. **How does a construction supervisor contribute to safety on the job site?**
    A) By conducting safety training sessions
    B) By ensuring that safety protocols are followed
    C) By inspecting equipment for

compliance with safety standards
D) All of the above

92. **What action should a construction supervisor take if a subcontractor's work does not meet quality standards?**
A) Ignore the issue to avoid conflict
B) Immediately halt all work on the project
C) Notify the subcontractor and request corrections
D) Report the issue to the client without addressing it

93. **Which of the following tools is commonly used by construction supervisors to monitor project progress?**
A) Gantt chart
B) Project charter
C) Risk register
D) Communication plan

94. **Which estimate is typically prepared to obtain Administrative Approval?**
A) Detailed Estimate
B) Preliminary or Approximate Estimate
C) Supplementary Estimate
D) Revised Estimate

95. **After obtaining Administrative Approval, what is the next step in the project approval process?**
A) Commencement of work
B) Technical Sanction
C) Release of funds
D) Final Acceptance

96. **When interpreting a bar chart, what is crucial to consider?**
A) The color of the bars
B) The scale and labels on the axes
C) The thickness of the bars
D) The background color of the chart

97. **In a grouped bar chart, what does each group represent?**
A) A single category
B) Multiple categories compared across different groups
C) The total of all categories
D) A time period

98. **What does a horizontal bar chart typically represent?**
A) Data over time
B) Categories with longer names
C) Proportions of a whole
D) Trends in data

99. **In a bar chart, if the bars are arranged in descending order of height, what does this arrangement help to identify?**
A) The average value of the data
B) The category with the highest value
C) The total number of categories
D) The frequency of each category

100. **Which of the following is a key advantage of using bar charts?**
A) They can display large amounts of data in a compact space
B) They are ideal for showing trends over time
C) They allow for easy comparison of different categories
D) They are best suited for displaying proportions of a whole

101. **What is a stacked bar chart primarily used for?**
A) To compare total sizes across categories
B) To show the distribution of categories within a total
C) To display data trends over time
D) To illustrate the relationship between two variables

102. **In a bar chart, what does the length of each bar represent?**
A) The category label
B) The frequency or count of the category
C) The total number of categories
D) The average value of the category

103. **Which of the following is NOT a type of bar chart?**
A) Simple Bar Chart
B) Stacked Bar Chart
C) Pie Chart
D) Grouped Bar Chart

104. **What are Milestones in project planning?**
A. Activity versus time
C. Only activities
B. vertical bar charts
D. beginning of various activities

105. **Contractors prequalification is required for project cost above:**
A. 20 lakhs
B. 60 lakhs
C. 1 crore
D. 2 crore

106. **For consulting service as per PPR, the maximum weight for a technical proposal is?**

A. ninety percentage

C. eighty percentage

B. seventy percentage

D. sixty percentage

A. before tender

B. at the time of tender

107. Acquisition of land for any construction should be performed:

C. after tender

D. at any time

108. According to PPR-064 the contractor can be black listed up to:
- A. 2 yrs
- B. 3yrs
- C. 5 yrs
- D. 7 yrs

109. The performance security for the foreign contractor is …..% of contract amount a
- A. 2.5
- B. 5
- C. 10
- D. 8

110. The Department head can extend the time up to.. % of initial contract duration
- A. 10
- B. 25
- C. 50
- D. 100

111. Direct Purchase for consulting services is limited to the amount NRs…………..

A. 1.5 lakh

B. 3 lakh

C. 5 lakh

D. 10 lakh

112. EOI is compulsory for procurement of consulting services if work amount exceeds
- A. 10 lakh
- B. 20 lakh
- C. both
- D. none

113. The dispute resolution method in any contract is

A. Amicable settlement

B. Dispute adjudication board

C. Arbitration

D. all of above

114. The bid evaluation committee consists of ………………numbers of persons.
- A. 1
- B. 2
- C. 3
- D. 5

115. The money of the contractor retained by the department during payments is called:

A. tender money

B. retention money

C. earnest money

D. security money

116. Which of following is not a bid document?

A. condition of contract

C. specification

B.

C. performance security form

D. letter of acceptance

117. Which is not the part of contract document

A. Letter of Intent

B. Letter of acceptance

B. Bill of quantities

D. special condition of contract

118. Physical contingency according to PPR -064 is
- A. 3-5%
- B. 8%
- C. 5%
- D. 10%

119. Price variation contingency according to PPR -064 is
- A. 3-5%
- B. 8%
- C. 5%
- D. 10%

120. Quality control is done by

A. Engineer

B. Supervisor

C. contractor

D. owner

121. Which of the following is not a part of bidding document?

A. Invitation to bidders

B. BOQ

C. Instruction to bidders

D. None of the above

122. Works can be executed using force account method if price doesn't exceed

A. 3 lakh

B. 1 lakh

C. 5 lakhs

D. 1.5 lakh

123. The Project Manager can extend the time up to……………..months
- A. 6
- B. 12
- C. 3
- D. none

124. Slack time in PERT analysis:

A. can never be greater than zero

    B.   is always zero for critical activities

    C.   can never be less than zero

    D.   Is minimum for critical activities

125. **The conception of idea for any construction work is the responsibility of:**

    A.   Owner   C. Engineer

    B.   Contractor   D. All

126. Unit of measurement of asbestos cement sheet roofing is

    A.   Sq.m

    B.   Kilograms

    C.   Metres

    D.   Number

127. Calculate the number of cement bags required for RCC (1:2:4) for 15 m3 of work.

    A.   24.6

    B.   38.9

    C.   56.7

    D.   93.8

128. In earthwork calculations, the average horizontal distance between the centre of deposition and the centre of excavation is known as

    A.   Lift

    B.   Flooring

    C.   Lead

    D.   Embankment

129. For painting corrugated steel sheet, surfaces shall be measured flat and the area worked out shall be increased by

    A.   10%

    B.   12%

    C.   14%

    D.   20%

130. The unit of measurement of brick soling is

    A.   Lump sum

    B.   Square meter

    C.   meter

    D.   Cubic meter

131. The essential requirements to prepare good estimate are

    A.   Schedule of rates

    B.   Fully dimension drawing to the scale

    C.   Detail specifications

    D.   All of the above

132. Estimate is

    A.   Cost of the structure using thumb rules.

    B.   Random guess of cost of structure.

    C.   Probable cost arrived at before construction.

    D.   Actual cost of construction

Answers

1	B	21	C	41	B	61	B	81	B
2	C	22	A	42	B	62	A	82	D
3	C	23	C	43	D	63	C	83	B
4	B	24	A	44	C	64	C	84	B
5	C	25	D	45	B	65	B	85	A
6	B	26	C	46	B	66	B	86	C
7	B	27	C	47	B	67	C	87	B
8	B	28	A	48	D	68	C	88	B
9	B	29	B	49	A	69	C	89	D
10	B	30	D	50	B	70	C	90	B
11	B	31	B	51	A	71	B	91	D
12	B	32	B	52	B	72	D	92	C
13	C	33	D	53	C	73	C	93	A
14	B	34	D	54	B	74	D	94	B
15	C	35	A	55	C	75	B	95	B
16	C	36	A	56	A	76	C	96	B
17	C	37	B	57	D	77	D	97	B
18	A	38	B	58	B	78	D	98	B
19	D	39	B	59	B	79	A	99	B
20	B	40	C	60	D	80	B	100	C

101	B	121	A
102	B	122	B
103	C	123	A
104	D	124	D
105	D	125	A
106	D	126	A
107	A	127	D
108	B	128	C
109	C	129	C
110	B	130	B
111	D	131	D
112	B	132	C
113	D		
114	C		
115	B		
116	D		
117			
118	D		
119	D		
120	A		

13 Airport Engineering

13.1 General

Airport engineering is a specialized branch of civil engineering focused on the planning, design, construction, and maintenance of airport infrastructure. It encompasses a wide range of facilities and systems to ensure the safe, efficient, and sustainable operation of airports.

13.1.1 introduction to air transport system

An **air transport system** is a complex network that facilitates the movement of passengers, cargo, and mail via aircraft. It encompasses various components and processes to ensure safe, efficient, and sustainable air travel.

*Advantage of air Transportation

A. Fastest Shipping Option

Air transport is the quickest mode of transportation, enabling rapid delivery of goods and passengers over long distances.

B. Reliable Schedules

Airlines offer frequent and dependable flight schedules, minimizing delays and ensuring timely arrivals.

C. Global Reach

Air transport connects virtually every part of the world, facilitating international trade, tourism, and global connectivity.

D. Lower Insurance Costs

Due to faster transit times, the risk of damage or loss is reduced, leading to lower insurance premiums for air shipments.

E. High Security

Airports implement stringent security measures, reducing the risk of theft or damage during transport.

F. Less Need for Warehousing

Faster delivery times decrease the need for extensive storage, reducing inventory costs.

G. Reduced Packaging Requirements

Air shipments often require lighter packaging compared to other modes, saving on packaging materials and costs.

H. **Track and Trace Capabilities**

Most air shipments can be tracked in real-time, providing transparency and improving supply chain visibility.

I. Speedy Customs Clearance

Airports are equipped with efficient customs facilities, ensuring faster clearance and minimal delays.

J. High Safety Standards

Air travel maintains one of the highest safety records among transportation modes, with rigorous maintenance and operational protocols.

*Disadvantage of air transportation

A. High Costs

Air transport is the most expensive mode of transportation due to high operational expenses such as fuel, maintenance, and airport fees.

B. Limited Cargo Capacity

Airplanes have limited cargo space and weight capacity, making them unsuitable for transporting large or bulky goods.

C. **Weather Dependency**

Adverse weather conditions, such as fog, thunderstorms, or snow, can lead to flight delays, cancellations, or rerouting, affecting reliability.

D. **Environmental Impact**

Aviation contributes significantly to carbon emissions and environmental pollution. In 2018, global commercial operations generated 2.4% of all emissions.

E. **Noise Pollution**

Aircraft noise, especially during takeoff and landing, can exceed 140 decibels, leading to health issues like hearing impairment and increased risk of heart disease.

F. **Health Risks**

Long flights increase the risk of deep vein thrombosis (DVT), and passengers are exposed to higher levels of cosmic radiation.

G. **Security Concerns**

Airports implement stringent security measures, which can lead to delays and inconvenience for passengers.

H. **Limited Accessibility**

Not all regions are served by airports, making air transport inaccessible for certain remote or underserved areas.

I. **Regulatory Restrictions**

Certain goods, such as hazardous materials, are prohibited from being transported by air due to safety regulations.

J. **Infrastructure Requirements**

Airports require significant investment in infrastructure, including runways, terminals, and air traffic control systems, which can be costly and require substantial space.

13.1.2 Historic development of airports in Nepal

A. **1947** — A lone pilot landed his glider on the old golf course, that makes the present location of Tribhuvan international airport.

B. **1950** — The first charter flight, operated by Himalayan Aviation using a Dakota, flew from Gauchar to Kolkata.

C. **1955** — King Mahendra inaugurated Gauchar Airport and renamed it Tribhuvan Airport.

D. **1957**----The grassy runway was transformed into a concrete one.

E. **1957**----Establishment of the Department of Civil Aviation.

F. **1958** — Royal Nepal Airlines began scheduled domestic and international services domestically and externally.

G. **1959** — civil aviation Act 2015 BS promulgated.

H. **1960** — Nepal attained membership in the International Civil Aviation Organization (ICAO).

I. **1964** — Tribhuvan Airport was renamed Tribhuvan International Airport.

J. **1967** — The runway (approximately 3,750 ft) was extended to 6,600 ft; Lufthansa's Boeing 707 landed, marking the first jet arrival.

K. **1972** — Royal Nepal Airlines' Boeing 727 made its debut landing at TIA; Air Traffic Control services were transferred from Indian technicians to Nepali personnel.

L. **1975** — The runway at TIA was further extended to 10,000 ft; the Civil Aviation Training Center (CATC) was established.

M. **1976** — A Flight Information Center (FIC) was established.

N. **1977** — Nepal began making its presence known on the world aeronautical stage.

O. **1985** — Completion of overlay work on the runway; development of the terminal building began.

P. **1987** — Construction of the Airlines Operations & Control Tower and taxiway overlay was completed. On 11 October, the Concorde made its first landing in Nepal.
Q. **1989** — The terminal building was fully completed.
R. **1990** — The new international terminal building of TIA was officially inaugurated by King Birendra on 18 February.
S. **1995** — Expansion work on the domestic terminal began.
T. **2002** — Expansion of the Civil Aviation Authority of Nepal (CAAN) apron and construction of a new air cargo complex.
U. **2011** — Resurfacing of the runway and taxiway was completed.

13.1.3 Classification on airports

The classification of airport by ICAO is based on following two ways:

A. Based on runway length (as per ICAO)

Airport type	Basic runway length (m)		Width of runway pavement (m)	Maximum longitudinal*grade(%)
	maximum	minimum		
A	>2100	2100	45	1.5
B	2099	1500	45	1.5
C	1499	900	30	1.5
D	899	750	22.5	2
E	749	600	18	2

B. Based on wheel load (as per ICAO)

Code No.	Single isolated wheel load (Kg)	Tyre pressure (Kg/cm²)
1	45000	8.5
2	34000	7
3	27000	7
4	20000	7
5	13000	6
6	7000	5
7	2000	2.5

C. Based on function
i. International airport i.e. TIA
ii. Domestic airport 42 in number
iii. Combination of international and domestic airport
iv. Military airport

D. Based on geometric design (as per ICAO)

Code NO	Aeroplane reference field	Code letter	Wing span	Outer main gear wheel span
1	Upto 800m	A	Upto 15m	Upto 4.5m
2	800m up but not including 1200m	B	15m up but not including 24m	4.5m up but not including 6m
3	1200m to higher but not including 1800m	C	24m up but not including 36m	6m to higher but not including 9m
4	1800 m and above	D	36m up but not including 52m	9m to higher but not including 14m

		E	52m up but not including 65m	9m to higher but not including 14m
		F	65m up but not including 80m	14m to higher but not including 16m

13.1.4 Airport terminologies

1. **Apron (Ramp):**
   The paved area where aircraft park, load/unload, refuel, board, or receive maintenance. It's part of the movement area but not the maneuvering area. Controlled by apron management or ATC depending on airport size.

2. **Taxiway:**
   A designated path connecting runways with aprons, hangars, and terminals. Typically paved with asphalt or concrete; some smaller airports may use gravel or grass.

3. **Jet Bridge (Passenger Boarding Bridge, PBB):**
   An enclosed, movable connector between the terminal gate and aircraft, allowing passengers to board and disembark in sheltered comfort. It may swing, extend, retract, and adjust to different aircraft heights.

4. **Ground Support Equipment (GSE):**
   Vehicles and equipment used on the apron to service aircraft between flights—this includes fueling trucks, baggage dollies, power units, and more.

5. **Fixed-Base Operator (FBO):**
   A company authorized to provide aeronautical services at an airport, such as fueling, hangaring, maintenance, flight instruction, and aircraft rental—especially common in general aviation.

6. **Control Zone (CTR):**
   A controlled volume of airspace around an airport—typically Class D in the U.S.—that extends from the surface up to a set altitude. Aircraft must obtain ATC clearance before entering.

7. **ATC (Air Traffic Control):**
   The ground-based service that manages aircraft movements—on the ground and in the airspace—to ensure safety and efficiency.

8. **Approach & Departure Control (ADC):**
   ATC services handling arriving and departing aircraft, ensuring safe sequencing and spacing using radar and other surveillance tools.

9. **Radar:**
   A system that emits radio waves to detect and track aircraft, helping ATC manage traffic by determining range, altitude, and speed.

10. **IFR (Instrument Flight Rules):**
    Regulations under which flights operate relying on instruments—not outside visual reference—for navigation and control.

11. **STAR (Standard Terminal Arrival Route):**
    A published flight path for IFR arrivals transitioning from en-route to approach procedures at busy airports.

12. **ATIS (Automatic Terminal Information Service):**
    A continuous broadcast of essential airport information (e.g., weather, runway in use, NOTAMs), updated regularly for pilots at busy airports.

13. **AODB:** Airport Operational Database – Manages flight schedules, gates, and baggage systems.

14. **CUTE:** Common Use Terminal Equipment – Shared check-in and baggage systems across airlines.
15. **FIDS:** Flight Information Display System – Screens displaying flight status and gate info.
16. **BHS:** Baggage Handling System – Automated luggage movement systems.
17. **A-CDM:** Airport Collaborative Decision Making – A data-driven process to optimize ground operations.
18. **PNR:** Passenger Name Record – Contains passenger itinerary and contact information.
19. **ICAO** – International Civil Aviation Organization (UN agency overseeing aviation safety)
20. **IATA** – International Air Transport Association (airline industry trade group).
21. **AGL:** Above Ground Level (altitude measurement).
22. **Aileron:** Hinged flight control surface on wings that controls roll.
23. **Airfoil:** Wing's cross-sectional shape responsible for lift.
24. **APU:** Auxiliary Power Unit – Provides onboard power when main engines are off.
25. **ATIS:** Automatic Terminal Information Service (as above).
26. **Clearance:** ATC's permission for specific aircraft movement (e.g., to taxi, take off).
27. **VFR:** Visual Flight Rules – Operating by visual reference outside, not instruments.
28. **Holding Pattern:** A racetrack-shaped flight path where aircraft wait for clearance or sequencing.
29. **METAR** – Hourly aviation weather observation report.
30. **TAF** – Terminal Aerodrome Forecast.
31. **NOTAM:** Notice to Airmen – Alerts about closed runways, hazards, or operational changes.

13.2 Design
13.2.1 Basic design control and criteria for design

13.2.2 General items contained in ANNEX 14 (ICAO publication)

the following are the general items contained is ANNEX 14 (ICAO publication):

A. General
B. Aerodrome data
C. Physical characteristics
D. Obstacle restriction and removal
E. Visual aids for navigation
F. Visual aids for denoting restricted use areas
G. Electrical systems
H. Aerodrome operational services, equipment and installations
I. Aerodrome maintenance

13.2.3 Planning of airport and it's element

*Planning of airport system

This is a strategic-level framework that guides the development of a regional or national network of airports in a cohesive and forward-thinking way.
A. **Exploration of Issues**
Identify regional aviation challenges capacity constraints, environmental concerns, socio-economic priorities, and policy alignment.
B. **Inventory of the Current System**

Catalog all existing airports, their functions (e.g., commercial, regional, general aviation), capacity, condition, and efficiencies.

C. **Forecasting System Demand**

Use data-driven modeling to estimate future passenger volumes, cargo, and aircraft movements, as well as operational demand.

D. **Consideration of Alternatives**

Evaluate various system configurations including expanding existing airports or creating new ones—and assess which best meets demand and policy goals.

E. **Defining Airport Roles and Policy Strategies**

Designate each airport's role (e.g., hub, reliever, regional) and develop policies around land use, environmental sustainability, and integration with broader transportation planning.

F. **Recommendations for System Changes**

Outline proposals for infrastructure development across the airport system layout improvements, terminal upgrades, runway enhancements, etc.along with financial estimates and prioritization.

G. **Implementation & Funding Plan**

Lay out long-range fiscal strategies, funding mechanisms, budgeting timelines, and project sequencing.

H. **Governance & Coordination Mechanisms**

Define structures for implementation engaging government bodies, private partners, and communities to align with existing laws, regulations, and political processes.
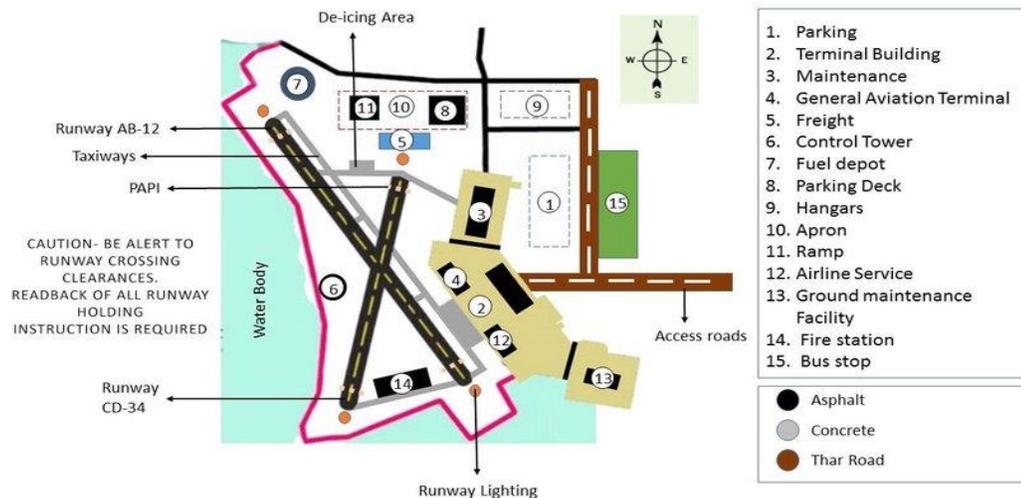
13.2.4 Terminal Building and Control tower
*Terminal Building

An **terminal building** is the central structure at an airport where passengers begin and end their journey, acting as the critical juncture between surface transport and aircraft operations.

*Main Purpose of a Terminal Building

A. Change of Transportation Mode

Facilitates transition between ground transport (like cars, buses, trains) and air travel, acting as the central hub where passengers move into and out of the airport building.

B. Passenger & Baggage Processing
Supports key procedures such as check-in**,** ticketing**,** security screening**,** and baggage handling, ensuring both passengers and their luggage are processed effectively.
C. Grouping / Ungrouping of Passengers
Organizes passengers into the correct flights before departure and deconsolidates them upon arrival, creating spaces for holding and orderly flow.

****Main component of terminal building**
  A. **Entrance and Exit Points**: Access points for passengers arriving and departing via ground transportation.
  B. **Parking Facilities**: Areas designated for short-term and long-term vehicle parking.
  C. **Check-in Counters**: Stations where passengers register for flights and drop off luggage.
  D. **Baggage Claim**: Carousels where arriving passengers collect their checked baggage.
  E. **Customs and Immigration (for international flights)**: Facilities for passport control and customs declaration.
  F. **Retail and Dining**: Shops, restaurants, and lounges providing services to passengers.
  G. **Restrooms and Amenities**: Facilities for passenger comfort and convenience.

***Control Tower**

An **airport control tower** is a tall, strategically located structure within an airport that houses air traffic controllers responsible for managing aircraft movements on the ground and in the immediate airspace around the airport. Its primary purpose is to ensure the safe and efficient flow of air traffic, preventing collisions and facilitating orderly operations.
  ➢
***Main function of an Airport control tower**
  A. **Ground Control**:
   Manages the movement of aircraft and vehicles on the airport's taxiways and apron areas, excluding active runways.
  B. **Local (Tower) Control**:
   Oversees aircraft movements on active runways, including takeoffs and landings.
  C. **Approach Control**:
   Coordinates the arrival of aircraft into the terminal area, providing instructions for safe and efficient sequencing of arrivals.
  D. **Flight Clearance Delivery**:
   Issues IFR (Instrument Flight Rules) clearances to departing aircraft, providing them with routing and altitude instructions.
  E. **Airspace Control**:
   Monitors and manages aircraft within a designated radius around the airport, typically up to 5 nautical miles.

13.2.5 Drainage system in airport engineering

Airport drainage systems are critical for maintaining operational safety and infrastructure integrity by efficiently managing stormwater runoff. These systems encompass both surface and subsurface components, tailored to handle the unique demands of airside and landside areas.

A. Airside Drainage
Airside areas, including runways, taxiways, and aprons, require robust drainage solutions due to heavy aircraft traffic and exposure to de-icing chemicals. Types of airside drainage are:

i. Surface Drainage: Utilizes channels, ditches, and sloped surfaces to direct water away from critical areas.

ii. Subsurface Drainage: Incorporates underdrains and storm sewers to collect and transport water underground.

B.   Landside Drainage

Landside areas, such as terminals and access roads, require drainage systems designed for public safety and aesthetic integration.

i. Surface Drainage: Features slotted channels and grated inlets to manage pedestrian and vehicular runoff.

ii. Aesthetic Integration: Designs that blend with the airport's architecture while ensuring functionality.

*Design Considerations

Effective airport drainage design considers:

i. Hydrologic Analysis: Calculating rainfall intensity, runoff coefficients, and drainage areas.

ii. Grading and Slope: Ensuring proper slope to facilitate water flow.

iii. Water Quality Management: Implementing best management practices (BMPs) like hydrodynamic separators to treat stormwater.

iv. Maintenance Access: Designing systems for easy inspection and cleaning.

13.2.5 Geometric design, pavement structure and it's component
*Pavement structure

According to the FAA Advisory Circular 150/5320-6G, the typical pavement structure consists of:

1. **Surface Course**: The topmost layer, providing a smooth, skid-resistant surface for aircraft operations.
2. **Base Course**: Located beneath the surface course, this layer distributes loads to the underlying subbase.
3. **Subbase Course**: Serves as a transition layer between the base course and the subgrade, offering additional load distribution and drainage.
4. **Subgrade**: The natural soil or rock layer that supports the entire pavement structure.

*Types of pavement

Airports primarily utilize two types of pavement structures:

- **Flexible Pavement**: Typically constructed with asphalt, this pavement type is designed to flex under loads, distributing stresses over a broader area.
- **Rigid Pavement**: Made from concrete, rigid pavements are designed to resist bending, providing a durable surface for heavy aircraft operations.

13.2.6 Basic knowledge of heliport and hangers
*Heliport

A **heliport** is a designated area on land, water, or a structure intended for the arrival, departure, and surface movement of helicopters. It serves as a critical infrastructure for helicopter operations, including emergency medical services, offshore transport, and urban air mobility.

Component of heliport

A. **Touchdown and Liftoff Area (TLOF)**: A load-bearing, usually paved area where helicopters land and take off. Its dimensions are typically at least equal to the rotor diameter of the largest helicopter using the heliport.

B. **Final Approach and Takeoff Area (FATO)**: A defined area over which the pilot completes the final phase of the approach to a hover or landing, and from which the pilot initiates takeoff.

C. **Safety Area**: A defined area surrounding the FATO intended to reduce the risk of damage to helicopters accidentally diverging from the FATO.

D. **Approach and Departure Paths**: Clear, unobstructed routes for helicopters to approach and depart the heliport safely.

E. **Wind Cone**: A device indicating wind direction and speed, aiding pilots in approach and departure planning.

F. **Marking and Lighting**: Visual indicators and lighting systems to enhance visibility and safety during operations, especially in low-light conditions.

Types of heliports

A. **Ground-Level Heliports**: Located on the ground, often in rural or undeveloped areas.

B. **Rooftop Heliports**: Situated atop buildings, commonly found in urban settings for emergency medical services.

C. **Offshore Heliports**: Built on platforms over water, serving offshore oil rigs and vessels.

D. **Mobile Heliports**: Portable setups used in temporary or emergency situations.

*Hangers

An **aircraft hangar** is a large, enclosed structure designed to house aircraft for protection, maintenance, and storage.

Components of a Hangar

A. Structure: The framework, often made of steel or aluminum, supports the hangar's roof and walls.

B. Doors: Large openings, such as sliding or bifolding doors, allow aircraft to enter and exit the hangar.

C. Flooring: Durable, flat surfaces, often made of reinforced concrete, support the weight of aircraft and equipment.

D. Lighting: Adequate illumination ensures visibility during operations, especially in low-light conditions.

E. Ventilation: Systems to maintain air quality and control temperature and humidity levels.

F. Fire Suppression Systems: Safety measures, such as foam or water-based systems, to protect against fire hazards.

Types of Aircraft Hangers

A. **T-Hangars**: Single-story structures shaped like the letter "T," offering individual bays for small aircraft. Commonly used at general aviation airports.

B. **Box Hangars**: Rectangular buildings that can accommodate multiple aircraft simultaneously. They often include additional spaces for maintenance and office areas.

C. **Maintenance Hangars**: Large facilities equipped with specialized tools and equipment for aircraft repair and servicing.

D. **Corporate Hangars**: Customized hangars that may feature amenities like offices and lounges, catering to business aviation needs.

E. **Military Hangars**: Designed to meet the specific requirements of military aircraft, often incorporating reinforced structures and security features.

F. **Underground Hangars**: Built into the side of mountains or underground, these hangars provide protection from potential attacks. They are commonly used by military forces.
G. **Bellman Hangars**: Temporary or semi-permanent structures, originally designed during World War II, still in use for various aviation purposes.

13.3 Airport Maintenance
13.3.1 Types of airport maintenance
A. **Preventive Maintenance (PM)**
   a. **Definition**: Scheduled upkeep aimed at preventing failures before they occur, this includes inspections, servicing, cleaning, lubricating parts, and replacing worn components.
   b. **Purpose**: Extends asset lifespan, reduces unexpected downtime, and supports budget planning.

B. **Predictive Maintenance (PdM)**
   a. **Definition**: Uses real-time data (e.g., from sensors) and analytics to forecast failures and perform upkeep just in time.
   b. **Purpose**: Avoids unnecessary maintenance, prevents unforeseen breakdowns, and improves resource allocation.
C. **Corrective (Reactive) Maintenance**
   a. **Definition**: Conducted post-failure to restore equipment or systems.
   b. **Types**:
      i. *Immediate*: Work starts as soon as the fault is detected.
      ii. *Deferred*: Scheduled based on maintenance policies.
D. **Operational (User-Level) Maintenance**
   a. **Definition**: Basic, routine maintenance performed by operators—tasks like cleaning, lubrication, or light adjustments.
   b. **Purpose**: Enhances readiness and frees technical staff for more complex tasks.
E. **Runway & Pavement Maintenance**
   a. **Scope**: Repairs cracks and joints, removes rubber buildup, handles surface contamination, clears snow/ice, and maintains drainage.
   b. **Practices include**: Rubber removal via water blasting or milling, surface sweeping, and de-icing.
F. **Infrastructure & Facilities Maintenance**
   a. **Includes**: Buildings and systems such as HVAC, lighting, electrical systems, boarding bridges, baggage belts, plumbing, elevators, communications, fire protection, and grounds (e.g., turf, landscaping).
G. **Ground Support Equipment (GSE) Maintenance**
   a. **Scope**: Maintenance of apron equipment—aircraft tugs, baggage dollies, chocks, fuel trucks, power units—essential for safe and efficient turnaround operations.
H. **Aircraft Maintenance (MRO)**
   a. **Line Maintenance**: Routine inspections and minor repairs, typically at gates between flights.
   b. **Hangar Maintenance**: More involved, such as engine swaps, A-checks, or significant component tasks.
   c. **Heavy Maintenance (Overhaul/D-Checks)**: Full-scale inspection and structural overhauls, often taking weeks.

            i. *Quote from aviation professionals*:
               "Heavy Maintenance is aircraft overhaul. Hangar maintenance is usually related to overnight maintenance for larger jobs, such as an engine change."

I. **Winter / Snow Operations Maintenance**
    a. **Tasks**: Snow removal, surface de-icing/anti-icing, clearing runways/taxiways/aprons to keep them operational and safe.

J. **Proactive Maintenance** (emerging best practice)

K. **Definition**: Strategic, engineering-driven approach focused on identifying root causes and addressing systemic issues to prevent repeat failures (e.g., redesigning systems, training, process improvements).

*Remaining part discuss in physical and online class.
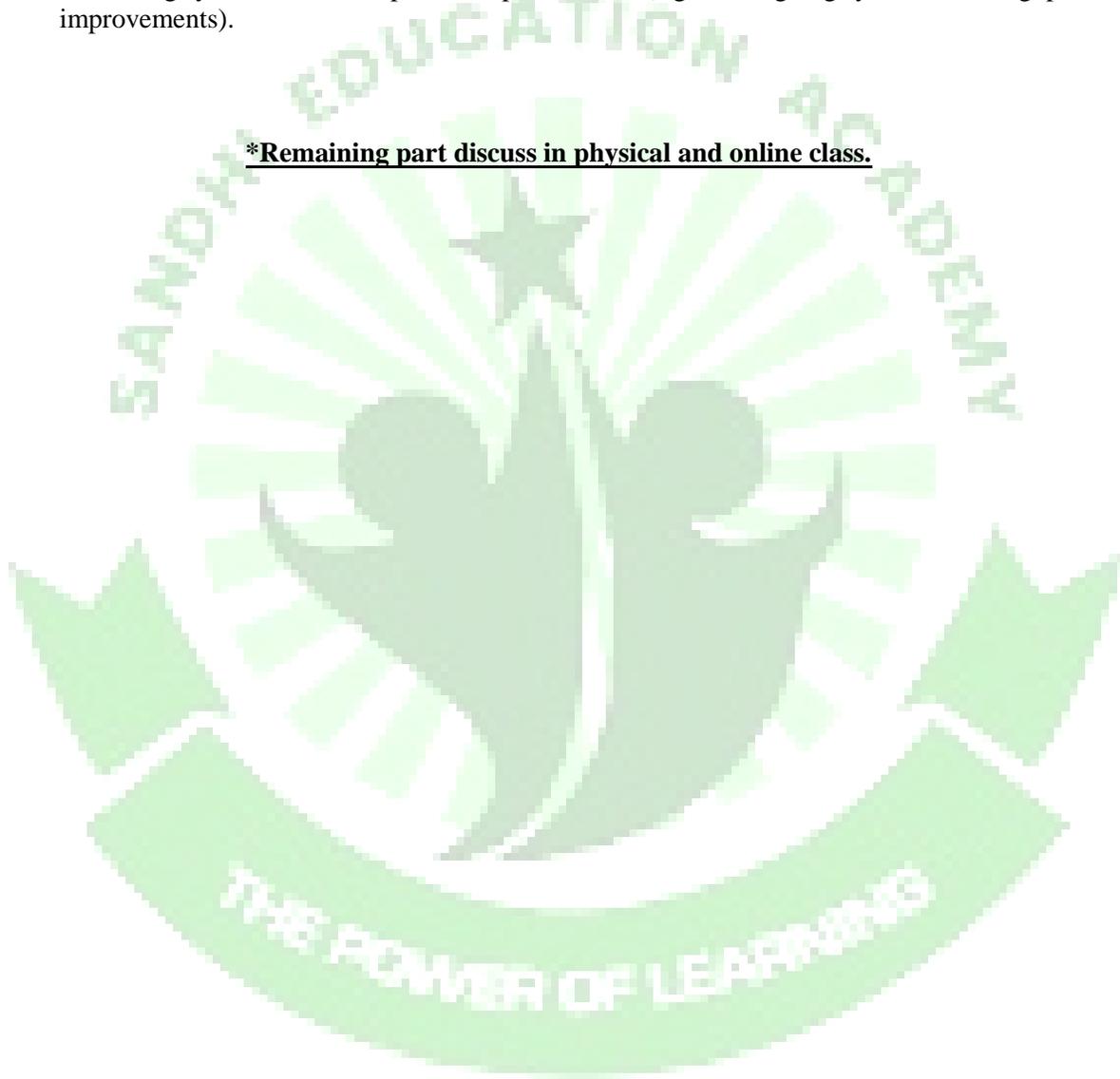
1. **Which of the following is a primary advantage of air transportation?**

   a) Low operational costs
   b) High speed and global reach
   c) Minimal environmental impact
   d) No need for infrastructure

2. **What is the main purpose of the International Civil Aviation Organization (ICAO)?**

   a) To regulate airline ticket prices
   b) To develop international standards and regulations for aviation safety
   c) To operate commercial airlines
   d) To manage airport ground services

3. **Which organization is responsible for setting standards for the safety, security, efficiency, and regularity of air transport?**

   a) International Air Transport Association (IATA)
   b) Federal Aviation Administration (FAA)
   c) International Civil Aviation Organization (ICAO)
   d) European Union Aviation Safety Agency (EASA)

4. **What does the term 'air cargo' refer to?**

   a) Passengers traveling by air
   b) Goods and materials transported by air
   c) Aircraft maintenance services
   d) Air traffic control services

5. **Which of the following is a disadvantage of air transportation?**

   a) High speed
   b) Limited capacity for cargo
   c) Global connectivity
   d) High fuel efficiency

6. **What is the primary function of the International Air Transport Association (IATA)?**

   a) To provide air traffic control services
   b) To set global standards for airline safety
   c) To represent and serve the airline industry worldwide
   d) To operate airports

7. **Which of the following is NOT a mode of air transportation?**

   a) Commercial airlines
   b) Private jets
   c) Helicopters
   d) Cargo ships

8. **Which of the following is a key component of the air transportation system?**

   a) Airports
   b) Air traffic control
   c) Aircraft
   d) All of the above

9. **When did the first aircraft land in Nepal, marking the beginning of air transportation in the country?**

   a) 1945
   b) 1949
   c) 1955
   d) 1964

10. **What was the original name of Tribhuvan International Airport before it was renamed in 1955?**

   a) Kathmandu International Airport
   b) Gauchar Airport
   c) Pashupatinath Airport
   d) Lumbini Airport

11. **Who inaugurated Tribhuvan International Airport in 1955?**

a) King Tribhuvan
b) King Mahendra
c) Sir Edmund Hillary
d) Tenzing Norgay

12. **In which year did Nepal join the International Civil Aviation Organization (ICAO)?**

a) 1955
b) 1960
c) 1972
d) 1980

13. **When did the first jet aircraft land at Tribhuvan International Airport?**

a) 1964
b) 1967
c) 1972
d) 1980

14. **Which airport was renamed Gautam Buddha Airport in 1977?**

a) Pokhara Airport
b) Bhairahawa Airport
c) Lumbini Airport
d) Biratnagar Airport

15. **Which airport is known as the gateway to Mount Everest and was built under the guidance of Sir Edmund Hillary?**

a) Pokhara International Airport
b) Lukla Airport
c) Gautam Buddha Airport
d) Tribhuvan International Airport

16. **When did Nepal Airlines Corporation (NAC) commence its operations?**

a) 1955
b) 1958
c) 1960
d) 1972

17. **Which airport in Nepal has been operational at full capacity for the**

first time in its 73-year history as of October 2023?

a) Gautam Buddha Airport
b) Pokhara International Airport
c) Tribhuvan International Airport
d) Lukla Airport

18. **On what basis does the Federal Aviation Administration (FAA) classify airports?**

a) Function and location
b) Aircraft approach speed
c) Runway length
d) Passenger capacity

19. **Which two factors does the International Civil Aviation Organization (ICAO) primarily consider for airport classification?**

a) Passenger capacity and terminal size
b) Runway length and aircraft wheel load
c) Location and function
d) Runway orientation and taxiway design

20. **How many categories are there in the ICAO classification system?**

a) 2
b) 3
c) 4
d) 5

21. **Which of the following is NOT a classification criterion for airports?**

a) Function (civil or military)
b) Geometric design standards
c) Aircraft approach speed
d) Passenger terminal amenities

22. **What is the primary purpose of classifying airports?**

a) To determine the airport's revenue
b) To establish design and operational

standards
c) To assign airline routes
d) To set passenger ticket prices

23. International civil aviation organization (I.C.A.O) was set up at montreal (Canada), in

a) 1929
b) 1939
c) 1947
d) 1950

24. The bearing of the longest line of a wind rose is S45°E, the bearing of the runway will be numbered
a) 135°
b) 13
c) 31
d) both b and c

25. **What is the area in the airport where passengers retrieve their checked luggage after a flight?**

a) Runway
b) VIP Lounge
c) Check-In Desk
d) Baggage Reclaim

26. **Which of the following is the area where aircraft are parked, unloaded or loaded, refueled, boarded, or maintained?**

a) Runway
b) Taxiway
c) Apron
d) Terminal

27. **What is the term for the designated area where aircraft wait before taking off?**

a) Holding Area
b) Runway
c) Taxiway
d) Gate

28. **Which of the following is a primary function of the terminal building at an airport?**

a) Aircraft maintenance
b) Passenger check-in and boarding
c) Air traffic control
d) Runway operation

29. **What is the purpose of a taxiway at an airport?**

a) To provide a path for aircraft to move between runways and terminals
b) To serve as a parking area for aircraft
c) To store luggage
d) To house air traffic control towers

30. **Which of the following is NOT typically found in the landside area of an airport?**

a) Check-in counters
b) Baggage claim
c) Security checkpoints
d) Duty-free shops

31. **What is the term for the area where aircraft are parked when not in use?**

a) Hangar
b) Runway
c) Apron
d) Taxiway

32. **Which of the following is a primary function of the control tower at an airport?**

a) Passenger check-in
b) Aircraft maintenance
c) Air traffic control
d) Baggage handling

33. **What is the term for the area where passengers wait before boarding their flight?**

a) Gate
b) Runway

c) Baggage claim
d) Terminal

34. **Which of the following is a primary function of the airside area of an airport?**

    a) Passenger check-in
    b) Baggage claim
    c) Aircraft parking and boarding
    d) Duty-free shopping

35. **What is the primary factor influencing the design of a runway?**

    a) Passenger capacity
    b) Aircraft type and performance
    c) Terminal size
    d) Number of gates

36. **According to ICAO, what is the maximum permissible longitudinal gradient for a runway at an 'A' type airport?**

    a) 1.0%
    b) 1.5%
    c) 2.0%
    d) 3.0%

37. **Which of the following is NOT a primary consideration in airport site selection?**

    a) Proximity to urban centers
    b) Availability of land
    c) Environmental impact
    d) Proximity to other airports

38. **What is the purpose of an airport master plan?**

    a) To document financial policies
    b) To develop physical facilities and land use
    c) To address environmental concerns
    d) All of the above

39. **Which of the following is a key factor in determining the required length of a runway?**

    a) Airport elevation
    b) Aircraft type and performance
    c) Environmental conditions
    d) All of the above

40. **What are the major components of an airport system?**

    a) Runways and taxiways
    b) Airside and landside
    c) Aprons and gates
    d) Master plan and financial feasibility

41. **Which factor influences runway alignments the most?**

    a) Aircraft speed
    b) Terrain features
    c) Passenger capacity
    d) Airport location

42. **What is a primary factor considered in airport site selection?**

    a) Proximity to urban areas
    b) Availability of cheap land
    c) Access to water resources
    d) Minimum environmental impact

43. **Which of the following is NOT typically considered in the design of taxiways?**

    a) Turning radius
    b) Pavement strength
    c) Aircraft parking positions
    d) Runway length

44. **What is the significance of the Airport Reference Temperature (ART) in runway design?**

    a) It determines the runway length required for aircraft takeoff
    b) It influences the pavement strength requirements

c) It affects the aircraft's performance characteristics
d) All of the above

45. **What is the purpose of an airport layout plan (ALP)?**

a) To depict current and future airport development
b) To establish financial policies
c) To address environmental concerns
d) To assign airline routes

46. **Which of the following is NOT typically found in an airport terminal building?**

a) Baggage claim area
b) Duty-free shops
c) Control tower
d) Check-in counters

47. **The primary function of an airport terminal building is to:**

a) Provide air traffic control services
b) Facilitate passenger processing and services
c) Store aircraft during non-operational hours
d) Serve as a maintenance facility for aircraft

48. **Which of the following is NOT a component of the terminal area section of an airport layout?**

a) Gates
b) Terminal building
c) Aircraft facilities
d) Landing strip

49. **The primary function of an airport control tower is to:**

a) Provide passenger services
b) Manage air traffic control for aircraft on the ground and in the vicinity
c) Store and maintain aircraft
d) Facilitate cargo handling operations

50. **Which instrument provides controllers at the ATC tower an overall picture of all aircraft within the airspace surrounding the terminal?**

a) Localiser
b) Glide slope antenna
c) Airport surveillance radar
d) Beacon

51. **Which of the following is NOT typically a responsibility of air traffic controllers in the control tower?**

a) Sequencing aircraft for takeoff and landing
b) Providing weather information to pilots
c) Managing aircraft movements on the ground
d) Conducting maintenance on aircraft

52. **What is the primary function of an airport drainage system?**

a) To remove surface runoff from the airfield
b) To intercept and divert surface and ground water flow
c) To lower the subsurface water level
d) All of the above

53. **Which formula is commonly used to estimate runoff in airport drainage design?**

a) $Q = CIA$
b) $Q = AR^{2/3}S^{1/2}/n$
c) $Q = AR$
d) $Q = A^2R$

54. **What is the minimum diameter for stormwater pipes in airport drainage systems?**

a) 15 cm
b) 25 cm
c) 30 cm
d) 45 cm

55. **Which material is commonly used as backfill in trenches where sub-drains are placed?**

    a) Filter paper
    b) Filter media
    c) Flocculation
    d) None of the above

56. **What is the minimum mean velocity required in drains to prevent scouring?**

    a) 0.075 m/sec
    b) 0.57 m/sec
    c) 0.75 m/sec
    d) 7.5 m/sec

57. **In a ponding condition of the drainage system, the spacing between inlets should be:**

    a) 1 to 2 meters center to center
    b) 3 to 5 meters center to center
    c) 6 to 8 meters center to center
    d) 10 to 12 meters center to center

58. **What is the primary function of an airport pavement structure?**

    a) To provide a smooth surface for aircraft operations
    b) To support the weight of aircraft during takeoff and landing
    c) To facilitate drainage and prevent water accumulation
    d) All of the above

59. **Which of the following is NOT a component of a flexible pavement structure?**

    a) Surface course
    b) Base course
    c) Subbase course
    d) Reinforced concrete layer

60. **Which material is commonly used in the surface course of flexible pavements?**

    a) Asphalt concrete
    b) Portland cement concrete
    c) Gravel
    d) Geotextile fabric

61. **Which of the following is a characteristic of rigid pavements?**

    a) High flexibility
    b) Use of asphalt concrete
    c) Use of Portland cement concrete
    d) Susceptibility to rutting

62. **What is the primary function of a heliport's Touchdown and Lift-Off (TLOF) area?**

    a) To provide a parking space for helicopters
    b) To serve as the landing and takeoff area for helicopters
    c) To house maintenance facilities for helicopters
    d) To store fuel for helicopters

63. **Which of the following is a recommended practice for heliport lighting during night operations?**

    a) Use of red lights for all areas
    b) Use of green lights for approach paths and TLOF perimeter
    c) Use of blue lights for taxiways
    d) No lighting is required

64. **What is the primary purpose of an aircraft hangar?**

    a) To provide a storage space for aviation fuel
    b) To house and protect aircraft from environmental elements
    c) To serve as a terminal for passenger check-in
    d) To store spare parts for aircraft maintenance

65. **Which factor is crucial when determining the size of an aircraft hangar?**

a) The number of aircraft to be stored
b) The color of the aircraft
c) The type of fuel used by the aircraft
d) The location of the airport

66. **What is the primary purpose of routine airport maintenance?**

a) To enhance the aesthetic appearance of the airport
b) To ensure the safety and operational efficiency of airport facilities
c) To increase passenger capacity
d) To reduce airport staff workload

67. **Which of the following is NOT typically part of airport pavement maintenance?**

a) Crack sealing
b) Surface milling
c) Runway resurfacing
d) Aircraft engine overhauling

68. **What does the acronym 'MRO' stand for in aviation?**

a) Maintenance, Repair, and Overhaul
b) Maintenance, Repair, and Operation
c) Management, Repair, and Overhaul
d) Management, Repair, and Operation

69. **Which type of maintenance is performed between scheduled base maintenance checks to ensure an aircraft remains in airworthy condition?**

a) Line maintenance
b) Base maintenance
c) Heavy maintenance
d) Routine maintenance

70. **What is the purpose of a Maintenance Operations Center (MOC) at an airport?**

a) To oversee the maintenance of ground support equipment
b) To coordinate and monitor all maintenance activities and resources
c) To manage passenger check-in processes
d) To handle baggage handling operations

71. **Which document is essential for tracking maintenance activities performed on an aircraft?**

a) Aircraft Maintenance Logbook
b) Passenger Boarding Pass
c) Baggage Claim Ticket
d) Flight Crew Schedule

Answers

1	b	21	d	41	B	61	C
2	b	22	b	42	D	62	B
3	c	23		43	D	63	B
4	b	24		44	D	64	B
5	b	25	d	45	A	65	A
6	c	26	c	46	C	66	B
7		27	a	47	B	67	D
8	d	28	b	48	D	68	A
9	b	29	a	49	B	69	A
10	b	30	c	50	C	70	B
11	b	31	a	51	D	71	A
12	b	32	c	52	D		
13	b	33	a	53	A		
14	b	34	c	54	B		
15	b	35	b	55	B		
16	b	36	b	56	C		
17	c	37	d	57	A		
18	b	38	d	58	D		
19	b	39	d	59	D		
20	a	40	b	60	A		

1. The unit weight of R.C.C. is taken as
   A. $2.2 + 1m^3$
   B. $2.3 + 1m^3$
   C. $2.4 + 1m^3$
   D. $2.5 + 1m^3$
2. A disadvantage of plane table survey is
   A. it is heavy, cumbersome and akward to carry
   B. it can't be used in wet climate
   C. details may not be available while redrawing to different scale
   D. accessories are likely to be lost
3. Horizontal distances obtained tacheometerically are corrected for
   A. slope correction
   B. temperature correction
   C. refraction and curvature correction
   D. all the above.
4. Irrigation canals are generally aligned along
   A. ridge line
   B. contour line
   C. valley line
   D. straight line
5. The excess quantity of cacl2 (>2%) and triethanolamine (>0.06%) admixture behaves like a
   A. Accelerator
   B. Retarder
   C. Both A and B of above
   D. None of the above
6. Excess of silica in brick earth causes
   A. Loss of cohesion
   B. Impermeability
   C. Cracking and warping on drying
   D. Brittleness
7. Bloating of bricks is due to
   A. Presence of excess carbonaceous matter and sulphur
   B. Presence of any gas forming material in clay
   C. Bad burning or rapid firing
   D. All of the above
8. The vehicle used in case of enamel paints is usually
   A. Linseed oil
   B. Water
   C. Varnish
   D. All of the above
9. The commonly used thinner in oil paints, is
   A. Naphtha
   B. Turpentine C.
   C. Olive oil
   D. Both (a) and (b)
10. Over-consolidation of soils is caused due to.
    A. erosion of over burden
    B. melting of ice sheets after glaciation
    C. permanent rise of water table
    D. all the above
11. The workability of concrete can be improved by
    A. Increase the size of aggregate
    B. Decrease the size of aggregate
    C. Increase the coarse aggregate
    D. Increase the flaky aggregate
12. The minimum length of overtaking zone should be
    A. 2 times   B. 3 times
    C. 4 times   D. 5 times
13. Volume of cement in 50 kg is
    A. 0.067 m3
    B. 0.050 m3
    C. 0.0347 m3
    D. 0.025 m3
14. The stability of slopes is considered while designing
    A. National highway
    B. State highway
    C. Hill roads
    D. District roads
15. Field capacity of an irrigation soil depends on

A. Porosity and pore size
B. Only one porosity
C. Only one pore size
D. Porosity and depth of root zone

16. Which of the following types of roads are most preferred for highways?
    A. Cement concrete roads
    B. Gravel roads
    C. Bituminous roads
    D. Unpaved surfaces

17. The field capacity of a soil depends upon.
    A. capillary tension in soil
    B. porosity of soil
    C. both (a) and (b)
    D. neither (a) nor (b)

18. For DPC at plinth level, what will be the ratio of concrete is used?
    A. 1:3:6
    B. 1:2:4
    C. 1:1.5:5
    D. 1:1:2

19. From the septic tank the effluents are discharged into
    A. Soak pit
    B. Drainage
    C. Oxidation pond
    D. Sewer

20. Who is responsible for accident occurring at site
    A. Consultant
    B. Contractor
    C. Himself
    D. Petti contractor

21. A manhole is generally not provided at each
    A. bend   B. junction   C. change of gradient   D. None

22. The soil good for making bricks is
    A. black cotton
    B. alluvial
    C. silty
    D. sand and silt

23. What is the length of Karnali Highway?

A. 232 km   B.352 km
C. 538 km   D. 501 km

24. For completion of a project, the critical path of the network represents
    A. minimum time
    B. maximum time
    C. maximum cost
    D. minimum cost

25. What play major role in concrete technology?
    A. Constituents
    B. Grading of aggregates
    C. Water cement ratio
    D. All of the above

26. The straight line distance between two station is called
    A. Straight line
    B. Traverse
    C. Traverse angle
    D. Traverse leg

27. The ultimate strength of an over reinforced R.C.C. beam is proportional to
    A. Tensile strength of steel
    B. Tensile strength of concrete
    C. Crushing strength of concrete
    D. Crushing strength of gravel used

28. The consumptive use of water for a crop
    A. is measured as the volume of water per unit area
    B. is measured as depth of water on irrigated area
    C. may be supplied partly by precipitation and partly by irrigation
    D. all the above

29. A load bearing partition of building is called
    A. External wall
    B. Internal wall
    C. Main wall
    D. None of the above

30. The shape of plot between shear and normal stress according to mohr's circle is
    A. Straight
    B. Curve
    C. Elliptical
    D. All of the above
31. The strength of a soil is usually identified by
    A. direct tensile stress
    B. direct compressive stress
    C. ultimate shear stress
    D. effective stress
32. A solid construction put across the river to raise its water level and divert the water into the canal, is known as
    A. marginal bund
    B. weir
    C. barrage
    D. dam
33. The measurement is made in square meter in case of
    A. Cement concrete in foundation
    B. R.C.C structure
    C. Hollow concrete block wall
    D. None of the above
34. Principle of surveying is
    A. Working from Whole to Part
    B. Consistency of Work
    C. Independent Check
    D. All of the above
35. The arrangement of supporting an existing structure by providing supports underneath, is known as
    A. shoring
    B. underpinning
    C. jacking
    D. piling
36. The rate of accumulation of sludge in septic tanks is recommended as
    A. 30 litres/person/year
    B. 25 litres/person/year
    C. 30 litres/person/month
    D. 25 litres/person/month

37. The detention period of a septic tank is
    A. 2 hours
    B. 12-36 hours
    C. 4 hours
    D. 1 week
38. What is the maximum design flow of sewage in a septic tank?
    A. 70 liters per person per day
    B. 100 liters per person per day
    C. 30 liters per person per day
    D. 40 liters per person per day
       Hints: The design flow of sewage in a septic tank lies between 40 to 70 liters per person per day.
39. As an admixture, paraffin wax, is used for improving
    A. Retardation
    B. Bleeding
    C. Colouring
    D. Water proofing
40. A contractor can start the construction works following the receipts of ...
    A. Award of construct
    B. Contract agreement
    C. Notice to proceed
    D. variation order
41. For one cubic metre of brick masonry, number of bricks required, is
    A. 400
    B. 450
    C. 500
    D. 550
42. Prolongation of chain line across an obstruction in chain surveying, is done by
    A. making angular measurements
    B. drawing perpendiculars with a chain
    C. solution of triangles
    D. all the above
43. An event is
    A. A definite job
    B. A definite time interval

C. The terminals of an activity
D. A definite position a an activity

44. The main ingredient of a good quality brick earth, is
    A. magnesia
    B. lime
    C. silica
    D. alumina

45. For brick construction, the lime-sand mortar, is
    A. 1 : 1
    B. 1 : 2
    C. 1 : 3
    D. 1 : 4

46. Minimum side lap required for asbestos cement sheet is
    A. 4cm
    B. 10cm
    C. 15cm
    D. 25cm

47. In scanty rainfall regions, the camber provided will be
    A. nil   B. flatter   C. steeper   D. normal

48. The presence of hydrogen sulphide in water causes
    A. Softening
    B. Alkalinity
    C. Acidity
    D. Bad test

49. The intensity of pressure at any point, in a liquid, is….. to the depth of liquid from the surface.
    A. Equal
    B. Directly proportional
    C. Inversely proportional
    D. None of these

50. When the pressure intensity at a point is more than the local atmospheric pressure, then the difference of these two pressures is called
    A. Gauge pressure
    B. Absolute pressure
    C. Positive gauge pressure
    D. Vacuum pressure

51. Working principle of dead weight pressure gauge tester is based on
    A. Pascal's law
    B. Dalton's law of partial pressure
    C. Newton's law of viscosity
    D. Avogadro's hypothesis

52. The velocity corresponding to Reynold number of 2800, is called
    A. Sub-sonic velocity
    B. Super-sonic velocity
    C. Lower critical velocity
    D. Higher critical velocity

53. The top of the weir over which the water flows is known as
    A. Sill or crest
    B. Nappe or vein
    C. Orifice
    D. None of these

54. For design, that length of transition curve should be taken which is
    A. based on allowable rate of change of centrifugal acceleration
    B. based on rate of change of super elevation
    C. higher of (A) and (B)
    D. smaller of (A) and (B)

55. For the design of super elevation for mixed traffic conditions, the speed is reduced by
    A. 15%   B. 20%   C. 25%   D. 75%

56. When the path travelled along the road surface is more than the circumferential movement of the wheels due to rotation, then it results in
    A. slipping
    B. skidding
    C. turning
    D. revolving

57. The cement, widely used in retaining walls, is
    A. rapid hardening cement

B. low heat cement

C. sulphate resisting cement

D. ordinary Portland cement

58. The setting time of cement is the governing factor for
    A. mixing of concrete
    B. placing of concrete
    C. compaction of concrete
    D. all of these

59. Stoke's law is applicable to particles upto
    A. 0.0002 mm   C. 0.002 mm
    B. 0.02 mm
    D. 0.2 mm

60. The lateral earth pressure exerted by the soil when the retaining wall moves into the soil, is known as
    A. earth pressure at rest
    B. active earth pressure
    C. passive earth pressure
    D. total earth pressure

61. In chain surveying tie lines are primarily provided
    A. to check the accuracy of the survey
    B. to take offsets for detail survey
    C. to avoid long offsets from chain lines
    D. to increase the number of chain lines

62. Closed contours of decreasing values towards their centre, represent
    A. a hill
    B. a depression
    C. a saddle or pass
    D. a river bed

63. In chain surveying field work is limited to
    A. linear measurements only
    B. angular measurements only
    C. both linear and angular measurements
    D. all the above

64. The main principle of surveying is to work
    A. from part to the whole
    B. from whole to the part
    C. from higher level to the lower level
    D. from lower level to higher level.

65. The angle between two plane mirrors of optical square, is
    A. 20°
    B. 30°
    C. 45°
    D. 60°

66. The technique of plotting all the accessible stations with a single set up for plane table is called:
    A. Radiation
    B. Intersection
    C. Resection
    D. Traversing

67. Minimum number of ranging rods required for direct ranging is:
    A. 2 nos
    B. 3 nos
    C. 4 nos
    D. 5 nos

68. Tensile internal force tends to
    A. crush the member
    B. elongate the member
    C. shorten the member
    D. smash the member

69. When the bubble of the level tube of a level, remains central
    A. line of sight is horizontal
    B. axis of the telescope is horizontal
    C. line of collimation is horizontal
    D. geometrical axis of the telescope is horizontal.

70. Plotting of inaccessible points on a plane table, is done by
    A. intersection
    B. traversing

C. radiation

D. none of these

71. Imaginary line passing through points having equal magnetic declination is termed as
    A. isogon
    B. agonic line
    C. isoclinic line
    D. none of these
    Hint: ISOGONIC= same declination.
    AGONIC= zero declination.
    ISOCLINIC= same dip.
    ACLINIC= zero dip

72. If the smallest division of a vernier is longer than the smallest division of its primary scale, the vernier is known as
    A. direct vernier
    B. double vernier
    C. retrograde vernier
    D. simple vernier.

73. Reciprocal ranging is adopted when which of the following is encountered during surveying?
    A. A dense forest
    B. A hillock
    C. A river
    D. A tail building

74. Chain surveying uses the principle of
    A. Traversing
    B. Chaining
    C. Ranging
    D. Triangulation

75. The horizontal angle between the true and magnetic meridian at a place is called
    A. Azimuth
    B. Declination
    C. Local attraction
    D. Magnetic bearing

76. The contour interval should be…..to the scale of the map
    A. Directly proportional
    B. Equal

C. Similar

D. Inversely proportional

77. Rate column of bill of quantity is filled by
    A. Client
    B. Contractor
    C. Consultant
    D. None of the above

78. The unit of brickwork having half brick thick is
    A. m   B. m2   C. m3
    D. None

79. Slack time refers to an
    A. Event   B. Activity   C. Both A & B   D. None

80. The liquid part of the paint is called
    A. pigment   B. vehicle
    C. solvent   D. drier

81. A section of beam is said to be in pure bending, if it is subjected to
    A. Constant bending moment and constant shear force
    B. Constant shear force and zero bending moment
    C. Constant bending moment and zero shear force
    D. None of the above

82. The effective span of a simply supported slab, is
    A. distance between the centres of the bearings
    B. clear distance between the inner faces of the walls plus twice the thickness of the wall
    C. clear span plus effective depth of the slab
    D. none of these.

83. A deep well
    A. is always deeper than a shallow well
    B. has more discharge than a shallow well

C. is weaker structurally than a shallow well
D. both (a) and (b)

84. Most important source of water for public water supply, is from
    A. lakes
    B. ponds
    C. streams
    D. rivers

85. When a canal is carried over a natural drainage, the structure provided, is known as
    A. syphon
    B. aqueduct
    C. super passage
    D. syphon-aqueduct

86. Gantt charts are used for
    A. Forecasting sales
    B. Production schedule
    C. Scheduling and routing
    D. Linear programming

87. Critical path

    A. Is always longest
    B. Always shortest
    C. May be longest
    D. May be shortest

88. Patching should be done just
    A. After rainy seasons
    B. After summer seasons
    C. Before winter seasons
    D. Before rainy seasons

89. Bulking of sand is.
    A. mixing of different sizes of sand particles
    B. mixing of lime with sand
    C. maximum water with sand
    D. swelling of sand when wetted

90. The form work from the sides of beams can be removed only after
    A. 1 day
    B. 4 days
    C. 7 days
    D. 14 days

    Hints: Shown in table below

| Types of formwork	Formwork Removal Time
Side of wall, Columns and Vertical face of beam	24 hrs to 48 hrs
Slab Excluding props	3 days
Beam Excluding props	7 days
Slab including props span upto 4.5m	7 days
Slab including props > 4.5 m	14 days
Beam including props span upto 6m	14 days
Beam including props span > 6m	21 days

91. Continuous flow of water can be expected from
    A. gravity springs

    B. surface springs
    C. artesiaan springs
    D. none of these

92. The best material for pipes to be laid under water is

A. cast iron
B. steel
C. cement concrete
D. asbestos cement

93. water supply scheme is usually designed for the period of
    A. 5 years
    B. 10 years
    C. 20 years
    D. 50 years

94. In a concrete canal the approximate permissible velocity of water should not exceed
    A. 0.5 m/sec
    B. 1 m/sec
    C. 1.5 m/sec
    D. 2 m/sec

95. Raising of outer edge of a road with respect to inner edge, is known
    A. super elevation
    B. camber
    C. gradient
    D. shoulder

96. The bending moment is maximum on a section where shearing force
    A. is maximum
    B. is minimum
    C. is equal
    D. changes sign

97. When algae grows on the surface of water, it preven
    A. access of bacteria in water
    B. access of sunlight in water
    C. growth of fungi
    D. growth of ferns and mosses

98. Fish in the ponds and lakes die because the algae
    A. takes all the minerals from water
    B. takes all the oxygen from water
    C. prevents sunlight to enter water
    D. prevent from respiring

99. Admixtures which cause early setting, and hardening of concrete are called

A. Plasticizers
B. Retarders
C. Super plasticizer
D. Accelerators

100.   Classification of admixtures are classified into……types.
    A. 1
    B. 2
    C. 3
    D. 5
        Hints: chemical admixtures and mineral admixtures.

101.   What is the main function of set retarders?
    A. Increase curing rate
    B. Slows curing rate
    C. Improves workability at low w/c ratio
    D. Speeds up start of finishing operations

102.   An ideal flow of a liquid obeys
    A. continuity equation
    B. newton's law of viscosity
    C. newton's second law of motion
    D. dynamic viscosity

103.   The atmospheric pressure varies with
    A. Altitude
    B. Temperature
    C. Weather conditions
    D. None of the above

104.   The types of instrument used to measure low pressure with accuracy is
    A. Piezometer
    B. Barometer
    C. Micro-manometer
    D. Mechanical gauge

105.   If the velocity in a fluid does not change with respect to length of direction of flow, it is called
    A. Steady flow
    B. Uniform flow
    C. Incompressible flow
    D. Rotational flow

106.   The upper surface of a weir over which water flows is known as
   A. vein
   B.   nappe
   C. sill
   D. weir top
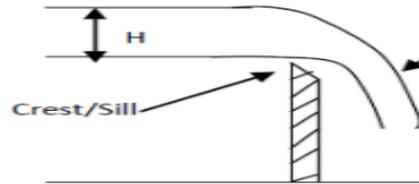
107.   What is the qualification of uniform flow?
   A. Slope of the energy line ≠ slope of the water surface = slope of the channel bed
   B. Slope of the energy line ≠ ∝ and slope of the water surface = slope of the channel bed
   C. Slope of the energy line = slope of the water surface = slope of the channel bed = ± a constant
   D. Slope of the energy line = slope of the water surface = slope of the channel bed

108.   The commonly used base for iron and steel work, is.
   A. Red lead
   B. zinc white
   C. white lead
   D. titanium white

109.   The angle of internal friction is maximum for
   A. angular-grained loose sand
   B. angular-grained dense sand
   C. round-grained dense sand
   D. round-grained loose sand

110.   Degree of a road curve is defined as the angle in degrees subtended at the centre by an arc of (Highway)
   A. 10 metres
   B. 20 metres
   C. 25 metres
   D. 30 metres

111.   The degree of the curve is the angle subtended by a chord of(survey)
   A. 15 m   B. 20 m
       C. 25 m   D. 30 m

112.   Terrazo flooring comprises of:
   A. Chips, powder, concrete
   B.   Chips, concrete
   C. Chips, cement
   D.   Chips, powder, cement

113.   Hardness of water is caused due to
   A. Calcium sulphate
   B. Magnesium sulphate
   C. Calcium bicarbonates
   D. All of the above

114.   The earnest money deposit in the form of bank guarantee is known as
   A. Bid bond
   B. Performance bond
   C. Mobilization
   D. Security deposit

115.   The specific gravity of water is taken as.
   A. 0.001
   B. 0.01
   C. 0.1
   D. 1

116.   The discharge per unit drawdown at the well is known as :
   A. Specific yield
   B. Specific storage
   C. Specific retention
   D. Specific capacity

117.   The discharge per unit draw in case of an aquifer is known as :
   A. Specific yield
   B. Specific storage
   C. Specific retention
   D. Specific capacity

118.   ……………….. is suspended in either quick drying spirit varnish or slow drying oil varnish as per requirement.
   A. Aluminium paint

B.   Anti-corrosive paint
C.   Asbestos paint
D.   Cellulose paint

119.   Traversing is generally done by
A.   Chain
B.   Compass or theodolite
C.   Plane table
D.   All the above

120.   Which of the following spillways is most suitable for an earthen dam?
A.   ogee spillway
B.   chute spillway
C.   side channel spillway
D.   shaft spillway
Hints:
Least suitable: ogee spillway
Most suitable: side channel spillway

121.   Slope deflection method is suitable for analysis of
A.   Continuous beam
B.   Simply supported beam
C.   Fixed beam
D.   Cantilever beam

122.   The vertical side member of a shutter frame, is known
A.   Style
B.   Reveal
C.   Mullion
D.   Post

123.   The function of
_____ is to make the paint thin so that it can be easily applied on the surface.
A.   Pigment
B.   Solvent
C.   Carrier
D.   Base

124.   ………contains binding material such as polyvinyl Acetate, synthetic resins, etc.
A.   Colloidal paint
B.   Emulsion paint

C.   Enamel paint
D.   Graphite paint
Hints:
✓   Emulsion paint is easy to apply and it drives quickly about 1 to 2 hours.
✓   It can be cleaned by washing with water.

125.   In …………roof, the common rafter slope upward from the opposite wall and they meet on a Ridge piece in the middle.
A.   Couple-close roof
B.   Lean-on roof
C.   Collar beam
D.   Couple

126.   The population forecasting method generally adopted in Nepal for water demand calculation is:
A.   comparative method
B.   geometric increase method
C.   arithmetic method
D.   logistic curve method

127.   The suitable method of forecasting population for a young and rapidly increasing city is
A.   Arithmetical increase method
B.   Geometrical increase method
C.   Incremental increase method
D.   Graphical method

128.   The sewage is treated by aerobic bacteria action in
A.   oxidation pond
B.   settling tank
C.   trickling filter
D.   all of the above

129.   The unit failure stress is taken as,
A.   rupture stress
B.   ultimate stress
C.   Failure stress
D.   Fracture stress

130.   With storage, strength of cement

A. increases
B. decreases
C. remains the same
D. none to these

131.   In one day the height of stone masonry construction should generally not exceeds
A. 0.8 m
B. 1.2m
C. 2.5 m
D. 3 m

132.   An artesian aquifer is the one where
A. water surface under the ground is at atmospheric pressure
B. water is under pressure between two impervious strata
C. water table serves as upper surface of zone of saturation
D. none of the above

133.   A good source of water requiring practically less treatment is
A. deep well
B. elevated lake
C. river
D. impounded reservoir

134.   In road surface,seal coat is layer of..
A. cement concrete
B. coarse sand + bitumen
C. water repellent agent
D. adhesive to improve bond between aggregates

135.   Irrigation canals are generally aligned along
A. ridge line
B. contour line
C. valley line
D. straight line

136.   Volume of cement in 50 kg is
A. 0.067 m3
B. 0.050 m3
C. 0.0347 m3
D. 0.025 m3

137.   Field capacity of an irrigation soil depends on
A. Porosity and pore size
B. Only one porosity
C. Only one pore size
D. Porosity and depth of root zone

138.   The field capacity of a soil depends upon.
A. capillary tension in soil
B. porosity of soil
C. both (a) and (b)
D. neither (a) nor (b)

139.   From the septic tank the effluents are discharged into
A. Soak pit
B. Drainage
C. Oxidation pond
D. Sewer

140.   A manhole is generally not provided at each
A. bend   B. junction   C. change of gradient   D. None

141.   For completion of a project, the critical path of the network represents
A. minimum time
B. maximum time
C. maximum cost
D. minimum cost

142.   What play major role in concrete technology?
A. Constituents
B. Grading of aggregates
C. Water cement ratio
D. All of the above

143.   The straight line distance between two station is called
A. Straight line
B. Traverse
C. Traverse angle
D. Traverse leg

144.   The ultimate strength of an over reinforced R.C.C. beam is proportional to
A. Tensile strength of steel

B. Tensile strength of concrete
C. Crushing strength of concrete
D. Crushing strength of gravel used

145. The consumptive use of water for a crop
A. is measured as the volume of water per unit area
B. is measured as depth of water on irrigated area
C. may be supplied partly by precipitation and partly by irrigation
D. all the above

146. A load bearing partition of building is called
A. External wall
B. Internal wall
C. Main wall
D. None of the above

147. The shape of plot between shear and normal stress according to mohr's circle is
A. Straight
B. Curve
C. Elliptical
D. All of the above

148. The strength of a soil is usually identified by
A. direct tensile stress
B. direct compressive stress
C. ultimate shear stress
D. effective stress

149. A solid construction put across the river to raise its water level and divert the water into the canal, is known as
A. marginal bund
B. weir
C. barrage
D. dam

150. The measurement is made in square meter in case of
A. Cement concrete in foundation

B. R.C.C structure
C. Hollow concrete block wall
D. None of the above

151. Principle of surveying is
A. Working from Whole to Part
B. Consistency of Work
C. Independent Check
D. All of the above

152. The arrangement of supporting an existing structure by providing supports underneath, is known as
A. shoring
B. underpinning
C. jacking
D. piling

153. The rate of accumulation of sludge in septic tanks is recommended as
A. 30 litres/person/year
B. 25 litres/person/year
C. 30 litres/person/month
D. 25 litres/person/month

154. The detention period of a septic tank is
A. 2 hours
B. 12-36 hours
C. 4 hours
D. 1 week

155. What is the maximum design flow of sewage in a septic tank?
A. 70 liters per person per day
B. 100 liters per person per day
C. 30 liters per person per day
D. 40 liters per person per day
Hints: The design flow of sewage in a septic tank lies between 40 to 70 liters per person per day.

156. As an admixture, paraffin wax, is used for improving
A. Retardation
B. Bleeding
C. Colouring
D. Water proofing

157. A contractor can start the construction works following the receipts of ...
   A. Award of construct
   B. Contract agreement
   C. Notice to proceed
   D. variation order

158. For one cubic metre of brick masonry, number of bricks required, is
   A. 400
   B. 450
   C. 500
   D. 550

159. Prolongation of chain line across an obstruction in chain surveying, is done by
   A. making angular measurements
   B. drawing perpendiculars with a chain
   C. solution of triangles
   D. all the above

160. The main ingredient of a good quality brick earth, is
   A. magnesia
   B. lime
   C. silica
   D. alumina