Part 1: Introduction, Chapter 1 & Chapter 2 Analysis

Introduction (Pages v - xvi)

Overview

This section outlines the purpose, scope, and background of the handbook. It serves as an explanatory guide to unify construction practices for residential, commercial, and industrial buildings, based primarily on the National Building Code of India and various Indian Standards. The goal is to cover the 'how' and 'why' of construction practices, providing rationale to help designers and engineers make informed decisions. It acknowledges that this handbook is supplementary and does not replace the mandatory provisions of the Indian Standards.

Key Standards and Codes Referenced

- Primary Reference: National Building Code of India, 1983 (NBC).
- Other BIS Handbooks (SP Series):
  - SP 16: 1980: Design Aids for Reinforced Concrete to IS 456 : 1978
  - SP 20: 1991: Handbook on Masonry Design and Construction (First Revision)
  - SP 21: 1983: Summaries of Indian Standards for Building Materials
  - SP 22: 1982: Explanatory Handbook on Codes of Earthquake Engineering (IS 1893:1975 & IS 4326:1976)
  - SP 23: 1982: Handbook on Concrete Mixes (Based on Indian Standards)
  - SP 24: 1983: Explanatory Handbook on Indian Standard Code of Practice for Plain and Reinforced Concrete (IS 456:1978)
  - SP 25: 1984: Handbook on Causes and Prevention of Cracks in Buildings
  - SP 32: 1986: Handbook on Functional Requirements of Industrial Buildings (Lighting and Ventilation)
  - SP 33: 1986: Handbook on Timber Engineering
  - SP 34: 1987: Handbook on Concrete Reinforcement and Detailing
  - SP 35: 1987: Handbook on Water Supply and Drainage with Special Emphasis on Plumbing
  - SP 38: 1987: Handbook on Typified Designs for Structures with Steel Roof Trusses
  - SP 40: 1987: Handbook on Structures with Steel Portal Frames (without Cranes)
  - SP 41: 1987: Handbook on Functional Requirements of Buildings (other than Industrial Buildings)

    - SP 43: 1987: Handbook on Structures with Reinforced Concrete Portal Frames (without Cranes)
    - SP 47: 1987: Handbook on Structures with Steel Lattice Portal Frames (without Cranes)
- Other Referenced Standards:
    - IS 875 (Part 3): 1987: Code of practice for design loads (other than earthquake) for buildings and structures, Part 3: Wind loads.
    - IS 1893 : 1984: Criteria for earthquake resistant design of structures.

Chapter 1: Construction Planning and Storage of Materials

Overview

This chapter emphasizes the necessity of pre-construction planning and proper material storage. It is divided into two parts. Part 1 introduces modern planning techniques like PERT and CPM to avoid time and cost overruns. Part 2 provides detailed specifications for the safe storage and stacking of various construction materials to prevent damage, deterioration, and hazards.

Key Standards and Codes Referenced

- IS 7969 : 1975: Code of practice for safety during storage of materials.
- IS 1141 : 1993: Code of practice for seasoning of timber.

Technical Specifications

Part 1: Construction Planning

- Planning Techniques: Recommends the use of Network Techniques for planning, management, and control of construction projects.
    - PERT (Programme Evaluation and Review Techniques)
    - CPM (Critical Path Method)
- Advantages over Bar Charts:
    - Provides a logical appreciation of the project from conception to completion.
    - Enables more accurate project completion forecasting.
    - Identifies critical activities that have a great bearing on project progress.
    - Forecasts potential delays before they occur.
    - Allows for rescheduling of resources for efficient deployment (slack).

    - Identifies interdependent activities to focus on coordination.

Part 2: Storage of Materials

- General:
    - Requirement: Materials must be stored to prevent deterioration, intrusion of foreign matter, and to preserve quality and fitness for use. Protection against atmospheric agencies, fire, and other hazards is mandatory.
- Cement:
    - Storage Structure: Must be a dry, leakproof, and moisture-proof building or shed with a minimum number of windows and close-fitting doors.
    - Stacking: Stacked off the floor on wooden planks.
    - Measurement/Tolerance:
        - Clearance from floor: 150 mm to 200 mm.
        - Clearance from walls: Minimum 450 mm all around.
        - Stack Height: Maximum 15 bags high to prevent lumping under pressure.
        - Stack Width: Not more than 4 bags length (approx. 3 m).
        - Arrangement: In stacks over 8 bags high, bags shall be arranged alternately lengthwise and crosswise to ensure stability.
    - Monsoon/Long-Term Storage: The stack must be completely enclosed by a waterproof membrane, like a polyethylene sheet.
- Lime:
    - Quick Lime: Should be slaked as soon as possible. If stored, must be in compact heaps on a suitable platform and covered to avoid contact with moisture/rain. A minimum space of 300 mm should be provided around heaps to avoid bulging of walls.
    - Hydrated Lime: Supplied in containers (jute bags, HDPE bags, paper bags). Must be stored in a building to protect from dampness.
- Bricks:
    - Handling: Bricks shall not be dumped at the site. They must be stacked in regular tiers to minimize breakage.
    - Stacking: On firm ground.
    - Measurement/Tolerance:
        - Stack Size: 50 bricks long and 10 bricks high, placed on edge.
        - Clear Distance between stacks: Not less than 0.8 m.
- Aggregate:
    - Storage Surface: Hard, dry, level ground. If not available, a platform of planks, corrugated iron sheets, or a floor of dry bricks or lean concrete shall be made.

- Stacking: Fine and coarse aggregates in separate piles, sufficiently removed to prevent intermixing. Suggested stack sizes are provided in the table below.

Material	Length (m)	Breadth (m)	Height (m)
Soling stone	5.0	2.0 or 1.0	0.50
Coarse aggregate	2.0 or 5.0	2.0 or 5.0	0.50 or 1.00
Fine aggregate	2.0 or 5.0	2.0 or 1.0	0.50

- Timber:
    - Stacking: On well-treated and even-surfaced beams, sleepers, or pillars.
    - Measurement/Tolerance:
        - Ground Clearance: At least 150 mm.
        - Air Space between members: About 25 mm.
        - Stack Dimensions: Recommended width 1.5 m and height 2 m.
    - Protection: Must be protected from hot dry winds, direct sun, and rain. Heavy weights (e.g., metal rails) can be placed on top to prevent warping.
- Steel:
    - Storage: Separate, marked areas for each classification (grade and type).
    - Reinforcement Steel: Stored to avoid distortion and corrosion. For long-term storage, a coat of cement wash is desirable.
    - Structural Steel Sections: Stored above ground level by at least 150 mm on platforms or other suitable supports.
- Roofing Sheets (Asbestos Cement):
    - Stacking: On firm, level ground with timber packing beneath.
    - Measurement/Tolerance: Stack height not more than 1 metre.
- Boards (Gypsum, Plywood, etc.):
    - Storage: Flat in a clean, covered, and dry place. Not in the open.
    - Stacking: On a flat dunnage, with a wooden frame (50 mm x 25 mm battens) to support all four edges and corners, with intermediate battens to prevent warping.
- Unplasticized PVC Pipes:
    - Stacking: On a reasonably flat surface, free from stones. Not to be stored on racks. Sockets and spigots should be at alternate ends to avoid lopsided stacks.
    - Measurement/Tolerance: Stack height not more than 1.5 m high.

Visual Elements Analysis

Figure 1.1: Typical Timber Stack

Description: The diagram illustrates the correct method for stacking timber to ensure proper air circulation and stability. Technical Details:

- Base: The stack is raised off the ground on evenly spaced sleepers or pillars.
- Layers: Multiple layers of timber members are shown stacked one on top of the other.
- Crossers: Each layer of timber is separated by "crossers," which are uniform wooden battens placed perpendicular to the main timber members. This creates air gaps for ventilation.
- Alignment: One end of the stack, including the crossers, is shown in true vertical alignment to maintain stability.
- Spacing: An implied air space is shown between adjacent members in the same layer. Construction Notes: This stacking method is crucial for preventing rot, fungal attack, and warping during storage by allowing air to circulate freely around each piece of timber. The heavy weights mentioned in the text (but not explicitly drawn) would be placed on the top-most layer. Relationship to Text: This figure visually represents the detailed specifications for timber storage described in section 7 of Part 2, including the use of sleepers for ground clearance and crossers for separation.

BOQ Implications

- Material Storage: Costs must be allocated for creating proper storage platforms (concrete, brick, or plank), sheds, and protective coverings (tarps, polyethylene sheets).
- Material Waste: Improper storage as detailed in this chapter can lead to significant material wastage (e.g., lumping of cement, breakage of bricks, warping of timber, corrosion of steel), which must be factored into cost estimates as a risk or accounted for by sourcing extra material.
- Labor: Labor costs are associated with the systematic stacking and handling of materials as per the specified guidelines, which is more time-consuming than simple dumping.

Chapter 2: Earthwork

Overview

This chapter details the practices related to earthwork. It begins with a classification of soils for excavation purposes, outlines general precautions, and provides specific procedures for various types of excavation (surface, rough, trenches). A significant portion is dedicated to shoring and timbering for trench safety and the chemical treatment of soil for anti-termite protection.

Key Standards and Codes Referenced

- IS 1498 : 1970: Classification and identification of soils for general engineering purposes.
- IS 4081 : 1986: Safety code for blasting and related drilling operations.
- IS 883 : 1970: Code of practice for design of structural timber in building.
- IS 6313 (Part 2) : 1981: Code of practice for anti-termite measures in buildings: Part 2 Pre-constructional chemical treatment measures.
- IS 6439 : 1978: Specification for heptachlor, emulsifiable concentrates.
- IS 2682 : 1984: Specification for chlordane, emulsifiable concentrates.
- IS 8944 : 1978: Specification for chlorpyrifos, emulsifiable concentrates.
- Indian Explosive Act, 1940

Technical Specifications

Classification of Soils

- Soft/Loose Soil: Yields to ordinary pick and shovel (e.g., sand, clay, loam).
- Hard/Dense Soil: Requires close application of picks or rippers (e.g., stiff heavy clay, compact murrum, shingle).
- Ordinary Rock: Can be quarried or split with crow bars (e.g., limestone, hard laterite). Light blasting may be used for loosening but does not reclassify it as Hard Rock.
- Hard Rock (requiring blasting): Rock for which blasting is required (e.g., quartzite, granite, basalt, reinforced concrete).
- Hard Rock (blasting prohibited): Excavation to be done by chiselling, wedging, or other agreed methods.

Excavation

- Surface Excavation: Exceeding 1.5 m width and 10 m^2 on plan, but not exceeding 30 cm in depth.
- Excavation in Firm Soils: Sides can be kept vertical up to a depth of 2 m. For greater depths, steps of 50 cm on either side for every 2 m of depth, or a side slope of 1:4 (1 horizontal to 4 vertical) is required.
- Trench Width for Pipes:
  - Up to 1 m depth: External pipe diameter + 25 cm.
  - Exceeding 1 m depth: An additional width of 5 cm/m depth for each side of the trench.

- Blasting: Not to be done within 200 m of existing structures without prior permission.

Shoring and Timbering

- Requirement: Mandatory for all trenches exceeding 2.0 m in depth, unless sides are sloped to within 1.5 m of the bottom and declared stable.
- Material: Approved quality of SAL wood or other structural material with no less strength.
- Design Stresses: Design stresses for timber members shall be taken as 2/3 of the values given in Table 2 of IS 883 : 1970.
- Member Sizing: Detailed tables are provided for member sizes and spacing based on soil type and trench depth.
    - Table 2.1: Hard Soil
    - Table 2.2: Soil which may Crack or Crumble
    - Table 2.3: Loose Sandy or Soft Soil
    - Table 2.4: Soil under Hydro-static Pressure

Anti-Termite Treatment (Chemical)

- Chemicals:
    - Heptachlor emulsifiable concentrate: 0.5% by weight.
    - Chlordane emulsifiable concentrate: 1.0% by weight.
    - Chlorpyrifos emulsifiable concentrate: 1.0% by weight.
- Application Rates:
    - Bottom of foundations/basements: 5 l/m^2 of surface area.
    - Backfill in immediate contact with foundation: 7.5 l/m^3 of the vertical surface of the sub-structure for each side.
    - Top surface of consolidated earth (plinth filling): 5 l/m^2 before sandbed/sub-grade is laid.
    - Junction of wall and floor: 7.5 l/m^2 of the vertical wall/column surface.
    - External perimeter of building: 7.5 l/m^2 of vertical surface.
    - Expansion Joints: 2 litres per linear metre.
- Procedure:
    - Treatment of Foundation Trenches: Treat bottom surface and sides up to about 30 cm.
    - Treatment of Backfill: Apply chemical emulsion after ramming is done (if water is used). Rod the earth at 15 cm centres to facilitate percolation.
    - Treatment for RCC Foundations: Treatment can start at 500 mm below ground level, as termites cannot penetrate RCC itself.
    - Plinth Filling Treatment: If emulsion does not seep, make holes 50 mm to 75 mm deep at 150 mm centres both ways with a 12 mm steel rod.

Visual Elements Analysis

Figure 2.1: Type Design for Temporary Site Bench Mark

Description: A detailed drawing of a masonry pillar used as a temporary benchmark for maintaining levels during construction. Technical Details:

- Base: 560 mm x 560 mm plan, 150 mm thick, made of C.C. (Cement Concrete) 1:5:10.
- Pillar: 340 mm x 340 mm brickwork in 1:4 cement mortar, rising to a height of 780 mm above the base.
- Cap: A concrete cap (C.C. 1:2:4) is placed on top of the pillar. A 20 mm slit for drainage is shown.
- Benchmark Point: A Φ25 MS (Mild Steel) hemispherical ball is welded to a plate and embedded in the cap, serving as the precise level point.
- Foundation: A concrete foundation (150 mm thick) is shown below the main base. Construction Notes: This provides a stable and visible reference point. It must be connected to a standard benchmark in the vicinity. It must be maintained throughout the excavation process.

Figure 2.2: Close and Open Planking and Strutting

Description: Isometric views illustrating two methods of timbering trenches to prevent collapse. Technical Details:

- Components: The system consists of vertical Poling Boards (250x30 mm), horizontal Walings (100x100 mm), and horizontal Struts that brace the walings against each other. Rakers and blocking are shown for wider excavations.
- Close Planking: Poling boards are placed edge-to-edge, providing continuous support. This is for loose, sandy, or soft soils.
- Open Planking: Poling boards are placed with gaps between them. This is suitable for more stable soil.
- Dimensions: Maximum spacing for walings is 600 mm vertically. Maximum spacing for struts is 1800 mm horizontally. Construction Notes: Sheathing is driven into the trench bottom. Wales are placed parallel to the trench bottom and support the sheathing. Struts are placed at right angles to the wales. This is a critical safety installation for deep trenches.

Figures 2.3, 2.4, 2.5: Anti-Termite Treatment Details

Description: These three cross-sectional diagrams illustrate the application of a chemical barrier for anti-termite treatment in different foundation scenarios.

- Figure 2.3 (Masonry Foundation without Apron): Shows treatment stages labelled A, B, C, D, E.
    - A: Treatment of bottom and sides of the trench.
    - B: Treatment of the backfill soil in immediate contact with the foundation wall.
    - C: Treatment at the junction of the internal wall and the floor.
    - D: Treatment of the entire top surface of the plinth filling.
    - E: Treatment of the soil along the external perimeter of the building.
- Figure 2.4 (Masonry Foundation with Apron): Similar to 2.3, but adds stage F.
    - F: Chemical treatment of the soil *below* the external concrete apron.
- Figure 2.5 (RCC Foundation): Illustrates that for a solid RCC foundation, the chemical barrier for the backfill (A) only needs to start from 500 mm below ground level, unlike for masonry where it starts from the bottom. The other stages (B, C, D) are similar. Construction Notes: The diagrams emphasize creating a *continuous* and unbroken chemical barrier that completely isolates the building's woodwork and other vulnerable materials from the ground soil where termites originate. Relationship to Text: These figures are direct visual representations of the procedures detailed in sections 16.5, 16.6, 16.9, and 16.10, making the complex, multi-stage application process clear.

BOQ Implications

- Excavation Measurement: Quantities are calculated based on plan dimensions and depth. Different rates apply to different soil classifications (Soft Soil, Hard Rock, etc.), making the initial soil classification (Section 1.1) critical for accurate costing.
- Shoring and Timbering: This is a separate measurable item, typically by area (m^2) of the trench face supported. The material specifications (SAL wood) and member sizes from Tables 2.1-2.4 influence the cost.
- Anti-Termite Treatment: Measured per square meter (m^2) of the treated area (horizontal or vertical). The quantity of chemical required is derived directly from the specified application rates (e.g., 5 l/m^2 or 7.5 l/m^2). This is a specialized item in the BOQ.
- Backfilling and Disposal: Quantities of suitable backfill material and the disposal of surplus excavated earth are also billable items.

Chapter 3: Foundations

Overview

This chapter provides a comprehensive guide to the construction of various types of foundations. It covers pre-construction activities, classifies foundations into shallow and deep categories, and outlines the construction procedures for each. The chapter heavily references specific Indian Standards for detailed design and execution. It also includes two crucial annexes: Annex A, which gives information on the selection and characteristics of different foundation types, and Annex B, which provides detailed guidelines for ground improvement techniques in weak soils.

Key Standards and Codes Referenced

- General Foundations & Soil:
  - IS 1080 : 1986: Code of practice for design and construction of shallow foundations on soils (other than raft, ring and shell).
  - IS 2950 (Part 1) : 1981: Code of practice for design and construction of raft foundations, Part 1: Design.
  - IS 9456 : 1980: Code of practice for design and construction of conical and hyperbolic paraboloidal types of shell foundations.
  - IS 11089 : 1984: Code of practice for design and construction of ring foundations.
  - SP 36 (Part 2) : 1988: Compendium of Indian Standards on soil engineering, Part 2: Field testing.
  - IS 6403 : 1981: Code of practice for determination of bearing capacity of shallow foundations.
  - IS 8009 (Part 1) : 1976: Code of practice for calculation of settlement of foundations: Part 1 Shallow foundations.
  - IS 8009 (Part 2) : 1980: Code of practice for calculation of settlement of foundations: Part 2 Deep foundations.
  - IS 13094 : 1992: Guidelines for ground improvement techniques.
- Pile Foundations:
  - IS 2911 (Part 1/Sec 1) : 1979: Driven cast in-situ concrete piles.
  - IS 2911 (Part 1/Sec 2) : 1979: Bored cast in-situ concrete piles.
  - IS 2911 (Part 1/Sec 3) : 1979: Driven precast concrete piles.
  - IS 2911 (Part 1/Sec 4) : 1984: Bored precast concrete piles.
  - IS 2911 (Part 2) : 1980: Timber piles.
  - IS 2911 (Part 3) : 1980: Under-reamed piles.
  - IS 2911 (Part 4) : 1985: Load test on piles.
- Special Foundations & Materials:
  - IS 9556 : 1980: Code of practice for design and construction of diaphragm walls.
  - IS 2974 (Parts 1-5): Machine foundations.

    - IS 4091 : 1979: Code of practice for design and construction of foundations for transmission line towers and poles.
    - IS 456 : 1978: Code of practice for plain and reinforced concrete.
    - IS 269, IS 455, IS 1489, IS 8041, IS 6909, IS 12269: Standards for various types of Cement.
    - IS 432 (Part 1), IS 1786, IS 2062: Standards for Reinforcement Steel.
    - IS 3629 : 1986: Specification for structural timber.
    - IS 401 : 1982: Code of practice for preservation of timber.

Technical Specifications

General Pre-Construction

- Setting Out: Must be done after excavation (as per Chapter 2). For intricate structures or sites > 16 m, theodolites should be used. For rectangular layouts, diagonals shall be checked for accuracy.
- Protection of Excavation: To prevent deterioration of the foundation bottom in clay or other soils, it must be protected immediately after excavation by an 8 cm thick layer of lean cement concrete (1:5:10 mix). Alternatively, the final 10 cm of excavation can be removed just before concreting.
- Backfilling: Must be done evenly on both sides of the foundation wall. Compaction must be in layers not exceeding 20 cm thick, with adequate sprinkling of water.

Shallow Foundations (Up to 3 m depth)

- Types: Spread or Pad (IS 1080), Strip (IS 1080), Raft (IS 2950), Ring and Shell (IS 11089, IS 9456).
- Construction: Primarily masonry and/or concrete (plain and reinforced) as per Chapters 4 and 5.

Deep Foundations (Piles, Caissons, Diaphragm Walls)

- Under-Reamed Piles (IS 2911 Part 3): Bored cast in-situ or bored compaction concrete piles with one or more bulbs formed by enlarging the bore hole.
    - Application: Used in expansive soils to avoid seasonal moisture changes, to reach firm strata, and to resist uplift forces.
    - Materials:
        - Concrete Slump: 100 mm to 150 mm for water-free unlined holes; 150 mm to 200 mm for tremie concreting.
        - Minimum Cement Content (Tremie Concreting): 350 kg/m³ for piles up to 10 m deep; 400 kg/m³ for larger/deeper piles. 10% extra cement is required if piles are exposed to water after casting.

    - Equipment: Auger, under-reamer, boring guide. For deep/large piles, a tripod hoist and winch are needed.
    - Construction Tolerances: Deviation from location must not be more than 75 mm or one-quarter of the stem diameter, whichever is less.
    - Concreting: Must be done as soon as possible after boring. If drilling mud is used, concreting must occur within 12 to 24 hours.
- Precast Piles (Bored and Driven):
    - Bored Precast (IS 2911 Part 1/Sec 4): Constructed in a casting yard and lowered into pre-bored holes, with the space grouted.
        - Grout: Cement and sand (1:2) mixed with water in a high-speed colloidal mixer. Grout strength must be at least equal to the surrounding soil.
    - Driven Precast (IS 2911 Part 1/Sec 3): Cast in a yard and driven into the ground with or without jetting.
        - Reinforcement Splicing: Joints in longitudinal reinforcement must be staggered and butt-welded.
        - Driving Sequence: For a pile group, driving is done from the centre to the periphery.
- Timber Piles (IS 2911 Part 2):
    - Classification:
        - Class A: For heavy-duty use (bridges, docks). Butt diameter ≥ 30 cm.
        - Class B: For foundation and temporary work. Diameter ≥ 100 mm.
    - Pile Tip: Pointed in the form of a truncated cone or pyramid with an end area of 25 cm^2 to 40 cm^2 and a length of 1.5 to 2 times the diameter.

Visual Elements Analysis

This chapter contains no figures. However, Annex B includes a comprehensive table on soil improvement methods.

Table 3.1: Soil Improvement Methods (Summary)

Description: This is a multi-page, highly detailed table that serves as a guide for selecting ground improvement techniques. It is categorized by the method's primary principle (e.g., In-situ Compaction, Precompression, Admixtures, Reinforcement). Each row details a specific technique. Technical Details: The columns provide a complete technical overview for each method:

- Method: Name of the technique (e.g., Blasting, Vibroflotation, Compaction Piles, Grouting, Soil Reinforcement, Heating, Freezing).

- Principle: The physical mechanism by which the soil is improved (e.g., densification by shock waves, chemical bonding, water expulsion).
- Most Suitable Soil Conditions/Types: The soil types for which the method is effective (e.g., Saturated clean sands, Cohesionless soils, Expansive clays).
- Maximum Effective Treatment Depth: The practical depth to which the method can be applied (e.g., >30 m, 20 m, 15 m).
- Special Materials Required: Any non-standard materials needed (e.g., Explosives, Granular backfill, Admixture stabilizers, Reinforcing bars).
- Special Equipment Required: Key machinery needed for the process (e.g., Jetting or drilling machine, Vibratory pile driver, Vibroflot, Tampers up to 200 tons, DC power supply).
- Properties of Treated Material: The outcome of the treatment (e.g., Can obtain relative densities up to 70-80%, Increased strength, Reduced compressibility).
- Special Advantages and Limitations: Practical pros and cons (e.g., Rapid and inexpensive but dangerous; Good for underwater work but slow; Can be used near existing structures).
- Relative Cost: A qualitative assessment of cost (Low, Moderate, High, Very High). Relationship to Text: This table is the core of Annex B and provides the detailed technical data that supports the guideline on choosing ground improvement methods when faced with weak soils, as mentioned in section A-1 of the annex.

BOQ Implications

- Foundation Type: The choice of foundation has massive cost implications.
  - Shallow Foundations: Measured by volume (m^3) of concrete and masonry.
  - Pile Foundations: Measured by linear meter (m) of pile constructed/driven. The cost per meter varies significantly based on type (bored, driven, under-reamed) and diameter.
  - Specialized Items: Formwork (m^2), reinforcement (kg or tonne), and excavation (m^3) are separate line items.
- Ground Improvement: Each method in Table 3.1 represents a highly specialized BOQ item.
  - Equipment Costs: Mobilization and operational costs for special equipment (vibroflots, heavy tampers, piling rigs, grouting pumps) are substantial.
  - Material Costs: Costs for special materials like chemical stabilizers, geotextiles, reinforcing elements, or large volumes of granular backfill must be included.
  - Labor: Requires skilled and specialized labor, leading to higher labor rates compared to standard construction.

Chapter 4: Masonry

Overview

This chapter provides an exhaustive guide to masonry work, divided into three main parts. Part 1 covers Mortars, detailing their types, selection, mix proportions, and preparation. Part 2 covers Brickwork and Blockwork, discussing material properties and construction practices, including bonding, crack control, and specialized walls. Part 3 covers Stonework, detailing the properties of different stones and the construction methods for various types of stone masonry, from random rubble to fine ashlar.

Key Standards and Codes Referenced

- Mortars and Materials:
    - IS 2250 : 1981: Code of practice for preparation and use of masonry mortars.
    - IS 712 : 1984: Specification for building limes.
    - IS 383 : 1970: Specification for coarse and fine aggregates from natural sources for concrete.
    - IS 1344 : 1981: Specification for calcined clay pozzolana.
    - IS 4098 : 1983: Specification for lime-pozzolana mixture.
    - IS 1635 : 1992: Code of practice for field slaking of building lime and preparation of putty.
- Bricks and Blocks:
    - IS 1077 : 1992: Specification for common burnt clay building bricks.
    - IS 2180 : 1988: Specification for heavy duty burnt clay building bricks.
    - IS 2185 (Parts 1-3): Specifications for Concrete Masonry Units (hollow, lightweight, autoclaved).
    - IS 12894 : 1990: Specification for sand lime bricks and fly ash lime bricks.
    - IS 1905 : 1987: Code of practice for structural use of unreinforced masonry.
    - IS 3495 : 1992: Methods of tests of burnt clay building bricks.
- Stonework:
    - IS 1127 : 1970: Recommendations for dimensions and workmanship of natural building stones for masonry work.
    - IS 1129 : 1972: Recommendations for dressing of natural building stones.

- IS 1597 (Parts 1 & 2) : 1992: Code of practice for construction of stone masonry.

Technical Specifications

Part 1: Mortars

- Types:
    - Cement Mortars: 1:3 to 1:8 (cement:sand). Richer than 1:3 not used due to high shrinkage. Leaner than 1:5 becomes harsh.
    - Lime Mortars: 1:2 or 1:3 (lime:sand/surkhi). Good workability and low shrinkage.
    - Cement-Lime Mortars: Combines properties of both. Typical binder-to-sand ratio is 1:3 (e.g., 1:2:9 cement:lime:sand).
- Mix Proportions (Table 4.1): This table specifies compressive strength for various mortar types (H1, H2, M1, M2, L1, L2) based on mix proportions.
    - Example: H1 Mortar (10 N/mm^2) uses a mix of 1 cement : 0-1/4C lime : 3 sand. M1 Mortar (5 N/mm^2) uses 1 cement : 0 lime : 5 sand.
- Optimum Mortar Mixes: Provides recommended mortar mixes based on brick strength to achieve maximum masonry strength.
    - For bricks < 50 kg/cm^2: Use M2 mortar (e.g., 1:2C:9).
    - For bricks > 250 kg/cm^2: Use H1 mortar (e.g., 1:0-1/4C:3).
- Water Quality: Must be clean and free from injurious materials. Limits are given for acidity, alkalinity, and solids content (e.g., max 200 mg/l organic, 3000 mg/l inorganic solids).

Part 2: Brickwork and Blockwork

- Brick Classification (IS 1077): Based on average compressive strength, from Class 3.5 (3.5 N/mm^2) to Class 35 (35 N/mm^2).
- Brick Sizes:
    - Modular: 190 x 90 x 90 mm and 190 x 90 x 40 mm.
    - Non-Modular: 230 x 110 x 70 mm and 230 x 110 x 30 mm.
- Concrete Block Classification (IS 2185):
    - Grade A: Min. block density 1500 kg/m^3. Strength 3.5 to 7.0 N/mm^2.
    - Grade B: Density 1000-1500 kg/m^3. Strength 2.0 to 5.0 N/mm^2.
    - Grade C: Non-load bearing. Strength 1.5 N/mm^2.
- Physical Properties:
    - Concrete Block Water Absorption: Not more than 10% by mass.
    - Concrete Block Drying Shrinkage: Not more than 0.1%.
- Joint Thickness:

    - Traditional Brick: Four courses + three bed joints should equal 4 x (brick thickness) + 3 cm.
    - Modular Brick: Maximum joint thickness 10 mm.
- Bond Beam for Crack Control (Blockwork):
    - Reinforcement: Minimum of two 8 mm dia mild steel bars or two 6 mm dia high-strength deformed bars.
    - Area of Influence: Assumed to extend 600 mm above and below its location.
    - Spacing: Placed at 1200 mm apart in walls without openings.
- In-situ Soil Cement Walls:
    - Cement Content: 2.5% to 3.5% for general walls; 5% to 7.5% below plinth level.
    - Shuttering: Planks not less than 200 mm wide and 50 mm thick.
    - Lifts: Soil poured in layers of 75 mm and compacted.

Part 3: Stonework

- Stone Dressing: Must be dressed on all beds and joints to be free from bushing. Face dressing depends on the masonry type.
- Bond Stones (Through Stones): To be provided between 1.5 m to 1.8 m apart in every course.
- Types of Masonry:
    - Random Rubble: Stones as quarried, with minimal dressing. Can be uncoursed or brought to courses at intervals of 300 to 900 mm.
    - Squared Rubble: Stones roughly squared. Can be uncoursed or coursed.
    - Ashlar Masonry: Stones cut to precise size and shape with fine chisel dressing. Joints are very thin.
- Joint Thickness:
    - Random Rubble: Max 20 mm.
    - Coursed Rubble (First Sort): Max 10 mm.
    - Plain Ashlar: Max 5 mm.
- Stone Veneering:
    - Fixing: Secured to backing with cramps (bronze, gun metal) or stone dowels. Cramps spaced not more than 600 mm apart.
    - Thickness: Veneer slabs not less than 20 mm thick.
    - Joints: Not more than 5 mm thick.

Visual Elements Analysis

Figure 4.1: Measurement of Tolerances of Common Building Bricks

Description: Three diagrams (A, B, C) illustrating how to measure the overall length, width, and height of a sample of 20 bricks to check for dimensional tolerances. The bricks are laid end-to-end or side-by-side on a level surface. Technical Details: The diagrams show 20 bricks laid in a straight line for measuring length, laid alternating for width, and stacked for height. This visualizes the procedure described in Annex C for checking compliance with size standards.

Figures 4.2 - 4.9: Types of Brick Bonds

Description: A series of isometric drawings clearly illustrating the arrangement of bricks in different bonding patterns.

- Fig 4.2 (English Bond): Shows alternate courses of headers and stretchers. A "queen closer" is shown next to the quoin header to create the lap.
- Fig 4.3 (Double Flemish Bond): Shows headers and stretchers alternating in the same course, on both faces. A queen closer is again used for the lap.
- Fig 4.4 (Single Flemish Bond): Shows Flemish bond on the facing side and English bond on the backing side.
- Fig 4.5 & 4.6 (English and Flemish Garden Wall Bond): Illustrate bonds with a higher ratio of stretchers to headers (e.g., three stretchers for every one header) to save on facing bricks.
- Fig 4.8 & 4.9 (Stretcher and Header Bond): Show walls built entirely of stretchers or headers, respectively. Stretcher bond is common for half-brick thick walls (e.g., cavity walls). Header bond is used for curved walls. Construction Notes: These drawings are fundamental for understanding masonry construction. They show how brick arrangement creates strength by ensuring vertical joints are not continuous between courses.

Figure 4.10 & 4.11: Joint Finishes & Cut Bricks

Description: Figure 4.10 shows cross-sections of different pointing finishes (Flush, Weathered, Keyed, Tucked, Ruled). Figure 4.11 shows a typical arrangement of cut bricks at a corner to maintain the bond pattern. Technical Details: These visuals provide practical details on finishing and construction at corners, which are crucial for both aesthetics and structural integrity.

Figure 4.13: Nominal Reinforced Concrete Bond Beam at Sill Level

Description: A cross-section of a concrete block wall showing a reinforced concrete bond beam cast within the blocks. Technical Details:

- Dimensions: The beam is shown with a width `w` and height `H` of 1200 mm².
- Reinforcement: Callouts specify 2 Nos. Φ8 mm bars as longitudinal reinforcement and Φ6 mm stirrups @ 175 mm c/c.

- Purpose: This visual clearly explains the concept of a bond beam used for crack control, as described in section 6.1.2.

Figures 4.19 - 4.24: Types of Stone Masonry

Description: Plan and section views illustrating the appearance and construction of different types of stone masonry.

- Fig 4.19 (Random Rubble Uncoursed): Shows irregularly shaped stones with large mortar joints. The section view highlights the use of "Through Stones" for bonding.
- Fig 4.20 (Random Rubble Brought to Courses): Similar to uncoursed but shows the wall leveled up at regular intervals.
- Fig 4.22 (Squared Rubble): Stones are roughly squared, resulting in a more regular appearance than random rubble.
- Fig 4.23 (Coursed Rubble): Stones are dressed to a uniform height within each course.
- Fig 4.24 (Polygonal Rubble): Stones are hammer-pitched into irregular polygonal shapes. Construction Notes: These figures are essential for differentiating between the masonry types, which have different structural capacities, labor requirements, and aesthetic outcomes.

Figure 4.32 - 4.35: Stone Veneer Fixing

Description: A series of highly detailed drawings showing methods for fixing stone veneer to a backing wall.

- Fig 4.32 & 4.33: Show the use of gun metal cramps and stone dowels to anchor the veneer. Full-size details show the dimensions of the cramps and how they fit into slots in the stone and backing.
- Fig 4.34 & 4.35: Provide details of various types of cramps, including non-corrosive angle cramps, flat cramps, and wire cramps, showing their geometry and how they are fixed with expansion bolts or dowels. Construction Notes: These drawings detail a specialized construction technique. The emphasis on non-corrosive materials and secure anchorage is critical for the durability and safety of the veneer.

BOQ Implications

- Mortar: The specified mix proportion (e.g., 1:3 vs. 1:6) directly impacts the quantity of cement required, which is a major cost driver.
- Masonry Work:
    - Measured in **cubic metres (m^3) ** for walls thicker than one brick/block.

    - Measured in square metres (m^2) for half-brick walls, partitions, and stone veneering, stating the thickness.
    - Different rates apply for different types of work (e.g., random rubble is cheaper than ashlar; English bond may be cheaper than Flemish if facing bricks are expensive).
- Reinforcement: Steel bars for bond beams or crack control are measured by weight (kg or tonne).
- Scaffolding: A separate item, measured per square meter of wall area. Double scaffolding is required for exposed brickwork or tile work, which increases costs.
- Labor: The level of skill and time required varies immensely. Ashlar masonry requires highly skilled masons and is very labor-intensive compared to random rubble or standard brickwork.

Chapter 3: Foundations

Overview

This chapter details the construction practices for various foundation types, emphasizing the transition from excavation to substructure construction. It covers pre-construction activities, the classification of foundations into shallow and deep categories, and the specific construction procedures for each, with extensive references to relevant Indian Standards. The chapter also provides critical information in its annexes regarding the selection of foundation types (Annex A) and methods for improving weak soils to enhance their bearing capacity (Annex B).

Key Standards and Codes Referenced

- Shallow Foundations:
    - IS 1080:1986: Design and construction of Spread, Pad, and Strip foundations.
    - IS 2950 (Part 1):1981: Design of Raft foundations.
    - IS 11089:1984: Design and construction of Ring foundations.
    - IS 9456:1980: Design and construction of Shell foundations.
- Deep Foundations:
    - IS 2911 (Part 1): Code of practice for concrete piles (Driven cast in-situ, Bored cast in-situ, Driven precast, Bored precast).
    - IS 2911 (Part 2):1980: Code of practice for timber piles.
    - IS 2911 (Part 3):1980: Code of practice for under-reamed piles.
    - IS 2911 (Part 4):1985: Code of practice for load test on piles.
    - IS 9556:1980: Code of practice for diaphragm walls.

- Special Structures:
  - IS 2974 (Parts 1-5): Covers foundations for various machine types (Reciprocating, Impact, Rotary).
  - IS 4091:1979: Foundations for transmission towers.
- Materials and Soil Mechanics:
  - IS 456:1978: Code of practice for Plain and Reinforced Concrete.
  - IS 269:1989, IS 455:1989, IS 1489:1991, IS 8041:1990, etc.: Various specifications for cement.
  - IS 432 (Part 1):1982, IS 1786:1985, IS 2062:1992: Specifications for reinforcement steel.
  - SP 36 (Part 2):1988: Field testing of soils.
  - IS 13094:1992: Guidelines for ground improvement techniques.

Technical Specifications

Pre-Construction & General

- Setting Out: Permanent pillars should be established beyond the building periphery for setting out walls. Datum lines must be set on these pillars. Pillar tops should be at the same level (preferably plinth/floor level) and be at least one brick wide.
- Protection of Excavation Bottom:
  - Method 1: Immediately after final excavation, place an 8 cm thick layer of lean concrete (not leaner than 1:5:10).
  - Method 2: Leave the last 10 cm of excavation and remove it just before placing foundation concrete.
- Backfilling:
  - Requirement: Must be compacted in layers.
  - Measurement/Tolerance: Layer thickness not to exceed 20 cm.

Shallow Foundations

- Definition: Foundations where load transfer is primarily through shear resistance of the soil, normally laid to a depth of 3 m.
- Types: Spread/Pad, Strip, Raft, Ring, and Shell foundations.
- Construction: Follows practices for Masonry (Chapter 4) and Concrete (Chapter 5).

Deep Foundations

- Under-Reamed Piles: Bored cast in-situ piles with one or more bulbs.
  - Purpose: Used in expansive soils to anchor against uplift and increase bearing area.

    - Concrete Specifications:
        - Slump: 100-150 mm for dry, unlined holes; 150-200 mm for tremie concreting.
        - Minimum Cement Content (Tremie):
            - 350 kg/m³ for piles up to 10 m deep.
            - 400 kg/m³ for piles deeper than 10 m.
        - Additional Cement: 10% extra cement is required if the pile is subsequently exposed to water.
    - Construction Tolerances:
        - Deviation from specified location: Max of 75 mm or 1/4 of stem diameter, whichever is less. For piles >600 mm diameter, deviation can be 75 mm or 10% of stem diameter.
- Precast Piles (Bored and Driven):
    - Longitudinal Reinforcement: Should be in one length where possible. If joints are needed, they must be staggered and butt-welded.
    - Driving Sequence: For a pile group, driving should proceed from the centre outwards to avoid compacting soil and preventing subsequent piles from being driven. In very soft soils, driving is from outside to centre.
- Timber Piles:
    - Tip Shape: Must be pointed in the form of a truncated cone or pyramid.
    - Tip Dimensions: End area of 25 cm² to 40 cm². Length of pointed section should be 1.5 to 2 times the pile diameter/side.

Machine Foundations

- Concrete Grade: Controlled concrete, between M15 to M20 for block foundations and M20 for formed foundations.
- Slump: 50 mm to 80 mm.
- Water-Cement Ratio: Shall not exceed 0.45.
- Reinforcement: Required at both top and bottom (two-way). Amount varies from 25 to 50 kg/m³ of concrete.
- Concrete Cover: 75 mm at bottom, 50 mm on sides, 40 mm on top.
- Construction Joints: To be avoided. If necessary, must be horizontal with 12 mm to 16 mm dowels at 60 cm centres, embedded at least 30 cm deep.

Ground Improvement (Annex B)

- Soil Densification: For cohesionless soils.
    - Vibroflotation/Vibrocompaction: Densifies soil via vibration.
    - Blasting: Uses shock waves for liquefaction and densification.
- Preconsolidation: For fine-grained soils (silts, clays).
    - Method: Expels water from pores by applying a preload (e.g., a mound of soil). Vertical drains can accelerate the process.

- Grouting: Injects materials (lime, cement, chemicals) into subsoils to form bonds.
- Soil Reinforcement: Introduces elements (stone chips, membranes) to increase stiffness and load-carrying capacity.

Visual Elements Analysis

Table 3.1: Summary of Soil Improvement Methods

Description: A comprehensive multi-page table detailing various ground improvement techniques. It is a critical decision-making tool for geotechnical and structural engineers when dealing with poor soil conditions. Technical Details: The table is structured to provide a complete profile for each technique.

- Technique Categories: The table organizes methods into logical groups such as *In-situ Deep Compaction*, *Injection and Grouting*, *Precompression*, *Admixtures*, and *Reinforcement*.
- Method-Specific Data:
  - Blasting: Principle is "Shock waves and vibrations cause liquefaction". Suitable for "Saturated, clean sands". Max depth ">30 m". Requires "Explosives". Can achieve "relative densities to 70-80%". Limitation is that it is "dangerous" and provides "no improvement near surface".
  - Vibrocompaction: Principle is "Densification by vibration and compaction of backfill". Suitable for "Cohesionless soils with less than 20 fines". Max depth "30 m". Requires "Granular backfill, water supply" and a "Vibroflot, crane, pumps". Result is "high relative densities, good uniformity".
  - Displacement Grout: Principle is "Highly viscous grout acts as radial hydraulic jack". Suitable for "Soft, fine grained soils". Requires "Soil, cement water" and "Batching equipment, high pressure pumps". Forms "Grout bulbs within compressed soil matrix". Advantage is "Good for correction of differential settlement".
  - Admixtures (Remove and Replace): Principle is "Foundation soil excavated, improved by drying or admixture and recompacted". Suitable for "In-organic soils". Max depth "10 m". Requires "Admixture stabilizers" and "Excavating mixing and compaction equipment". Result is "Increased strength and stiffness, reduced compressibility".
  - Reinforcement (Strips and Membranes): Principle is "Horizontal tensile strips, membranes buried in soil". Suitable for "Cohesionless soils". Can construct "earth structures to heights of several tons of m". Requires "Metal or plastic strips, geo-textiles" and "Excavating, earth handling, and compaction equipment". Result is "Self-supporting earth structures, increased bearing capacity". Relationship to Text: This table provides the

exhaustive detail supporting Annex B, which is introduced in Section 5.2 of the main chapter as a reference for improving weak soils.

BOQ Implications

- Foundation Work: The choice between shallow and deep foundations is a primary cost driver.
  - Piling: A major BOQ item, measured in linear meters for supply and driving/boring, with different rates for different pile types and diameters. Load tests are a separate high-cost item.
  - Specialized Concrete: Machine foundation concrete (controlled grade, low w/c ratio) will have a higher unit rate than standard concrete.
- Ground Improvement: Each technique is a specialized, high-cost BOQ item.
  - Mobilization/Demobilization: Cost for bringing specialized heavy equipment (vibroflot, dynamic compaction rigs, piling rigs, grout mixers) to the site.
  - Consumables: Costs for special materials like chemical grouts, admixtures, geotextiles, and large quantities of engineered fill.
  - Labor: Requires highly specialized crews, leading to premium labor rates.
  - Measurement: Varies by technique, e.g., per linear meter of stone column, per cubic meter of soil grouted, or as a lump sum for a specific treatment area.

Chapter 4: Masonry

Overview

This is an exhaustive chapter covering all aspects of masonry construction. It is meticulously organized into three parts and multiple sections. Part 1 focuses on Mortars, covering their types, properties, selection criteria based on strength and exposure, and preparation methods. Part 2 covers Brick and Blockwork, detailing the properties of various units (clay bricks, concrete blocks, etc.) and outlining construction practices, including bond types, jointing, crack control measures, and in-situ soil-cement walling. Part 3 is dedicated to Stonework, describing different types of stones and the specific construction techniques for each class of stone masonry, from uncoursed rubble to finely dressed ashlar, including veneer work.

Key Standards and Codes Referenced

- Mortar: IS 2250:1981 (Preparation and use), IS 712:1984 (Lime), IS 1635:1992 (Slaking of lime).

- Brickwork: IS 1077:1992 (Common Bricks), IS 2180:1988 (Heavy Duty Bricks), IS 1905:1987 (Structural use of unreinforced masonry), IS 3495:1992 (Testing of bricks).
- Blockwork: IS 2185 (Parts 1-3) (Concrete Masonry Units), IS 12894:1990 (Sand Lime Bricks).
- Stonework: IS 1597:1992 (Construction), IS 1129:1972 (Dressing), IS 1127:1970 (Dimensions).

Technical Specifications

Part 1: Mortars

- Water Quality for Mortar:
    - Acidity: To neutralize 200 ml water, requires ≤ 2 ml of 0.1N NaOH.
    - Alkalinity: To neutralize 200 ml water, requires ≤ 10 ml of 0.1N HCl.
    - Solids Content (Max): Organic: 200 mg/l; Inorganic: 3000 mg/l; Sulphates: 500 mg/l; Chlorides: 2000 mg/l; Suspended Matter: 2000 mg/l.
    - pH Value: Not less than 6.
- Mix Proportions (Table 4.1): Links mix proportions to mortar strength designation.
    - High Strength (H1): 10 N/mm²; Mix: 1 Cement : 3 Sand.
    - Medium Strength (M1): 5 N/mm²; Mix: 1 Cement : 5 Sand.
    - Low Strength (L1): 0.7 N/mm²; Mix: 1 Cement : 8 Sand.
- Lime Putty Preparation: Requires slaking in large vessels, with the mix standing for 72 hours before use. Can be stored for a fortnight.
- Mud Mortar: Soil plasticity index should be between 6 and 10 (or 12-15 for important projects). Sulphate content not to exceed 0.1%.

Part 2: Brickwork and Blockwork

- Brick Strength: Average strength of bricks in India varies widely by region.
    - Delhi/Punjab: 7-10 N/mm².
    - Uttar Pradesh/West Bengal: 10-20 N/mm².
    - Madhya Pradesh/Gujarat/Rajasthan/Assam: 3-5 N/mm².
- Brick Tolerances (from Annex C): For a sample of 20 bricks:
    - Length: 372 to 388 cm (Target: 380 cm ± 8 cm).
    - Width/Height: 176 to 184 cm (Target: 180 cm ± 4 cm).
- Water Absorption (Annex C): Not to exceed 20% for bricks up to class 12.5; not to exceed 15% for higher classes.
- Efflorescence Test (Annex C): Bricks immersed 2.5 cm in distilled water. Assessed as 'Nil', 'Slight' (<10% area covered), or 'Moderate' (<50% area).
- Laying of Brickwork:

  - Soaking: Bricks must be soaked (for ~6 hours) until fully penetrated, then allowed to become skin-dry before laying.
  - Joints: To be properly filled. No hollow spaces.
  - Lifting: No part of a wall should rise more than 1 m above the general construction level.
- Crack Control in Blockwork:
  - Mortar: Should be weaker than the block to distribute movement. Table 4.4 provides recommended proportions (e.g., 1:1:9 C:L:S for normal work).
  - Bond Beams: Reinforced concrete beams within the masonry. Figure 4.13 shows a nominal beam with 2Φ8mm bars and Φ6mm stirrups @ 175mm c/c.
  - Control Joints: Vertical separations to accommodate movement. Spacing depends on panel L/H ratio (Table 4.5), from 3.0 for 200mm thick walls down to 1.75 for 300mm thick walls.

Part 3: Stonework

- Stone Properties (Table 4.6): Minimum Crushing Strength.
  - Granite: 100 N/mm².
  - Basalt: 40 N/mm².
  - Limestone: 20 N/mm².
- Construction:
  - Bedding: Stones must be laid on their natural bed, so pressure is perpendicular to stratification.
  - Bond: Provided by using "through stones" or interlocking headers and stretchers.
  - Joints: Must be completely filled with mortar.
- Coursed Rubble Masonry (First Sort):
  - Bed Joints: Rough chisel dressed for at least 80 mm from the face.
  - Face Joints: Not more than 10 mm thick.
- Plain Ashlar Masonry:
  - Joints: Not more than 5 mm thick.
  - Dressing Tolerance: Adjoining faces must be fine chisel dressed for 6 mm with no point varying by more than 1 mm from a straight edge. Bed joints must be dressed so variation from a 60 cm straight edge does not exceed 3 mm.
- Stone Veneering:
  - Anchorage: Requires non-corrodible cramps. Figure 4.32 shows gun metal cramps and copper pins. The details show the precise geometry of the cramps and how they engage with both the veneer and the backing wall.

Visual Elements Analysis

Figures 4.13 & 4.14-4.15: Crack Control in Blockwork

Description: Figure 4.13 shows a reinforced concrete Bond Beam at a window sill level, providing horizontal reinforcement. Figures 4.14 and 4.15 illustrate various methods of creating vertical Control Joints. Technical Details:

- Bond Beam (Fig 4.13): Clearly shows the placement of 2Φ8mm longitudinal bars and Φ6mm stirrups inside the hollow cores of concrete blocks, which are then filled with concrete. This provides tensile strength to resist horizontal cracking.
- Control Joints (Fig 4.14):
  - Method A: A straight vertical joint filled with caulking compound.
  - Method B: A joint with greased wires (e.g., 5mm) laid in every course to create a slip plane.
  - Method C: A purpose-made joint using a jamb block to create a clean, keyed separation. Construction Notes: These figures detail the two primary methods for controlling shrinkage and thermal cracking in long concrete block walls: adding reinforcement to resist tensile forces (bond beams) or providing dedicated planes of weakness for movement to occur harmlessly (control joints).

Figure 4.16: Shuttering for In-situ Soil Cement Walls

Description: Shows the formwork arrangement for constructing rammed earth walls. Technical Details: The drawing labels wooden planks as formwork, held in place by MS Angles (50x50x6 mm) acting as walings, which are in turn secured by M16 bolts that pass through the wall space. An end plank is shown for casting near an opening. Construction Notes: This illustrates a temporary works setup crucial for this specific construction method. The formwork must be robust enough to withstand the pressure of ramming the soil.

Figure 4.17: Joint in In-situ Soil Cement Walls

Description: Shows a plan and section of a vertical tongue-and-groove joint. Technical Details: A plank with a trapezoidal section is used to form a groove in one cast section. When the adjacent section is cast against it, a corresponding tongue is formed, creating an interlocking vertical joint. Construction Notes: This detail is important for ensuring shear transfer and stability between adjacent panels of rammed earth walls, preventing them from moving independently.

Figure 4.32: Fixing Stone Veneer with Cramps and Pins

Description: Extremely detailed drawings (plan, elevation, full-size detail) showing how thin stone veneer panels are anchored to a backing wall using gun metal cramps and copper pins. Technical Details:

- Overall: A plan view shows cramps at regular intervals connecting the veneer to the backing.
- Detail 'A': The full-size detail shows a 6.75 mm long copper pin doweled into both the veneer and the backing, with the space filled with mortar. It also shows a gun metal cramp embedded in mortar, hooking into both elements.
- Callouts: "Exposed faces and face joints to be fine tooled", "Mortar", "Copper Pin", "Gun Metal Cramp". Construction Notes: This visual explains the high level of precision required for stone veneer work. The use of non-ferrous, corrosion-resistant fixings (gun metal, copper) is a critical specification for ensuring the long-term durability of the facade.

BOQ Implications

- Mortar: Quantities calculated based on wall volume and specified joint thickness. The cost is heavily influenced by the cement-to-sand ratio.
- Masonry: Unit rates vary significantly by type.
  - Brickwork: Simple to measure and price.
  - Blockwork: BOQ should specify if hollow cores are to be filled with concrete and reinforced, as this is a major additional cost.
  - Stonework: Labor cost is the dominant factor. The rate for Ashlar masonry can be many times that of Random Rubble due to the skilled dressing required. Measured in m^3.
  - Stone Veneer: Measured in m^2, stating the stone type and thickness. The cost of non-corrosive cramps and dowels must be included.
- Crack Control:
  - Reinforced Bond Beams: Reinforcement measured by weight (kg); in-fill concrete measured by volume (m^3).
  - Control Joints: Measured by linear meter (m). The cost includes the joint filler, sealant, and any specialized forming work.
- # Part 3: Chapter 5: Plain and Reinforced Concrete & Chapter 6: Anti-termite Measures

  ## Chapter 5: Plain and Reinforced Concrete

  ## Overview

  This is a foundational chapter covering the principles and practices of concrete work. It is structured into four main parts:

    - Part 1: Common requirements for both plain and reinforced cement concrete, including materials, grades, production, placement, curing, and special concreting conditions.
    - Part 2: Additional requirements specific to reinforced concrete, focusing on formwork and reinforcement.
    - Part 3: Use of lime and lime-pozzolana concrete.
    - Part 4: An introduction to shotcreting methods.
- The chapter emphasizes that concrete quality depends on a combination of mix proportions, constituent material quality, workability, compaction, and proper curing.

Key Standards and Codes Referenced

    - General Concrete Practice:
        - IS 456 : 1978: Code of practice for plain and reinforced concrete.
        - IS 1199 : 1959: Methods of sampling and analysis of concrete.
        - IS 10262 : 1982: Recommended guidelines for concrete mix design.
        - SP 23 (S&T) : 1982: Handbook on concrete mixes.
    - Materials:
        - Cement: IS 269, IS 455, IS 1489, IS 8041, IS 8043, IS 8112, IS 12269, IS 12600.
        - Aggregates: IS 383 : 1970, IS 2386 (Parts 1 to 8) : 1963.
        - Reinforcement: IS 432 (Part 1), IS 1786, IS 1566, IS 2062.
        - Water & Admixtures: IS 3025 : 1964, IS 9103 : 1979.
        - Pozzolanas: IS 3812 : 1981 (Fly Ash), IS 1344 : 1981 (Burnt Clay Pozzolana).
    - Special Conditions & Testing:
        - IS 7861 (Parts 1 & 2): Concreting in extreme weather.
        - IS 4926 : 1976: Ready mixed concrete.
        - IS 13311 (Parts 1 & 2) : 1992: Non-destructive testing (Ultrasonic pulse velocity, Rebound hammer).
        - IS 9013 : 1978: Rapid determination of compressive strength.
    - Formwork: IS 883 : 1970, SP 33 (S&T) : 1986, IS 4990 : 1981.
    - Lime Concrete: IS 2541 : 1991.
    - Shotcrete: IS 9012 : 1978.

- ## Technical Specifications

  Part 1: Common Requirements for Plain and Reinforced Cement Concrete

    - Materials:
        - Aggregates: Coarse and fine aggregates must conform to IS 383. The aggregate crushing value shall not exceed 30% (tested as per

IS 2386). For fine aggregates (sand), Zone II is typical, while Zone IV (very fine) should not be used in nominal mixes.

- Concrete Grades:
    - Designation: Designated by 'M' followed by the characteristic compressive strength in N/mm^2 at 28 days (e.g., M15, M20).
    -

 - **Table 5.6 - Grades of Cement Concrete**:

Grade Designation	Specified Characteristic Compressive Strength at 28 Days (N/mm^2)
M10	10
M15	15
M20	20
M25	25
M30	30
M35	35
M40	40

 - **Critical Note**: Grades lower than **M15 shall not be used in reinforced concrete**. M5 and M7.5 are for lean concrete bases and simple masonry foundations.

- **Mix Proportions (Nominal Mix)**:

 - **Table 5.7 - Proportions for Nominal Mix Concrete**:

Grade of Concrete	Total Quantity of Dry Aggregate by Mass per 50 kg of Cement (kg, Max)	Proportion of Fine to Coarse Aggregate	Quantity of Water per 50 kg of Cement (Litres, Max)
M5	800	Generally 1:2	60

M7.5	625	Generally 1:2	45
M10	480	Generally 1:2	34
M15	350	Generally 1:2	32
M20	250	Generally 1:2	30

- **Note**: Proportion of fine to coarse aggregate is adjusted based on grading and max size of aggregate (from 1:1.5 to 1:2.5).

- Workability & Slump:
  - Table 5.9 - Slump: Specifies slump values for different placing conditions.
    - Lightly reinforced sections with vibration: 25-75 mm slump (Low workability).
    - Heavily reinforced sections without vibration: 75-125 mm slump (High workability).
- Production and Control:
  - Batching: Shall be done by mass, not volume. If volume batching is unavoidable, allowance for bulking of moist fine aggregate must be made.
  - Mixing Time: For machine mixing, typically 1.5 to 2 minutes.
- Transporting, Placing, and Compacting:
  - Placing: Concrete shall be deposited as near as practicable to its final position to avoid rehandling. Layers should be placed such that the bottom layer does not set before the top layer is placed.
  - Compaction: Mechanical vibrators (to IS 2505, IS 2506, etc.) are recommended. Over-vibration, especially of wet mixes, is harmful.
- Construction Joints:
  - Procedure: When resuming work on a hardened surface, the surface must be roughened, swept clean, and wetted. For vertical joints, a neat cement slurry is applied. For horizontal joints, a 10-15 mm layer of mortar (with the same cement:sand ratio as the concrete mix) is applied immediately before placing new concrete.
- Curing:
  - Duration: Exposed surfaces shall be kept continuously wet for at least seven days from the date of placing.
- Concreting Under Special Conditions:
  - Hot Weather (Ambient > 40°C):
    - Effects: Accelerated setting, reduced strength, increased shrinkage cracking.

            - Control: Cool ingredients (especially water), minimize time between mixing and placing, cure promptly. Temperature of wet concrete should not exceed 38°C.
    - Cold Weather (Ambient < 4.5°C):
        - Effects: Delayed setting, potential frost damage to green concrete.
        - Control: Heat mixing water and/or aggregates, use insulating materials on formwork, use rapid hardening cement. Concrete must be protected from freezing.
- Ready Mixed Concrete:
    - Must conform to IS 4926. Divided into centrally mixed and truck mixed.

Part 2: Requirements of Reinforced Concrete

- Formwork:
    - Material: Timber, plywood (to IS 4990), steel, or other approved material.
    - Stripping Time (Table 5.11 & 5.12): The time after which formwork can be removed depends on the structural element, span, and cement type.
        - Walls, columns, vertical faces of beams: 24 to 48 hours.
        - Slab soffits (props left under): 3 days.
        - Beam soffits (props left under): 7 days.
        - Removal of props under slabs: 7 days (for spans up to 4.5 m), 14 days (for spans over 4.5 m).
- Reinforcement:
    - Tolerances on Placing (IS 456):
        - For effective depth ≤ 200 mm: Tolerance is ±10 mm.
        - For effective depth > 200 mm: Tolerance is ±15 mm.
    - Cover: Shall be as per drawings, subject to requirements of IS 456. Shall not be reduced by more than 1/3 of specified cover or 5 mm, whichever is less.

Part 3: Lime and Lime-Pozzolana Concrete

- Application: Used in well foundations, under floor finishes, filling haunches over arches, and roof terracing.
- Properties: Slower hardening than cement concrete but possesses considerable resistance to sulphate attack.
- Strength: For mixes in Table 5.14, compressive strength not less than 1 N/mm² at 28 days.

Part 4: Shotcrete

- Definition: Mortar or concrete pneumatically projected at high velocity onto a surface.
- Processes:

- Dry-Mix Process: Most water is added at the nozzle.
- Wet-Mix Process: All ingredients, including water, are mixed before being conveyed to the nozzle.

- Rebound: Aggregate and cement paste that ricochets off the surface.
    - Floors or slabs: 5-15%.
    - Vertical walls: 15-30%.
    - Overhead work: 25-50%.

Visual Elements Analysis

Figure 5.1: Required Temperature of Mixing Water to Produce Heated Concrete

Description: A graph with three sets of curves, each for a different cement content (300, 375, 520 kg/m³), used to determine the required temperature of mixing water to achieve a desired final concrete temperature. Technical Details:

- Axes: Y-axis is "Temperature of Mixing Water (°C)", X-axis is "Temperature of Concrete (°C)".
- Curves: For each cement content, a family of curves is plotted for different water-cement ratios (0.40, 0.50, 0.60, 0.70). Two sets of lines are shown for "Damp" and "Wet" aggregate moisture content.
- How to Use: An engineer determines the desired final concrete temperature, identifies the planned w/c ratio and cement content, and uses the graph to find the necessary temperature for the mixing water. Relationship to Text: This figure directly supports Section 7.3.2 (Temperature Control of Concrete Ingredients) for cold weather concreting, providing a practical tool for site engineers.

Figures 5.2 & 5.3: Typical Relation between Accelerated and 28-Days Compressive Strength

Description: Two graphs showing the linear correlation between the strength of concrete cured using an accelerated method (Warm Water or Boiling Water) and the standard 28-day cured strength. Technical Details:

- Axes: Y-axis is "28-Day Compressive Strength (N/mm²)", X-axis is "Accelerated Strength (N/mm²)".
- Data Points: A scatter plot of test results is shown with a "Regression Equation" line plotted through them. Example equation: $R_{28} = 12.05 + 1.48 R_a$.
- Curing Cycle Diagram: A small diagram within each graph shows the timing of the accelerated curing process (e.g., for Warm Water Method: 1.5 to 3.5 h wait, then 20h 10min curing cycle, then 1h cooling). Relationship to Text: These figures are the output of the process described in Annex C and Section 3.3.3.

They illustrate how rapid testing can be used to reliably predict the final 28-day strength of concrete, which is crucial for quality control.

BOQ Implications

- Concrete Grade: A primary cost factor. Higher grades (M25, M30) require more cement and better quality control, increasing the unit rate per m^3.
- Formwork: Measured in square metres (m^2). The cost depends on the complexity of the shape and the material (plywood, steel). Stripping time requirements affect the reusability cycle and thus the overall quantity of formwork needed for a project.
- Reinforcement: Measured by weight (tonne or kg). The rate includes cutting, bending, and placing.
- Admixtures: Added cost per cubic meter of concrete for accelerators, retarders, plasticizers, etc.
- Special Conditions:
  - Hot Weather: Costs for cooling water (ice), shading aggregates, and extended curing.
  - Cold Weather: Costs for heating water/aggregates, insulating blankets, and potentially longer formwork retention times.
- Shotcrete: A highly specialized item measured per m^2 at a specified thickness. The rate is high due to specialized equipment, skilled labor (nozzleman), and material rebound (waste factor of up to 50%).

Chapter 6: Anti-termite Measures

Overview

This chapter focuses exclusively on constructional anti-termite measures, which are physical barriers designed into the building to prevent termite infestation. This is distinct from the chemical soil treatments covered in Chapter 2. The methods detailed here are intended to be permanent and work by creating impassable barriers at potential entry points for subterranean termites. The chapter is presented as a step-by-step construction sequence, heavily supported by detailed diagrams.

Key Standards and Codes Referenced

- IS 401 : 1982: Code of practice for preservation of timber.

- IS 1141 : 1993: Code of practice for seasoning of timber.
- IS 216 : 1961: Specification for coal tar pitch.

Technical Specifications

Design Criteria & Principles

- Objective: To create a continuous, unbroken physical barrier that prevents termites from accessing the building's timber and other cellulosic materials from the soil.
- Key Methods:
    i. Solid Foundations: Use of dense, void-free materials. Masonry mortar mix should not be leaner than 1:3 (cement:lime) in areas contacting soil.
    ii. Continuous Concrete Sub-base: The ground floor sub-base must be extended under all walls to create a continuous slab across the entire plinth area.
    iii. Coarse Sand Barrier: A layer of coarse sand (particle size > 3 mm) laid under the flooring can check the rise of soil moisture.
    iv. Masonry Groove: A specially constructed groove at the plinth level that can be inspected and treated.
    v. Termite Shields: A metal shield projecting from the plinth to physically block termite tubes.

Construction Methods (Step-by-Step Sequence)

- Stage 1 (Fig 6.1): Insert a dry brick at least 50 mm into the outer masonry wall to create a placeholder for the future concrete apron.
- Stage 2 (Fig 6.2): At plinth level, lay brick-on-edge in cement mortar. Place dry bricks on either side to create voids for the coarse sand layer and the anti-termite groove.
- Stage 3 (Fig 6.3): Cast the 1:3:6 concrete sub-floor, forming a continuous anti-termite groove in the process.
- Stage 4 (Fig 6.4): Raise the superstructure masonry.
- Stage 5 (Fig 6.5): Remove the dry brick placeholder and fill the void with graded coarse sand (particle size 3 mm to 5 mm) to a thickness of at least 100 mm.
- Stage 6 (Fig 6.6): Lay the final concrete sub-floor, at least 75 mm thick, over the sand filling.
- Stage 7 (Fig 6.7): Construct the external apron floor. Remove the dry brick placeholder from Stage 1. Lay a 75 mm thick lime concrete (1:3:6) bed for the apron.
- Stage 8 (Fig 6.8): Finish the apron with a 25 mm thick concrete topping (1:2:4) and apply 12 mm plaster to the plinth.

Termite Shields

- Material: Galvanized sheets, aluminum sheets, etc.
- Installation (Fig 6.10):
    - The sheet must be embedded in the sub-floor/plinth masonry.
    - It must have a projection of about 50 mm.
    - The projecting edge must be bent downwards at an angle of 45°.

Visual Elements Analysis

Figures 6.1 to 6.8: Staged Construction of Anti-Termite Measures

Description: This series of eight diagrams forms a visual construction manual, illustrating the sequential integration of physical anti-termite barriers into the foundation and plinth. Technical Details and Sequence:

- Fig 6.1: Shows a single dry brick embedded in the foundation masonry, creating a void for the future apron.
- Fig 6.2: At the plinth level, it shows brick-on-edge masonry with dry bricks on both the inner and outer sides, forming voids. The inner void is for a coarse sand layer; the outer void creates the anti-termite groove.
- Fig 6.3: Shows the casting of the concrete sub-floor, which fills the groove created in the previous step. Detail A provides a close-up of the finished groove, showing dimensions 75 mm x 100 mm.
- Fig 6.4: A simple diagram showing the superstructure wall being built on top of the completed sub-floor.
- Fig 6.5: Shows the inner dry brick being removed and the void being filled with a compacted 100 mm thick sand layer.
- Fig 6.6: Shows the final 75 mm thick dense cement concrete sub-floor being cast over the sand layer, with skirting added.
- Fig 6.7: Shows the outer dry brick being removed and the apron base being constructed with lime concrete. Key dimensions are shown: apron width 600 mm, offset from wall 25 mm.
- Fig 6.8: Shows the final finishes: a 25 mm thick 1:2:4 concrete topping on the apron and 12 mm plaster on the plinth wall. Relationship to Text: These figures are inextricably linked to the text in Section 4.1. They provide a clear, step-by-step visual guide that is essential for understanding and correctly executing the complex, layered construction process.

Figure 6.9: Anti-Termite Construction - Final Recommendations

Description: This is the master drawing, a composite cross-section showing all the individual stages (from Fig 6.1-6.8) integrated into one complete system. Technical

Details: It clearly labels all the components: Earth Filling, Sand Filling, Brick on Edge, 75mm Concrete Subfloor, Floor Finish, Lime Concrete Apron, Concrete Topping, and the 12mm Plaster. It provides key dimensions like the 600 mm apron width.

Figure 6.10: Termite Shield at Plinth Level

Description: A cross-section showing the installation of a metal termite shield.
Technical Details:

- The "Anti-Termite Shield" is shown as a metal sheet embedded in the plinth masonry.
- It projects outwards by 50 mm.
- The projecting edge is bent downwards at a 45° angle.
- A detail view 'A' shows the precise geometry of the bend. Construction Notes: This is a critical physical barrier. The downward-angled projection makes it mechanically difficult, if not impossible, for subterranean termites to build their mud tubes around it to reach the superstructure. Regular inspection of the shield is implied to check for and destroy any attempted tubes.

BOQ Implications

- Specialized Labor: The multi-stage, intricate process of creating grooves, laying sand barriers, and installing shields requires careful workmanship and supervision, which can affect labor costs.
- Material Costs:
    - Coarse Sand/Graded Sand: This is a specific material requirement, potentially more expensive than standard sand used for mortar or concrete. Measured in m^3.
    - Lime Concrete: Requires separate batching and materials (lime, brick aggregate) from cement concrete. Measured in m^3.
- Termite Shields: A distinct BOQ item.
    - Measurement: By linear meter (m) of shield installed.
    - Cost Components: Includes the cost of the specified metal sheet (e.g., galvanized iron), labor for cutting and bending to the specified 45° angle, and installation.
    -

Part 4: Chapter 7: Doors and Windows (Wood and Metal) & Chapter 8: Steel Construction

Chapter 7: Doors and Windows (Wood and Metal)

Overview

This chapter provides comprehensive guidelines for the installation and finishing of doors, windows, and ventilators made of wood, steel, and aluminum. Part 1 focuses on timber, covering classification, moisture content requirements (a critical factor), panel products, and detailed joinery practices. Part 2 covers metal (steel and aluminum) units, detailing their installation into various types of openings. The chapter is heavily reliant on visual diagrams to explain complex joinery and assembly details.

Key Standards and Codes Referenced

- Timber & Joinery:
    - IS 399 : 1963: Classification of commercial timbers and their zonal distribution. (Crux: Foundation for selecting appropriate local timber).
    - IS 287 : 1993: Permissible moisture content for timber. (Crux: Critical for preventing warping and dimensional instability).
    - IS 1141 : 1993: Seasoning of timber.
    - IS 401 : 1982: Preservation of timber.
    - IS 1003 (Parts 1 & 2): Timber panelled and glazed shutters.
    - IS 2202 (Part 1): Wooden flush door shutters (solid core).
- Metal Doors & Windows:
    - IS 4351 : 1976: Steel door frames.
    - IS 1038 : 1983: Steel doors, windows and ventilators.
    - IS 6248 : 1979: Steel rolling shutters.
- Hardware: IS 208 : 1987 (Door Handles) and a long list of standards in Annex A for hinges, bolts, locks, etc.
- Glazing: IS 2835 : 1987 (Sheet Glass), IS 5437 : 1969 (Wired and Figured Glass).

Technical Specifications - CRUX & IMPORTANT INFORMATION

Timber Doors and Windows (Part 1)

- Moisture Content (IS 287): This is the most critical specification for timber. The country is divided into four zones based on average annual humidity, and the maximum permissible moisture content for timber varies accordingly.
-

- **Table 7.1 - Permissible Moisture Content of Timber**:

Use	Zone 1 (<40% Hum.)	Zone 2 (40-50%)	Zone 3 (50-67%)	Zone 4 (>67%)
Beams & Rafters	12%	14%	17%	20%
Door/Window Frames (≥ 50mm)	**10%**	**12%**	**14%**	**16%**
Door/Window Frames (< 50mm)	**8%**	**10%**	**12%**	**14%**

    - Crux: Using timber with moisture content outside these ranges for the given zone will lead to severe warping, shrinkage, or swelling after installation, causing doors and windows to jam or develop large gaps.
- Joinery:
    - Mortise and Tenon Joints: This is the fundamental joint type for timber frames. The thickness of each tenon shall be approximately one-third of the finished thickness of the member.
    - Rebates: The depth of rebate in frames for housing shutters shall be 1.25 cm. The rebate in the meeting stiles of double shutters shall be not less than 2 cm.
    - Hardware Fixing: Each wooden door shutter must have a minimum of three hinges.
- Glazing:
    - Clearance: A clearance must be left between the glass edge and the surround: 2.5 mm for wood/metal surrounds, 3.0 mm for stone/brick.
    - Nomogram (Fig 7.19): This is a critical tool for determining the required thickness of glass based on the pane dimensions and the design wind pressure. It prevents the use of undersized glass that could break under wind load.

Metal Doors and Windows (Part 2)

- Installation in Openings: The key is providing the correct clearance between the metal frame and the structural opening.
    - Flush Openings (Fair-faced): Requires a clearance of 3 mm.
    - Flush Openings (Rendered): Clearance must equal the thickness of the render (e.g., 12.5 cm as per Fig 7.22).
    - Rebated Openings (Fair-faced): Requires a clearance of 3 mm.

- Fixing: Metal frames are fixed to masonry using lugs. They should be fixed into prepared openings, not "built-in" as the wall is constructed, to avoid distortion.

Visual Elements Analysis

Figure 7.1: Tenon and Haunched Tenon in Joinery

Description: A detailed illustration of the fundamental joint used in high-quality timber frame construction. Technical Details: The diagram shows a "single tenon" and a "haunched single tenon". The haunch is the extra piece of wood left between the tenon and the end of the rail.

- Callout: Shows the tenon thickness `t/3` (one-third of the rail thickness). Construction Notes: The haunch is critical. It fills the groove in the stile, preventing the stile from twisting and significantly increasing the joint's rigidity and strength against racking forces. This is a crucial detail for durable door and window frames.

Figure 7.5: Ledged, Braced and Battened Timber Door Shutter

Description: A complete assembly drawing of a traditional battened door. Technical Details:

- Components: Vertical Battens (planks), horizontal Ledges (top, middle, bottom), and diagonal Braces.
- Crux of the Design: The diagram shows the Braces running from the hinge side upwards to the opposite side. This is fundamentally important. This orientation places the brace in compression, effectively transferring the door's weight to the hinges and preventing the door from sagging over time. If oriented the other way, the brace would be in tension and would not prevent sagging.
- Dimensions: Modular Opening (M) and Floor Finish (F) dimensions are shown, indicating how the door fits into a standardized opening.

Figure 7.19: Nomogram for Determining Thickness of Glass Plate and Sheet for Window Panes

Description: A graphical chart used to select the appropriate glass thickness for a window pane to withstand a given wind pressure. Technical Details:

- Axes: Y-axis is "Length of Longer Side (mm)", X-axis is "Length of Shorter Side (mm)".
- Curves: A family of curves radiates from the origin, each representing a specific glass thickness (e.g., 3 mm, 4 mm, 5 mm).

- Secondary Axis: A vertical axis on the right shows the corresponding "Wind Pressure (N/m^2)".
- How to Use: An engineer finds the intersection of the pane's longer and shorter dimensions on the chart. The curve that passes through or just above this point indicates the minimum required glass thickness. This can then be cross-referenced with the design wind pressure. Relationship to Text: This nomogram is a vital practical tool that directly supports the text on glazing (Section 14). It translates complex structural calculations into a simple graphical method for ensuring the safety and compliance of glazed elements.

BOQ Implications

- Timber: A major cost item, measured in **cubic metres (m^3) **. The cost is highly dependent on the species selected (as per IS 399) and whether it is seasoned and treated.
- Doors/Windows: Can be measured in two ways:
    - By Area (m^2): For supply and installation of shutters. The rate will vary based on type (panelled, glazed, flush door).
    - Per Number: For supply and installation of complete door/window units (frame + shutter).
- Hardware: A significant cost component. Each item (hinges, locks, bolts, handles) is enumerated and priced per piece.
- Glazing: Measured by area (m^2), specifying the type and thickness of glass. The thickness, determined by the nomogram, directly impacts the material cost.
- Finishing: Painting or varnishing is a separate item, measured per m^2.

Chapter 8: Steel Construction

Overview

This chapter details the fabrication and erection practices for structures using hot-rolled steel sections, including tubular sections. It is divided into two main parts. Part 1 covers hot-rolled sections, detailing materials, fabrication procedures (cutting, holing, assembly), connection methods (riveting, bolting, welding), erection, and painting. Part 2 briefly introduces cold-formed sections. The chapter's crux is the emphasis on precision in fabrication and following correct procedures for connections to ensure the structure behaves as designed.

Key Standards and Codes Referenced

- Design & Fabrication:
  - IS 800 : 1984: Code of practice for general construction in steel. (The primary design code).
  - IS 9595 : 1980: Recommendations for radiographic examination of fusion welded butt joints in steel.
  - IS 7215 : 1974: Tolerances for fabrication of steel structures.
- Materials:
  - Structural Steel: IS 2062 : 1992, IS 8500 : 1992.
  - Rivets: IS 1929 : 1982, IS 1148 : 1982.
  - High Strength Friction Grip (HSFG) Bolts: IS 3757, IS 6623, IS 6649.
  - Welding Consumables: IS 814 : 1991 (Electrodes), IS 3613 : 1974 (Wire and flux).
- Tubular Structures: IS 806 : 1968 (Use of steel tubes), IS 1161 : 1979 (Steel tubes).
- Cold-Formed Sections: IS 801 : 1975 (Design), IS 811 : 1988 (Sections).

Technical Specifications - CRUX & IMPORTANT INFORMATION

Fabrication of Hot Rolled Sections

- Minimum Thickness of Metal: This is a critical durability requirement.
  - Steel exposed to weather & accessible for cleaning: 6 mm minimum.
  - Steel exposed to weather & inaccessible: 8 mm minimum.
  - Steel not exposed to weather: 6 mm minimum.
- Hole Formation:
  - Punching: Permitted only for material up to 16 mm thick. For dynamically loaded structures, punching is avoided. If used, holes must be punched 3 mm smaller than the final size and then reamed.
  - Drilling: The standard and preferred method. Holes for turned and fitted bolts must be drilled to the nominal diameter of the bolt shank.
  - Gas Cutting: Not permitted for forming rivet or bolt holes.
- Assembly: Members must be assembled such that they are not twisted or otherwise damaged. Contact surfaces for HSFG bolts must be specially prepared (e.g., grit blasted) to achieve the required slip factor.

Connections

- Riveting: Rivets must be heated uniformly to a light cherry red and driven to completely fill the hole.

- Bolting:
  - Black Bolts: Used in clearance holes.
  - HSFG Bolts: Rely on friction between connected surfaces. Requires controlled tightening (e.g., torque control or turn-of-nut method) to achieve the specified minimum shank tension. This is a critical procedure.
- Welding: Must be done by qualified welders. Procedures must follow codes like IS 816.
- Lug Angles (Fig 4.7 in Chapter 4, referenced here):
  - Purpose: Used to connect members (like angles and channels) to gusset plates more effectively by transferring force from the outstanding leg.
  - Strength Requirement: The lug angle and its connection must be ableto develop a strength 20% in excess of the force in the outstanding leg. This is a crucial detail to prevent connection failure.

Tubular Structures

- Connections: Wherever possible, connections should be made directly tube-to-tube without gusset plates.
- Eccentricity (Fig 8.1): Gravity axes of tubes meeting at a joint should intersect at a single point to avoid eccentricity. If eccentricity is unavoidable, it must be within the limits shown in the diagram.
- Sealing: The ends of all tubular members must be sealed to prevent internal corrosion. Flattened ends are permissible for connections.

Visual Elements Analysis

Figure 8.1: Diagram Showing Limits of Eccentricity for Tube Connections

Description: A series of diagrams illustrating the acceptable geometric limits for eccentric connections in tubular structures. Technical Details:

- Components: Shows a "main tube" and a "branch tube" intersecting.
- Eccentricity (`e_max`, `e_min`): The diagram defines the maximum allowable offset between the centreline of the branch tube and the centreline of the main tube.
- Formulas: Provides formulas to calculate the maximum eccentricity based on the diameters of the main (`D□`) and branch (`D_b`) tubes.
  - For a Butt Weld: e_max = ± 1/4 (D□ - D_b)
  - For a Fillet-Butt Weld: e_max = ± 1/4 (D□ - D_b) and e_min = ± 1/4 (D□ - D_b)
- Dotted Circle: Represents the largest permissible non-eccentric branch tube, visually defining the acceptable zone for the actual branch tube's intersection. Construction Notes: This diagram is fundamentally important for the design and

fabrication of tubular trusses. Adhering to these limits is critical to ensure that secondary bending stresses due to eccentricity are kept within manageable levels, preventing premature failure of the connection. It prevents fabricators from making arbitrary connections that would violate the design assumptions.

BOQ Implications

- Structural Steel: Measured by weight (tonne). The rate includes fabrication, supply, and erection. The BOQ should specify the type of steel (e.g., IS 2062).
- Connections: The type of connection significantly impacts cost.
  - Bolting: HSFG bolting is more expensive than black bolting due to the higher cost of bolts and the requirement for calibrated torque wrenches and special surface preparation. Measured per number of bolts, specifying type and size.
  - Welding: Measured by linear meter of weld, specifying the size and type (fillet, butt). Requires skilled, certified welders.
  - Riveting: Now largely obsolete, but was a very labor-intensive and costly process.
- Fabrication: The complexity of fabrication (e.g., complex tube-to-tube profiled cuts vs. simple gusset plate connections) affects the unit rate for steelwork.
- Protective Coating: Painting is a separate item, measured per square metre (m^2). The cost depends on the number of coats (primer, intermediate, finish) and the type of paint (e.g., standard enamel vs. zinc-rich primer).

Part 5: Chapter 9: Floors and Floor Coverings

Overview

This is an exceptionally detailed chapter that covers a vast range of flooring systems, from basic utility floors to highly specialized industrial and decorative finishes. The chapter is meticulously structured into five parts, each dealing with a specific category of flooring material. The overarching principle of the chapter is to guide the selection of an appropriate flooring system based on its intended use, considering factors like durability, wear resistance, chemical resistance, aesthetics, ease of maintenance, and cost. It emphasizes that the success of any flooring system is critically dependent on the proper preparation of the sub-floor or base concrete.

Key Standards and Codes Referenced

- Brick Flooring: IS 5766:1970 (Burnt clay brick flooring), IS 10440:1983 (Reinforced brick floors).
- Concrete Flooring & Tiles: IS 1237:1980 (Cement concrete flooring tiles), IS 2571:1970 (Laying in-situ cement concrete flooring).
- Industrial & Chemical Resistant Floors:
  - IS 4971:1968: Recommendations for selection of industrial floor finishes.
  - IS 4457:1982: Ceramic unglazed vitreous acid-resistant tiles.
  - IS 4860:1968: Acid-resistant bricks.
  - IS 4832 (Parts 1-3): Specifications for chemical resistant mortars (Silicate, Resin, Sulphur types).
- Special Floors: IS 658:1982 (Magnesium oxychloride), IS 1196:1978 (Bitumen mastic), IS 1197:1970 (Rubber floors), IS 4631:1986 (Epoxy resin floor toppings), IS 5318:1969 (Flexible PVC sheet and tile).
- Timber Floors: IS 3670:1989 (Timber-boarded floor), IS 5389:1969 (Hardwood parquet).

Technical Specifications - CRUX & IMPORTANT INFORMATION

Part 1: Brick Floors

- Crux: A durable and cost-effective solution for areas with heavy wear, like godowns and platforms. Its success depends entirely on a stable, well-compacted base.
- Key Specifications:
  - Bricks: For heavy duty floors, use heavy duty bricks to IS 2180 or IS 3583.
  - Base: A base concrete layer is essential. For heavy duty, this should be 150 mm thick. For light duty, 75 mm thick.
  - Mortar: Bedding mortar should be no leaner than 1:4 cement mortar for heavy duty floors.

Part 2: Cement Concrete Floors

- Crux: The most common type of flooring. The primary challenge and critical factor for success is ensuring a permanent bond between the structural base and the wearing surface (topping). De-bonding is the most common failure mode.
- Key Concepts:
  - Monolithic Finish (Type I): The topping is laid within hours while the base concrete is still green (plastic). This creates the best possible bond. Panel dimensions can be larger, up to a max of 4 m.
  - Bonded Finish (Type II): The topping is laid on a hardened, cured base. This requires careful surface preparation (hacking, cleaning) to achieve a

bond and is more prone to failure. Panel dimensions must be smaller, with a max of 2 m.

- Terrazzo Finish:
  - Crux: A decorative, multi-stage process where the aesthetic outcome depends on meticulous execution of the grinding and polishing sequence. Rushing this process or using incorrect materials will result in a poor finish.
  - Key Specifications:
    - Layers: Consists of a base, an underlayer (1:2:4 concrete), and the terrazzo topping.
    - Grinding Sequence: This is a non-negotiable, multi-step process. 1st grind (60 grit) -> Grout -> Cure -> 2nd grind (80 grit) -> Grout -> Cure -> 3rd grind (120-150 grit) -> Final Polish with oxalic acid powder. Skipping steps or curing times will ruin the finish.
- Concrete Tiles:
  - Crux: The entire system relies on a rigid, stable sub-floor. Any movement or cracking in the base will telegraph through to the tiles, causing them to crack or de-bond.
  - Key Specifications:
    - Bedding: 10-30 mm thick layer of 1:6 cement mortar.
    - Joints: To be kept as close as possible, typically 1.5 mm wide.
    - Curing: Floor must be kept moist for 7 days for light traffic, and heavy traffic is not allowed for at least 14 days.

Part 3: Industrial Floor Finishes

- Crux: Selection is based on matching the floor's properties to the specific industrial hazard (e.g., impact, abrasion, chemicals, temperature). The selection tables (9.6 & 9.7) are the core of this section.
- Key Selection Criteria:
  - Heavy Impact/Abrasion: Use Steel/Cast Iron Tiles or grids embedded in granolithic concrete.
  - Chemical Resistance: Use Epoxy Resin Toppings or Acid-Resistant Bricks/Tiles with the appropriate chemical-resistant mortar. Standard concrete is not suitable for acidic environments.
  - Non-Sparking: For explosive environments, use Magnesium Oxychloride floors or rubber.

Part 4: Special Floors and Floor Coverings

- Crux: This section covers high-performance or decorative finishes. For almost all types, success is dictated by substrate preparation. The base must be perfectly dry, clean, and smooth. The correct adhesive must be used.

- Key Specifications:
    - Magnesium Oxychloride: A non-sparking floor, but it is highly sensitive to moisture and must not be used in damp locations.
    - Bitumen Mastic: Provides a seamless, waterproof, and resilient surface. Thickness ranges from 20 mm to 25 mm.
    - Chemical Resistant Mortars:
        - Silicate Type: Good for most acids, but not resistant to alkalis or water.
        - Sulphur Type: Good for acids, but very poor resistance to alkalis.
        - Resin Type (Epoxy, etc.): Offer the broadest range of resistance but are the most expensive and require skilled application.

Part 5: Timber Floors

- Crux: The primary concern is preventing decay due to moisture. Adequate and permanent cross-ventilation of the sub-floor space is the most critical design requirement to prevent dry rot.
- Key Specifications:
    - Support: Timber joists are supported on honey-combed dwarf walls to allow for airflow.
    - DPC: A damp-proof course must be laid on top of the dwarf walls, below the timber wall plates.
    - Ventilation Gap: There must be a clear air gap between the underside of the joists and any ground/filling below.
    - Joints: Floor boards should be tongued and grooved.

Visual Elements Analysis

Figures 9.2, 9.3, 9.4, 9.5, 9.6: Concrete Floor Construction

Description: A series of diagrams illustrating the fundamental difference between monolithic and bonded concrete floor toppings, both on the ground and on suspended slabs. Technical Details:

- Monolithic (Fig 9.2, 9.4): Clearly shows the topping layer being laid directly on the "green" or plastic base concrete, forming a single, integrated slab. This is structurally superior.
- Bonded (Fig 9.3, 9.5): Shows the topping laid as a separate layer on top of a hardened base. It highlights the two-layer application (under-layer and wearing layer) often used for high-quality finishes.
- Cushioning Layer (Fig 9.6): Shows a topping laid over a lime concrete cushioning layer on a structural slab. This is used to achieve correct levels or to separate the

finish from structural movements. Relationship to Text: These figures are essential for understanding the critical construction difference between monolithic and bonded systems, which dictates panel size, thickness, and performance.

Figures 9.9 & 9.10: Industrial Flooring Tiles

Description: These diagrams show two types of heavy-duty metal flooring used in industrial settings.

- Fig 9.9 (Steel Flooring Tiles): Illustrates a typical "anchor plate" type steel tile, which is a shallow tray with punched grips. Crux: The text and drawing imply that these must be completely filled with the bedding concrete to prevent the thin steel from bending under load.
- Fig 9.10 (Honeycomb Cast Iron Tiles): Shows a cast iron tile with a tapered honeycomb structure. This design provides excellent mechanical keying with the bedding mortar and is extremely durable. Construction Notes: These visuals explain flooring systems designed for the most severe impact and abrasion, common in dairies or heavy workshops.

Figures 9.17-9.21: Timber Floor Construction

Description: A set of drawings detailing the construction of timber floors.

- Fig 9.17 (Basement Timber Floor): This is a key diagram. It shows the floorboards on joists, which are supported by honey-combed dwarf walls. It explicitly labels the DPC on top of the dwarf wall and the air gap below the joists for ventilation. This illustrates the fundamental principle of preventing rot.
- Fig 9.19 & 9.20 (Double and Triple Joisted Floors): These show the structural framing for upper-level timber floors. They introduce Binders and Girders to support the bridging joists over longer spans, creating a more rigid and stable floor structure.

BOQ Implications

- Unit of Measurement: Almost all flooring and covering types are measured per square metre (m^2). The BOQ must clearly state the material, thickness, and number of coats/layers.
- Cost Factors:
  - Base Preparation: A major, often hidden, cost. Hacking old concrete, applying bonding agents, or laying a lean concrete base are separate billable items.
  - Material Type: Cost varies dramatically, from low-cost brick-on-edge to high-cost chemical-resistant epoxy toppings or parquet flooring.

    - Labor:
        - Standard Finishes (Concrete, Tiles): Standard skilled labor rates.
        - Specialized Finishes (Terrazzo, Epoxy, Parquet): Requires highly skilled, specialized applicators at a premium rate. The multi-stage process for terrazzo (grinding, curing, grouting) is particularly labor-intensive.
- Waste Factor: Rebound in shotcrete (Part 4, though not flooring) and cutting of tiles/boards for patterns should be factored into material quantities.

Part 6: Chapter 10: Wall and Ceiling Finishes and Coverings and Walling

Overview

This comprehensive chapter details the application of various interior and exterior finishes to walls and ceilings, as well as the construction of specific types of non-structural walls. The chapter is divided into two main parts:

- Part 1: Covers Wall and Ceiling Finishes and Coverings. It provides in-depth specifications for traditional plaster finishes (lime, cement), external renderings, stone and concrete facings, and various board-based wall coverings. The critical theme throughout this part is background preparation and ensuring compatibility between the substrate and the finish to prevent defects like cracking, de-bonding, and efflorescence.
- Part 2: Covers Walling. It details the construction of specialized wall types, including traditional reed walling and modern gypsum block partitions and no-fines concrete walls, often used for their lightweight or insulating properties.

Key Standards and Codes Referenced

- Plaster & Renderings:
    - IS 1661:1972: Code of practice for cement and cement-lime plaster finish.
    - IS 2394:1984: Code of practice for lime plaster finish.
    - IS 2402:1963: Code of practice for external rendered finishes.
- Facings & Coverings:
    - IS 4101 (Parts 1, 2, 3): Code of practice for external facings and veneers (Stone, Concrete, Tile/Mosaics).
    - IS 1414:1989: Code of practice for fixing of wall coverings.
    - IS 5390:1984: Code of practice for construction of timber ceiling.
- Walling Materials:

    - IS 4407:1967: Code of practice for reed walling.
    - IS 2849:1983: Specification for gypsum partition blocks.
    - IS 12727:1989: Code of practice for no-fines in-situ concrete.
- Fixing Devices: IS 1946:1961 (Use of fixing devices in walls, ceilings and floors).

Technical Specifications - CRUX & IMPORTANT INFORMATION

Part 1: Wall and Ceiling Finishes and Coverings

- Background Preparation (Crux of Plastering): The success of any plaster or render finish depends almost entirely on the condition of the background surface.
    - Bond/Key: Joints in masonry must be raked out to a depth of at least 12 mm to provide a mechanical key. Smooth concrete surfaces must be hacked or treated with a bonding agent.
    - Suction Control: The background must be dampened before plastering, but not soaked. Excessive suction will draw water out of the plaster too quickly, making it weak and friable. Insufficient suction will cause the plaster to slide.
    - Drying: The background masonry or concrete must be allowed to complete its initial drying shrinkage *before* plastering begins; otherwise, the plaster will crack.
- Plaster & Render Coats:
    - Thickness (Table 10.1):
        - Single Coat Plaster: 10 to 15 mm.
        - Two-Coat Plaster: Backing coat 10 to 12 mm; Finishing coat 3 to 8 mm.
        - Three-Coat Plaster: Base coat 10 to 15 mm; Second coat 3 to 8 mm; Finishing coat 3 to 5 mm.
    - Mix Proportions: The mix for each successive coat should never be richer in cement than the coat to which it is applied. This prevents the stronger outer coat from cracking as the weaker undercoat shrinks.
- External Facings & Veneers (Stone/Concrete):
    - Fixing (Crux): Thin stone or precast concrete panels are anchored to the backing wall using non-corrodible metal cramps. These cramps must be designed to handle both the weight of the panel and any wind loads.
    - Types of Fixing:
        - Supporting Cramps: Transfer the weight of the facing unit to the backing structure.
        - Restraining Cramps: Only hold the unit in position against lateral forces, while the weight is supported by the unit below.

- Wall Coverings (Boards):
    - Crux: Boards (gypsum, fibreboard, plywood) must be fixed to a true and stable framework (studs). Joints between boards are a critical detail and must be treated correctly to avoid being visible in the final finish.
    - Fixing Spacing (Table 10.5): Provides maximum spacing for supports and nails/screws for different board types and thicknesses. For example, for 12.5 mm gypsum board, supports can be at 500 mm centres, with edge nails at 100-150 mm and centre nails at 150-200 mm.

Part 2: Walling

- Reed Walling: A traditional lightweight construction method.
    - Construction: Reeds (like *Ekra* or *Sarkanda*) are tied with galvanized wire to form boards, or are placed individually into grooves in a timber frame. The wall is then plastered on both sides.
- Gypsum Block Partitions:
    - Crux: Lightweight, fire-resistant blocks used for non-load-bearing partitions. They are highly susceptible to damage from moisture.
    - Key Specifications:
        - Mortar: A gypsum-based mortar is used (1 part gypsum to 3 parts fine aggregate).
        - Joints: Should be as thin as possible. Vertical joints must be reinforced with mesh if required for stability (Fig 10.26).
        - Crack Control: Edges of partitions must be isolated from the main structure using resilient packing to accommodate differential movement (Fig 10.29).
- No-Fines Concrete Walls:
    - Crux: A lightweight concrete made using only coarse aggregate and cement paste. The large interconnected voids give it good thermal insulation but low strength.
    - Key Specifications:
        - Mix Proportions (Table 10.7): Typically 1 part cement to 8-12 parts aggregate.
        - Handling: Cannot be compacted by vibration. Must be placed carefully and rodded.
        - Fixing: It is impractical to nail into no-fines concrete. All fixings must be cast-in during construction.

Visual Elements Analysis

Figure 10.1 & 10.7: Fixing Facings with Cramps

Description: These diagrams are fundamental to understanding how heavy external cladding panels are safely attached to a building. Technical Details:

- Fig 10.1: Shows a matrix of possible cramp arrangements (side, top, bottom, or combinations). This allows the designer to choose a fixing method based on panel size, shape, and structural requirements.
- Fig 10.7: A more detailed view showing the different types of cramps and how they connect to the backing wall and the facing panels. It illustrates side cramps, top/bottom cramps, and combined systems, providing a visual vocabulary for specification. Construction Notes: The crux here is ensuring a secure, non-corrosive, and durable connection that can accommodate differential movement between the facing and the backing wall. The choice of cramp type is a critical design decision.

Figure 10.9 & 10.10: Precast Concrete Facing Joints

Description: These diagrams illustrate different types of joints used between precast concrete facing panels. Technical Details:

- Joint Types: Shows Butt joints, single Joggle joints, double Joggle joints, and Grouted joints. The diagrams clearly illustrate the geometry of each joint type.
- Fig 10.9D (Grouted Joint): This is a key detail. It shows a void being created between two panels, which is then filled with grout. This type of joint, along with embedded cramps, stabilizes the entire facing system. Construction Notes: The type of joint selected affects the ease of installation and the overall stability and weather-tightness of the facade. Joggle joints provide mechanical interlock, while grouted joints provide monolithic action.

Figure 10.12 & 10.13: Fixing Board Coverings

Description: These two figures show the standard method for fixing lightweight boards to a timber frame.

- Fig 10.12 (Gypsum Board): Illustrates the use of a "Reinforcing Scrim Cloth" over the joint between two boards, which is then covered by "Gypsum Plaster or Filling Material". This is the standard "tape and joint" method.
- Fig 10.13 (Fibreboard): Shows boards fixed to a timber frame with studs and horizontal sheathing. It provides critical nail spacing information: 150 to 200 mm c/c at the edges and 75 mm c/c in the field of the board. Construction Notes: The main purpose of these fixing details is to prevent cracks from appearing at the joints between boards due to movement. The scrim provides tensile strength across the joint.

Figure 10.26 & 10.29: Gypsum Block Partition Details

Description: These are critical diagrams for the correct installation of gypsum block partitions.

- Fig 10.26: Shows vertical steel bars (12 mm dia) being placed in the core holes of the blocks at a vertical joint and grouted in place. This provides reinforcement against cracking at the joint.
- Fig 10.29: Illustrates various methods of Edge Isolation. It shows a "Resilient Packing" or a "Wooden Fillet" being placed in the gap between the top of the partition and the structural slab/beam above. Construction Notes: The isolation joint (Fig 10.29) is absolutely critical. It prevents the structural slab from deflecting and imposing load onto the non-load-bearing gypsum partition, which would otherwise cause the partition to crack or crush. This is a common point of failure if not executed correctly.

BOQ Implications

- Plastering/Rendering: Measured per square metre (m²). The rate depends on:
    - Number of coats (one, two, or three).
    - Mix proportion (cement-rich mixes are more expensive).
    - Background preparation (hacking concrete is an extra-over item).
- External Facings: Measured per m². This is a high-cost item. The BOQ must specify:
    - The type and thickness of stone/concrete panel.
    - The type, material (e.g., gun metal), and spacing of cramps.
- Board Linings: Measured per m². The BOQ should include the cost of the timber/metal framework, the board itself, and the specified joint treatment (taping, skimming, etc.).
- Specialized Walling:
    - Gypsum Block Partitions: Measured per m². The rate includes the blocks, special gypsum mortar, and any required reinforcement or isolation joints.
    - No-Fines Concrete: Measured per m³. The rate must account for the specialized forming and the impracticality of post-fixing, meaning all services must be planned and cast-in.
    -

Part 7: Chapter 11: Roofs and Roofing

Overview

This chapter provides an exhaustive guide to a wide variety of roofing systems prevalent in Indian construction, ranging from traditional methods to more modern composite and prefabricated systems. The chapter is structurally divided into five parts based on the roof type: Flat Roofs, Sloping Roofs, Shell Roofs, Mud Phuska Finish, and Thatched Roofs. The core principle of this chapter is to detail the specific materials, construction sequences, and critical design parameters for each system to ensure structural integrity, weather-proofing, and durability. Special attention is given to layering, overlaps, joints, and the use of appropriate mortars and aggregates.

Key Standards and Codes Referenced

- Materials:
    - Bricks: IS 1077:1992 (Common), IS 2690 (Parts 1 & 2):1992/1993 (Terracing Tiles).
    - Cement, Lime, Aggregate: IS 269, IS 455, IS 1489 (Cement); IS 712:1984 (Lime); IS 383:1970 (Sand/Aggregate); IS 3068:1986 (Broken Brick Aggregate); IS 1344:1981 (Pozzolana).
    - Steel: IS 805:1968 (Joists), IS 432 (Part 1):1982 (Tie Rods), IS 277:1992 (Galvanized Steel Sheets).
    - Tiles: IS 654:1992 (Mangalore Tiles), IS 1464:1992 (Ridge/Ceiling Tiles).
    - Asbestos Cement (AC) Sheets: IS 459:1992.
    - Timber: IS 3629:1986 (Structural Timber), IS 883:1970 (Design), IS 1141:1993 (Seasoning).
- Fixings:
    - Nails & Screws: IS 723:1972 (Nails), IS 1120:1975 (Coach Screws).
    - Hook Bolts: IS 730:1978.
- Design & Construction Practice:
    - Concrete: IS 456:1978 (RCC Design), IS 1343:1980 (Prestressed Concrete).
    - Shell Roofs: IS 2204:1962, IS 6332:1984.
    - Waterproofing: IS 1322:1993 (Bitumen Felt), IS 7193:1974 (Glass Fibre Felt).

Technical Specifications - CRUX & IMPORTANT INFORMATION

Part 1: Flat Roofs

- Jack-Arch Type Roof:

    - Crux: A composite system where brick arches span between steel joists, with their thrust counteracted by steel tie rods. The system's strength comes from the combined action of the brick arch and the overlying lime concrete.
    - Key Specifications:
        - Arch Rise (Z): Must be between 1/6 to 1/8 of the span (X).
        - Joist Spacing (X): Not to exceed 2 m. Joists must have a minimum concrete cover of 40 mm.
        - Brickwork: Laid in 1:4 cement mortar or equivalent lime mortar.
        - Lime Concrete Topping: Laid to an initial thickness of 75 mm and consolidated to a final thickness of 60 mm.
- Brick-Cum-Concrete (Madras Terrace):
    - Crux: A traditional, durable, and waterproof flat roof where terracing bricks are laid on edge in diagonal rows, creating a flat arch action. This is overlaid with lime concrete.
    - Key Specifications:
        - Bricks: Special terracing bricks to IS 2690. Must be soaked for at least 4 hours before use.
        - Laying: Bricks laid in 1:1.5 lime putty:sand mortar. Mortar joints must not be less than 10 mm.
        - Lime Concrete Layer: 1:2.5 (slaked lime:aggregate) mix, spread to 100 mm and consolidated to 75 mm by hand-beating for at least 7 days.
- Roofs with Joist and Filler Blocks (Hollow Concrete/Clay):
    - Crux: A semi-prefabricated system using precast concrete joists with lips, upon which hollow filler blocks are placed. A structural concrete topping is then cast in-situ, creating a composite T-beam floor that is lighter than a solid slab and requires no major shuttering.
    - Key Specifications:
        - Concrete Grade: M15 for topping and precast joists.
        - Topping Thickness: Designed thickness, with a minimum of 50 mm.
        - Reinforcement: Critical for composite action. Minimum 0.15% steel along joists and 0.20% across joists. Bar spacing not to exceed 300 mm.

Part 2: Sloping Roofs

- Wooden Shingle Roof:
    - Crux: Relies on a three-course overlap system for water-tightness. Proper ventilation is essential to prevent rot.
    - Overlap: Minimum overlap must be one-third of the shingle length.

    - Side Gap: A gap of 3 to 6 mm must be left between adjacent shingles in a course to allow for expansion when wet.
- Roofing with Mangalore Tiles:
    - Crux: An interlocking tile system. The roof pitch and reeper spacing are critical for proper function.
    - Pitch: Must be between 24° and 45°.
    - Fixing: Reepers (battens) are nailed to rafters. Tiles are interlocked and may be tied down with galvanized wire in windy areas.
- Sloped Roof Covering - Slating:
    - Crux: Slates are fixed with nails to reepers. The 'lap' (the distance the upper slate overlaps the slate two courses below) is the key to waterproofing.
    - Fixing: Two nails per slate, fixed through holes 3.75 cm from the top edge.
- Corrugated Sheets (GI and AC):
    - Crux: Fixing must be done at the crown of the corrugation, never in the valley, to prevent leakage. Proper lapping is essential.
    - Key Specifications:
        - End Lap: Minimum 150 mm.
        - Side Lap (GI): Minimum 2 corrugations.
        - Side Lap (AC): Half a corrugation.
        - Hole Diameter: Should be 2 mm larger than the bolt diameter to allow for thermal movement.
        - Fixing Bolt: Must use a bitumen felt washer under a G.I. washer to seal the hole.

Calculations and Formulas

- Jack-Arch Rise Calculation:
    - Formula: `Z = (1/6 to 1/8) * X`
    - Variables:
        - `Z` = Rise of the arch.
        - `X` = Spacing of joists (span of the arch).
- Dead Load Calculation for Mangalore Tiled Roofs:
    - Method: The dead load is not a single value but is specified based on the construction method and roof pitch.
    - Values:
        - Tiles embedded in mortar: 110 kg/m² (for rise/span of 1/4 to 1/2).
        - Tiles with flat tiles, no mortar: 80 kg/m² (for rise/span of 1/4 to 1/3).
        - Mangalore tiles alone: 90 kg/m² (for rise/span of 1/4 to 1/3).
- Purlin Spacing for Galvanized Steel Sheet Roofing:

- Method: The maximum spacing of purlins depends on the thickness of the steel shee

Purlin Spacing for Galvanized Steel Sheet Roofing:

  - **Method**: The maximum spacing of purlins depends on the thickness of the steel sheet.

  - **Values**:

    | Thickness of Steel Sheet (mm) | Maximum Spacing of Purlins, c/c (m) |

    | :--- | :--- |

    | 1.00 | 2.0 |

    | 0.80 | 1.8 |

    | 0.63 | 1.6 |

- **Fixing Bolt Length Calculation for AC Sheets**:

  - **Formula 1 (J-bolt/Crank bolt)**: `Length = Purlin Depth + 75 mm` (for single sheet) or `+ 90 mm` (for double sheet/ridges).

  - **Formula 2 (Coach Screw)**: Minimum length = **110 mm**.

Visual Elements Analysis

Figure 11.1: Typical Details of Jack-Arch Floor or Roof Construction

Description: A plan and section view showing the complete assembly of a jack-arch roof. Technical Details:

- Plan View: Shows the parallel arrangement of Steel Joists and the perpendicular Tie Rods that connect them. Spacing `X` (joists) and `Y` (tie rods) are indicated.
- Section View: This is the critical view. It shows the brick arch springing from the bottom flange of the steel joists. The Tie Rod is clearly visible, positioned to counteract the outward thrust from the arch. The arch is covered by a Levelling Course of Broken Brick Aggregate Concrete, which is then topped by the Roof Finish. Construction Notes: This drawing clearly illustrates the structural principle. The tie rod is not optional; it is an essential tension member without which the joists would be pushed apart and the arches would collapse.

Figure 11.9: Precast Concrete Joists and Hollow Filler Block Flooring and Roofing

Description: An isometric cutaway view showing a composite floor system using precast elements. Technical Details: The diagram shows Precast Reinforced/Prestressed Concrete Joists with a distinct 'T' shape. Hollow Blocks (concrete or clay) are placed between the joists, resting on the extended lower flange (the "lip"). A layer of Structural Concrete is cast over the top, embedding the top of the joists and forming a monolithic topping. Construction Notes: This visual is crucial for understanding semi-prefabricated construction. It shows how the system creates a series of parallel T-beams, where the precast joist is the stem and the in-situ topping acts as the flange, working together to carry the load. This method significantly reduces on-site formwork.

Figure 11.16: Typical Detail Showing Roofing with Wooden Shingles

Description: Plan, section, and detail views of a wooden shingle roof. Technical Details: The Enlarged Section XX is the most important part. It clearly shows the three-layer overlap principle.

- Overlap: A shingle of total length `L` is shown with an Exposed Length of L/3. The remaining 2L/3 is overlapped by the two courses above it.
- Fixing: The diagram shows 2 Wire Nails used to fix each shingle to the Wooden Battens. The battens themselves are fixed to the main Wooden Rafter. Construction Notes: This detail visually explains why this type of roofing is waterproof despite being made of individual small elements. The 1-in-3 exposure and the offset joints between courses create a tortuous path that prevents water penetration.

Figure 11.28: Fixing Details of Steel Sheets

Description: A detailed view of the fixing of a corrugated steel sheet to a purlin using a hook bolt. Technical Details: This diagram shows:

- A J or L Hook Bolt hooking around the Purlin.
- The bolt passing through the crown (the highest point) of the sheet corrugation.
- The sealing assembly on top of the sheet, consisting of a Bitumen Washer below a Limpet Washer (a dished metal washer), all secured by a Nut.
- The 150 mm overlap for the end lap is also dimensioned. Construction Notes: This drawing illustrates a critical "best practice" detail. Fixing through the crown ensures that rainwater flows away from the bolt hole, minimizing the risk of leaks. Fixing in the valley would cause water to pool around the hole, leading to inevitable leakage. The bitumen washer acts as a compressible gasket to seal the hole.

BOQ Implications

- Measurement: Most roofing systems are measured per square metre (m²) of the roof area (for flat roofs) or sloped area (for pitched roofs).
- Cost Drivers:
  - Labor vs. Material: Traditional systems like Madras Terrace are highly labor-intensive but use cheaper materials. Prefabricated systems (filler blocks) have higher material costs but are faster to install, saving on labor and formwork.
  - Supporting Structure: The cost of the roofing material (e.g., GI sheets) is only part of the total cost. The cost of the supporting structure (rafters, purlins, trusses) must be accounted for separately.
  - Complexity: Jack-arch roofs require skilled masons and steelworkers. Shell roofs are highly specialized and expensive.
- Specific BOQ Items:
  - Jack-Arch Roof: Can be a composite item per m², specifying all components, or broken down into structural steel (per tonne), tie rods (per tonne), brickwork (per m²), and lime concrete (per m³).
  - Mangalore Tiles: Measured per m², specifying the type of under-layer (flat tiles, ceiling tiles, or none).
  - Sheet Roofing: Measured per m², specifying the material (GI, AC) and thickness. The BOQ must also include line items for fixings (hook bolts, screws per number) and accessories (ridges, flashings per linear meter).

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    - Pitch: Must be between 24° and 45°.
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- Sloped Roof Covering - Slating:
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    - Key Specifications:
        - End Lap: Minimum 150 mm.
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Calculations and Formulas

- Jack-Arch Rise Calculation:
    - Formula: `Z = (1/6 to 1/8) * X`
    - Variables:
        - `Z` = Rise of the arch.
        - `X` = Spacing of joists (span of the arch).
- Dead Load Calculation for Mangalore Tiled Roofs:
    - Method: The dead load is not a single value but is specified based on the construction method and roof pitch.

○ Values:

Construction Method	**Rise/Span Ratio**	**Dead Load (kg/m²)**
Tiles embedded in mortar	1/4 to 1/2	110

Tiles with flat tiles, no mortar	1/4 to 1/3	80
Mangalore tiles alone	1/4 to 1/3	90

- Purlin Spacing for Galvanized Steel Sheet Roofing:
  - Method: The maximum spacing of purlins depends on the thickness of the steel sheet.
  - Values: | Thickness of Steel Sheet (mm) | Maximum Spacing of Purlins, c/c (m) | | :--- | :--- | :--- | | 1.00 | 2.0 | | 0.80 | 1.8 | | 0.63 | 1.6 |
- Fixing Bolt Length Calculation for AC Sheets:
  - Formula 1 (J-bolt/Crank bolt): `Length = Purlin Depth + 75 mm` (for single sheet) or `+ 90 mm` (for double sheet/ridges).
  - Formula 2 (Coach Screw): Minimum length = 110 mm.

Visual Elements Analysis

Figure 11.1: Typical Details of Jack-Arch Floor or Roof Construction

Description: A plan and section view showing the complete assembly of a jack-arch roof. Technical Details:

- Plan View: Shows the parallel arrangement of Steel Joists and the perpendicular Tie Rods that connect them. Spacing `X` (joists) and `Y` (tie rods) are indicated.
- Section View: This is the critical view. It shows the brick arch springing from the bottom flange of the steel joists. The Tie Rod is clearly visible, positioned to counteract the outward thrust from the arch. The arch is covered by a Levelling Course of Broken Brick Aggregate Concrete, which is then topped by the Roof Finish. Construction Notes: This drawing clearly illustrates the structural principle. The tie rod is not optional; it is an essential tension member without which the joists would be pushed apart and the arches would collapse.

Figure 11.9: Precast Concrete Joists and Hollow Filler Block Flooring and Roofing

Description: An isometric cutaway view showing a composite floor system using precast elements. Technical Details: The diagram shows Precast Reinforced/Prestressed Concrete Joists with a distinct 'T' shape. Hollow Blocks (concrete or clay) are placed between the joists, resting on the extended lower flange (the "lip"). A layer of Structural Concrete is cast over the top, embedding the top of the joists and forming a monolithic topping. Construction Notes: This visual is crucial for understanding semi-prefabricated construction. It shows how the system creates a series of parallel T-beams, where the precast joist is the stem and the in-situ topping acts as the flange, working together to carry the load. This method significantly reduces on-site formwork.

Figure 11.16: Typical Detail Showing Roofing with Wooden Shingles

Description: Plan, section, and detail views of a wooden shingle roof. Technical Details: The Enlarged Section XX is the most important part. It clearly shows the three-layer overlap principle.

- Overlap: A shingle of total length `L` is shown with an Exposed Length of L/3. The remaining 2L/3 is overlapped by the two courses above it.
- Fixing: The diagram shows 2 Wire Nails used to fix each shingle to the Wooden Battens. The battens themselves are fixed to the main Wooden Rafter. Construction Notes: This detail visually explains why this type of roofing is waterproof despite being made of individual small elements. The 1-in-3 exposure and the offset joints between courses create a tortuous path that prevents water penetration.

Figure 11.28: Fixing Details of Steel Sheets

Description: A detailed view of the fixing of a corrugated steel sheet to a purlin using a hook bolt. Technical Details: This diagram shows:

- A J or L Hook Bolt hooking around the Purlin.
- The bolt passing through the crown (the highest point) of the sheet corrugation.
- The sealing assembly on top of the sheet, consisting of a Bitumen Washer below a Limpet Washer (a dished metal washer), all secured by a Nut.
- The 150 mm overlap for the end lap is also dimensioned. Construction Notes: This drawing illustrates a critical "best practice" detail. Fixing through the crown ensures that rainwater flows away from the bolt hole, minimizing the risk of leaks. Fixing in the valley would cause water to pool around the hole, leading to inevitable leakage. The bitumen washer acts as a compressible gasket to seal the hole.

BOQ Implications

- Measurement: Most roofing systems are measured per square metre (m²) of the roof area (for flat roofs) or sloped area (for pitched roofs).

- Cost Drivers:
    - Labor vs. Material: Traditional systems like Madras Terrace are highly labor-intensive but use cheaper materials. Prefabricated systems (filler blocks) have higher material costs but are faster to install, saving on labor and formwork.
    - Supporting Structure: The cost of the roofing material (e.g., GI sheets) is only part of the total cost. The cost of the supporting structure (rafters, purlins, trusses) must be accounted for separately.
    - Complexity: Jack-arch roofs require skilled masons and steelworkers. Shell roofs are highly specialized and expensive.
- Specific BOQ Items:
    - Jack-Arch Roof: Can be a composite item per m^2, specifying all components, or broken down into structural steel (per tonne), tie rods (per tonne), brickwork (per m^2), and lime concrete (per m^3).
    - Mangalore Tiles: Measured per m^2, specifying the type of under-layer (flat tiles, ceiling tiles, or none).
    - Sheet Roofing: Measured per m^2, specifying the material (GI, AC) and thickness. The BOQ must also include line items for fixings (hook bolts, screws per number) and accessories (ridges, flashings per linear meter).

Chapter 12: Damp-Proofing and Waterproofing

Overview

This chapter provides critical guidelines for protecting buildings from moisture. It makes a clear distinction between two key functions:

- Damp-Proofing: Preventing the movement of moisture from the ground into the structure, primarily by capillary action.
- Waterproofing: Preventing the penetration of liquid water, either from precipitation (roofs) or from hydrostatic pressure (basements, reservoirs).

The chapter is divided into two parts covering these functions and details the materials and application methods for various treatments, including bitumen-based systems, lime concrete, and polyethylene films. The fundamental principle is the creation of a continuous, unbroken barrier at all potential points of moisture ingress.

Key Standards and Codes Referenced

- General Preparatory Work: IS 3067:1988.
- Bitumen-Based Materials:

    - IS 1322:1993: Bitumen felts for waterproofing and damp-proofing.
    - IS 7193:1974: Glass fibre base bitumen felts.
    - IS 1580:1991: Bituminous compounds for waterproofing.
    - IS 3384:1986: Specification for bitumen primer.
    - IS 702:1988: Specification for industrial bitumen (blown type).
    - IS 5871:1987: Bitumen mastic for tanking and damp-proofing.
- Lime Concrete & Waterproofing Compounds:
    - IS 2541:1991: Code of practice for preparation and use of lime concrete.
    - IS 2645:1975: Specification for integral cement waterproofing compounds.
- Underground Structures: IS 6494:1988 (Waterproofing of underground water reservoirs).

Technical Specifications - CRUX & IMPORTANT INFORMATION

Part 1: Damp-Proofing

- Crux: The creation of a continuous horizontal and/or vertical barrier (DPC) to stop capillary rise of moisture. The integrity of the laps and junctions is paramount.
- Bitumen Felt Treatment: The system is built up in layers. The level of treatment depends on the expected severity of conditions.
    - Below Ground Level (Basements):
        - Normal Treatment: 2 layers of felt.
        - Heavy Treatment: 3 layers of felt.
        - Extra Heavy Treatment: 4 layers of felt.
    - Application Rate (Hot Bitumen): A bonding layer of hot blown bitumen at a rate of 1.5 kg/m² is applied between each layer of felt.
    - Primer: A bitumen primer is applied to vertical faces at a rate of 0.27 l/m².
- Bitumen Mastic Treatment:
    - Crux: A thick, jointless material applied hot, which forms a dense, impermeable barrier.
    - Application Thickness:
        - Above Ground (Walls/Floors): Minimum 10 mm in one coat.
        - Below Ground (Vertical/Steep Slopes): Minimum 20 mm in three coats.
        - Below Ground (Horizontal/Flat Slopes): Minimum 30 mm in three coats.

Part 2: Waterproofing

- Crux: To create a robust, weather-resistant barrier, especially on roofs. The treatment of junctions, projections, and drainage outlets is where most systems fail if not executed correctly.
- Lime Concrete Waterproofed Finish:
    - Mix: Lime concrete is made waterproof by careful proportioning and the addition of pozzolana.
    - Compaction: The key to impermeability is thorough compaction. The layer is laid to an initial thickness (e.g., 100 mm) and then hand-beaten with *Thapis* for at least 7 days until it is consolidated (e.g., to 75 mm) and the beater rebounds readily.
    - Curing Solution: The surface is sprinkled with a special solution during compaction.
        - Recipe: 3 kg of jaggery and 1.5 kg of *Bael* fruit boiled in 100 litres of water.
- Bitumen Felt Treatment for Roofs:
    - Crux: A multi-layer system where the number of layers ("courses") determines the level of protection.
    - Treatment Levels:
        - Normal Conditions (~50 cm rainfall): 5 Courses (Primer, Bitumen, Felt, Bitumen, Gravel).
        - Severe Conditions (50-150 cm rainfall): 7 Courses (Adds one more layer each of felt and bitumen).
        - Extra Heavy Conditions (>150 cm rainfall): 9 Courses (Adds a third layer each of felt and bitumen).
- Polyethylene Film Treatment:
    - Material: Must be ultraviolet stabilized. Water vapour transmission not to exceed 5.53 g/24h/m².
    - Bonding: Bonded to the substrate with hot applied bitumen (0.70 kg/m² min) and covered with a cold cutback bitumen (1.0 kg/m²).
    - Laps: Minimum lap width is 100 mm at both ends and sides. Laps must be sealed with cold cutback bitumen.

Visual Elements Analysis

Figure 12.6 & 12.7: Damp-Proof Treatment for Basements

Description: These two diagrams are a masterclass in basement "tanking". They show how a continuous damp-proof membrane is enveloped by protective structural layers. Technical Details:

- Sequence (Crux):

i. An outer protective wall is built first.
ii. The vertical damp-proof membrane is applied to the inner face of this outer wall.
iii. The main structural wall is cast against the membrane.
iv. The horizontal membrane is laid over the base slab.
v. The inner protective screed/wall is constructed.

- Fig 12.6 (External Tanking): Shows the standard method where there is space to excavate. The DPC membrane is applied to the *exterior* of the structural wall.
- Fig 12.7 (Internal Tanking - "Alternate"): Shows the method for confined spaces. The DPC membrane is applied to the *interior* of the structural wall. A crucial detail is the space between the outer protective wall and the DPC, which is later grouted solid with cement to ensure the DPC is fully supported against external hydrostatic pressure. Construction Notes: The key principle is that the waterproof/damp-proof membrane must always be fully supported on a rigid substrate and protected from puncture by a subsequent layer.

Figure 12.9: Waterproofing Treatment of Junction on Roof and Parapet Wall

Description: This figure shows the critical detail of how a roof's waterproofing membrane is terminated at a parapet wall to prevent leaks at this common failure point. Technical Details:

- Chase: A groove, min. 65 mm deep, is cut into the parapet wall.
- Angle Fillet: A 75 mm x 75 mm cement mortar or bitumen fillet is formed at the junction of the roof and the wall. This prevents the felt from being bent at a sharp 90° angle, which would crack it.
- Tucking: The waterproofing felt is carried up the wall and tucked securely into the chase.
- Sealing: The chase is then filled with 1:4 cement mortar to seal the edge of the felt permanently. Construction Notes: This detail is of paramount importance. Without the angle fillet and the chase, the membrane would fail at the junction due to differential movement and stress concentration, leading to guaranteed leaks.

Figure 12.21: Bitumen Mastic Skirting to Brick Wall

Description: This diagram shows how to achieve a good key for applying bitumen mastic to a vertical brickwork surface. Technical Details: The drawing explicitly shows the mortar joints in the brickwork being raked out. This creates a physical, mechanical key for the bitumen mastic to adhere to. Without this, the mastic would likely fail to bond to the smooth face of the bricks. A 50 mm metal tack is also shown for additional support.

BOQ Implications

- Measurement: All treatments (felt, mastic, film) are measured per square metre (m^2). The BOQ description must be highly specific, detailing:
  - The material (e.g., "7-course waterproofing with bitumen felt...").
  - The location and orientation (e.g., "on vertical surfaces," "on roofs," "in basements").
- Cost Components:
  - Material: Cost varies significantly with the number of layers. A 9-course treatment has nearly double the material and labor cost of a 5-course treatment.
  - Labor: Application of hot bitumen is a skilled and hazardous job, demanding higher labor rates.
  - Preparatory Work: Chasing, hacking, forming angle fillets, and surface cleaning are all separate, measurable items that add to the cost.
  - Associated Items: Protective screeds or walls are measured separately (e.g., concrete in m^3, brickwork in m^2).

Chapter 13: Joints in Buildings

Overview

This chapter deals with the critical, and often overlooked, aspect of managing structural movement. The central theme is that all buildings move due to thermal and moisture changes, and instead of trying to prevent this movement (which is impossible), structures must be designed to accommodate it in a controlled manner. This is achieved through the correct design, location, and installation of various types of joints. The chapter provides the 'why' (causes of movement) and the 'how' (joint types and details).

Technical Specifications - CRUX & IMPORTANT INFORMATION

- Types of Joints and Their Functions:
  - Expansion Joint (Crux): A complete separation through the structure to accommodate expansion and contraction. It is filled with a compressible filler and an elastic sealant.

    - Contraction Joint: A formed or sawn groove in concrete that creates a plane of weakness, forcing shrinkage cracks to occur in a neat, straight line.
    - Construction Joint: A simple butt joint where one concrete pour stops and another begins. Keyed or dowelled for shear transfer.
- Spacing of Expansion Joints (Table 13.1): This table is the core design guide of the chapter.
    - Crux: The spacing is the most critical decision. If joints are too far apart, uncontrolled cracks will form. If too close, it adds unnecessary cost and complexity.
- Key Values:

Structure/Condition	**Maximum Spacing of Expansion Joints**
Load-bearing masonry walls	30 m
Unprotected thin RCC roof slabs	15 m
Protected RCC roof slabs (with insulation/mud phuska)	20 to 30 m
Framed structures (L, T, H, C shapes)	At corners and at 30 m intervals

- Joint Materials:
    - Joint Filler (IS 1838): Compressible material placed in the joint gap (e.g., bitumen-impregnated fibreboard). Must regain at least 75% of its original thickness after compression.

- Sealing Compound (IS 1834): Flexible, weatherproof material applied to the exposed face of the joint to prevent water ingress (e.g., polysulphide, polyurethane).
- Waterbar: A continuous strip of rubber, PVC, or metal cast across a joint below grade to provide a positive waterproof seal against hydrostatic pressure.

Visual Elements Analysis

Figure 13.1, 13.2, 13.3: Types of Waterbars

Description: These diagrams show the cross-sectional profiles of various waterbars. Technical Details:

- PVC/Rubber (Fig 13.1, 13.2): Show dumbbell and ribbed profiles. The key feature is the central hollow bulb. This bulb is designed to deform and accommodate the opening and closing of the joint without tearing the waterbar, thus maintaining the seal.
- Metallic (Fig 13.3): Shows various folded shapes, typically made of copper. The 'V' or 'U' shaped folds serve the same purpose as the bulb in a PVC waterbar—they allow for movement. Construction Notes: The waterbar is cast halfway into the first concrete pour. The other half projects out and is cast into the second pour, creating a continuous barrier across the joint. This is a critical component for any water-retaining structure or deep basement.

Figure 13.4 & 13.5: Expansion Joint Details

Description: These diagrams provide the fundamental construction details for expansion joints in walls and roofs. Technical Details:

- Core Components: Both drawings show the same core assembly:
    i. A structural gap.
    ii. A compressible Joint Filler filling most of the gap.
    iii. A flexible Sealing Compound applied in a prepared groove at the exposed surface.
- Fig 13.5A (Roof Joint): This is a critical detail. It shows an RCC Precast Tile bridging the joint. One side of the tile is mortared down, while the other side rests on a bitumen filler, allowing it to slide as the roof slab expands and contracts. This detail provides a walkable surface while accommodating movement. Construction Notes: These details illustrate the two primary functions of an expansion joint: accommodating movement (via the filler) and preventing weather ingress (via the sealant).

Figure 13.12: Expansion Joints at Twin Columns

Description: This figure shows the ultimate form of an expansion joint in a large framed structure. Technical Details: Instead of a simple gap, the drawing shows two separate columns placed side-by-side, each supporting its own section of the building. The gap between the columns is then treated as a standard expansion joint with filler and sealant. Construction Notes: This is the only structurally sound way to create a true separation in a large, continuous frame. It allows entire sections of the building to settle or move independently without transferring stress to the adjacent section.

BOQ Implications

- Measurement: Expansion and contraction joints are measured by linear meter (m).
- Cost Components: This is a composite item with several parts:
  - Forming the Gap: Labor and formwork to create the void.
  - Joint Filler: Cost of the fibreboard or other specified filler per meter.
  - Sealing Compound: Cost of the polysulphide or other high-performance sealant per meter. This is often a high-cost material.
  - Waterbar: Cost of the PVC, rubber, or copper waterbar per meter. This can be a very significant cost, especially for metallic waterbars.
- Structural Cost: In framed buildings, the decision to include an expansion joint often necessitates the construction of twin columns and twin beams, which can nearly double the structural cost at that location. This major cost implication must be considered during the design phase.

Part 9: Chapter 14: Whitewashing, Colour Washing & Painting, & Chapter 15: Painting, Varnishing & Allied Finishes

Chapter 14: Whitewashing, Colour Washing and Painting of Masonry, Concrete and Plaster Surfaces (Calcareous Surfaces)

Overview

This chapter provides detailed procedures for applying traditional and modern paint finishes to alkaline surfaces such as plaster, concrete, and masonry. The chapter is divided into two parts. Part 1 covers traditional, low-cost finishes like whitewashing and colour washing. Part 2 deals with the application of modern paints. The crux of this entire chapter is the understanding and management of the substrate. The performance of any paint system on these surfaces is almost entirely dependent on proper background preparation, suction control, and moisture management.

Key Standards and Codes Referenced

- Lime & Whitewash: IS 712:1984 (Fat Lime, Class C), IS 6278:1971 (Code of practice for whitewashing).
- Paints & Distempers:
    - IS 427:1965: Dry distemper.
    - IS 428:1969: Oil bound distemper.
    - IS 5410:1992: Cement paint.
    - IS 5411 (Parts 1 & 2): Plastic emulsion paint.
    - IS 109:1968: Ready mixed paint, brushing, priming, plaster.
- Pigments & Additives: IS 44:1991 (Iron Oxide Pigments), IS 55:1970 (Ultramarine Blue), IS 261:1982 (Copper Sulphate).

Technical Specifications - CRUX & IMPORTANT INFORMATION

Background Preparation (The Most Critical Step)

- Moisture: The background (wall/plaster) must be allowed to dry thoroughly. Painting over a damp background is the primary cause of failure (blistering, peeling, saponification).
- Alkalinity: New lime and cement plaster are highly alkaline and will saponify (turn to soap) oil-based paints. The surface must be allowed to carbonate and neutralize over several months, or an alkali-resistant primer must be used.
- Suction: The porosity of the plaster must be managed. High or variable suction will cause the paint to dry unevenly, leading to patchiness. A primer or sealer coat is used to equalize suction.
- Efflorescence: White, salty deposits on the surface must be dry-brushed off, never washed with water, as washing can dissolve the salts and draw them back into the plaster. A persistent efflorescence problem indicates a deeper moisture issue that must be resolved before painting.
- Mould/Fungi: Must be physically removed and the surface sterilized with a fungicidal wash before painting.

Materials & Mixes

- Whitewash Preparation:
  - Base: Fat lime (Class C to IS 712) slaked on site.
  - Additives (Crux):
    - Gum (Adhesive): 1 kg of gum dissolved in hot water per cubic meter of lime cream.
    - Salt (Hardener): 1.3 kg of sodium chloride per 10 kg of lime to aid carbonation and create a harder, more rub-resistant finish.
- Colour Wash: Prepared by adding lime-fast mineral pigments (e.g., oxides) to the whitewash base.

Application

- Whitewash/Colour Wash: Applied with a *Moonj* brush in a specific pattern: one stroke top-to-bottom, one bottom-to-top, followed by one left-to-right and one right-to-left before the wash dries. This ensures even coverage. A minimum of two coats is required for new work.
- Painting Schedules (Table 14.1 & 14.2): These tables are the core of the painting section, providing a systematic guide for building up a paint system.
  - System: A paint finish is a multi-coat system, typically: Primer -> Undercoat -> Finishing Coats.
  - Primer: The first coat, designed to adhere to the substrate, seal it, and provide a key for subsequent coats. The type of primer is critical and depends on the substrate and the type of finish coat (e.g., alkali-resistant primer for oil paint on new plaster).
  - Undercoat: Provides the "build" and colour foundation for the finish coat.
  - Finishing Coat(s): Provides the final colour, texture (matt, gloss), and weather resistance. Typically two coats are applied.

Visual Elements Analysis

This chapter contains no figures, but the tables are the key visual elements.

Table 14.1 & 14.2: Schedules for Painting New Calcareous Surfaces

Description: These tables provide a matrix of recommended painting systems for interior and exterior surfaces. They are a crucial reference for specifiers and contractors. Technical Details:

- Columns: Final Finish Required, Primer Coat, Under Coat, Finishing Coats.
- Example System (Interior Gloss Paint):
  - Final Finish: Gloss Paint (IS 133).
  - Primer: One coat of alkali-resistant primer.

    - Undercoat: One coat of undercoat, with filler applied as required after priming.
    - Finish: Two coats of Gloss Paint. Relationship to Text: These tables synthesize all the principles discussed in the chapter into a practical, step-by-step specification for a variety of common paint finishes.

BOQ Implications

- Measurement: All painting and washing works are measured per square metre (m^2).
- BOQ Description: The description must be very specific and state:
    - The number of coats (e.g., "Applying two coats of...").
    - The type of paint/wash (e.g., "oil bound distemper," "plastic emulsion paint").
    - The surface it is applied to (e.g., "on new plastered surfaces").
- Crucial Cost Factor: Preparation: Surface preparation is a separate, measurable item that is critical for a good finish and is often underestimated. The BOQ must include line items for:
    - "Preparing surfaces previously painted": This includes scraping, sanding, and removing old, loose paint. Measured per m^2.
    - "Preparing new surfaces": Includes brushing down and cleaning. Measured per m^2.
    - Specialist Treatments: Application of fungicidal wash or treatment for heavy efflorescence are also separate billable items.

Chapter 15: Painting, Varnishing and Allied Finishes (Wood and Metals)

Overview

This chapter details the finishing of non-calcareous surfaces, specifically wood and metal. It is divided into three parts: Finishing of Wood, Painting of Ferrous Metals, and Painting of Non-Ferrous Metals. The crux for this chapter shifts from managing substrate moisture and alkalinity to ensuring adhesion and preventing corrosion.

Key Standards and Codes Referenced

- Wood Finishing:

    - IS 2338 (Parts 1 & 2):1967: Code of practice for finishing of wood.
    - IS 348:1968: French polish.
    - IS 524:1983: Varnish.
- Metal Painting & Pretreatment:
    - IS 6005:1970: Code of practice for phosphating of iron and steel. (Crux for ferrous metal prep).
    - IS 1477 (Parts 1 & 2):1971: Code of practice for painting of ferrous metals in buildings.
    - IS 2524 (Parts 1 & 2):1968: Code of practice for painting of non-ferrous metals in buildings.
- Primers: IS 3536:1966 (Wood Primer), IS 2074:1992 (Red oxide-zinc chrome primer).

Technical Specifications - CRUX & IMPORTANT INFORMATION

Part 1: Finishing of Wood and Wood-Based Materials

- Crux: The primary purpose of the finish is to control the rate of moisture exchange between the wood and the atmosphere, thus enhancing dimensional stability and preventing defects.
- Preparation:
    - Sanding: Wood must be sanded smooth *with the grain*. Sanding across the grain leaves scratches that will be highlighted by stain or varnish.
    - Knotting: Resinous knots must be sealed with two coats of shellac knotting to prevent resin from bleeding through and discolouring the final paint film.
- Clear Finishes (Varnish, Polish):
    - Staining: Applied to enhance or alter the natural colour of the wood before the protective clear coats are applied.
    - Sealing: A sealer coat (often diluted varnish or shellac) is applied after staining/filling to prevent the stain from "bleeding" into the top coats.
- French Polish: A traditional high-gloss finish created by applying multiple thin layers of shellac dissolved in methylated spirit with a special pad (*rubber*). This is a highly skilled, labor-intensive process.

Part 2: Painting of Ferrous Metals

- Crux: The absolute priority is corrosion prevention. This is achieved by completely removing all rust and mill scale before applying a protective primer. Painting over rust is the most common cause of failure.
- Surface Preparation: This is the most important step.

    - Mechanical Cleaning: Chipping, scraping, and wire brushing. For complete removal of mill scale, sand-blasting or shot-blasting is the only truly effective method.
    - Chemical Cleaning: Pickling with acids (sulphuric, hydrochloric) to remove rust and scale in a factory setting.
    - Phosphating (IS 6005): A chemical pretreatment process that deposits a layer of phosphate crystals on the steel surface. This provides excellent corrosion resistance and an ideal key for paint adhesion. It is the preferred factory treatment.
- Painting System:
    - Primer: Must be an anti-corrosive primer (e.g., red oxide, zinc chromate). At least two coats of primer should be applied.
    - Shop vs. Site: Pretreatment and priming are best done under controlled factory conditions ('shop coat'). Site work should be limited to cleaning, touching up damaged areas, and applying the finishing coats.

Part 3: Painting of Non-Ferrous Metals

- Crux: The primary challenge is not corrosion (as these metals are inherently resistant) but adhesion. Many non-ferrous metals (like aluminum and galvanized steel) have a smooth, chemically passive surface to which paints do not bond well.
- Pretreatment:
    - Galvanized Steel: Best practice is to allow it to weather for about three months to form a stable, slightly roughened surface of zinc oxides. If immediate painting is required, it must be degreased and treated with an etching primer (wash primer).
    - Aluminum: Must be thoroughly degreased and either mechanically abraded (sanded) or chemically treated with an etching primer.

Visual Elements Analysis

This chapter contains no figures. The key information is conveyed through the detailed procedural descriptions and the schedules in Table 15.1 and 15.2.

Table 15.1 & 15.2: Schedules for Finishing New Woodwork (Interior & Exterior)

Description: These tables provide systematic finishing schedules for wood, similar to the painting schedules in Chapter 14. Technical Details: They lay out the sequence of coats for various finishes.

- Example (Exterior Oil Gloss):
    - Primer: One or two coats of wood primer (e.g., IS 102).

    - Filler: Applied after priming, as needed.
    - Undercoat: One coat of exterior undercoat (e.g., IS 3536).
    - First Finishing Coat: One coat of exterior oil gloss paint (e.g., IS 3531).
    - Second Finishing Coat: Second coat of the same. Relationship to Text: These tables serve as the definitive specification guide for achieving a durable and aesthetically pleasing finish on woodwork, summarizing the principles of priming, filling, and building up coats.

BOQ Implications

- Wood Finishing: Measured per m².
    - BOQ Description: Must specify the type of finish (e.g., "Two coats of synthetic enamel paint over a coat of primer...", "French polishing...").
    - Crux for Costing: The level of preparation dictates the cost. A high-gloss French polish finish requires far more labor (sanding, filling, multiple applications) than a simple two-coat paint finish.
- Metal Painting: Measured per m².
    - Crux for Costing: The cost is dominated by surface preparation.
        - Standard Preparation: "Preparing and painting steelwork" might include simple wire brushing.
        - High-Performance Preparation: BOQ items for sand-blasting or phosphating will have a much higher unit rate and must be specified separately.
    - BOQ Items:
        - "Preparing and applying one coat of red oxide zinc chromate primer..."
        - "Preparing and applying two coats of synthetic enamel paint..."
        - Rates should be different for structural steel, railings, gates, etc., due to complexity.

Part 10: Chapter 16, 17, 18, and Referred Standards

Chapter 16: Water Supply and Drainage

Overview

This chapter covers the fundamental principles and practices for plumbing systems within a building's property lines. It is divided into three parts:

- Part 1: Water Supply, covering materials, conveyance, and distribution from the municipal main to the fixtures.
- Part 2: Building Drainage, covering the safe removal of waste water, sewage, and storm water.
- Part 3: Special requirements for systems in high-altitude or sub-zero temperature regions.

The crux of this chapter is the prevention of contamination and the assurance of a safe, functional system. This is achieved through the elimination of cross-connections, proper trapping and venting, and correct pipe sizing and gradients.

Key Standards and Codes Referenced

- General & Design:
    - NBC, 1983: National Building Code of India.
    - SP 35 (S&T):1987: Handbook on water supply and drainage.
    - IS 1172:1993: Basic requirements for water supply, drainage and sanitation.
    - IS 2065:1983: Code of practice for water supply in buildings.
- Pipes:
    - Cast Iron: IS 1536:1989, IS 1537:1976.
    - Mild Steel: IS 1239 (Part 1):1990.
    - Asbestos Cement: IS 1626 (Part 1):1991.
    - Plastics: IS 4985:1988 (PVC), IS 4984:1987 (HDPE).
    - Stoneware: IS 651:1992 (Glazed stoneware pipes).
- Drainage & Sanitation:
    - IS 4111 (Part 1):1986: Code of practice for ancillary structures in sewerage system: Part 1 Manholes.
    - IS 5329:1983: Code of practice for sanitary pipe work above ground.

Technical Specifications - CRUX & IMPORTANT INFORMATION

Part 1: Water Supply

- No Cross-Connection (The Golden Rule):
    - Crux: The most critical principle of safe water supply. There shall be no physical connection whatsoever between a pipe carrying potable (drinking) water and a pipe carrying non-potable water.

    - Implementation: The system must be protected from backflow by ensuring a definite air gap at all appliances and tanks. The air gap must be equal to twice the nominal bore of the inlet pipe, and in no case less than 150 mm.
- Pipe Installation:
    - Underground: Service pipes must be laid at a depth of not less than 0.75 m to protect from traffic loads and frost.

○ Support Spacing (Table 16.1): This table is critical for preventing pipe sagging. Spacing depends on material and diameter.

Pipe Material		**Horizontal Spacing (m)**	**Vertical Spacing (m)**
Lead		2.0	3.0
Copper (Heavy)		2.5	3.0

Cast Iron		2.0	2.0
Plastic		0.75	1.5 x Horizontal Spacing

- Note: The significantly closer support spacing for plastic pipes is a critical detail often missed, leading to sagging pipelines.

Part 2: Building Drainage

- Pipe Gradients:
  - Crux: Gradients must be sufficient to achieve a self-cleansing velocity (minimum 0.75 m/s) to prevent solids from settling, but not so steep as to cause solids to be left behind by fast-moving liquids (maximum velocity 2.4 m/s).
- Key Gradients:

Pipe Diameter (mm)	**Minimum Gradient for Self-Cleansing Velocity**
100	1 in 57
150	1 in 100

200	1 in 145

- Manholes:
  - Location: Must be provided at every change of alignment, gradient, or diameter.
  - Minimum Internal Size: Depends on depth. For depths > 1.5 m, minimum size is 1.2 m x 0.9 m.
  - Benching: The channels at the bottom of the manhole must be semi-circular and smooth to ensure uninterrupted flow.

Part 3: High-Altitude/Sub-Zero Regions

- Crux: All systems must be protected from freezing.
- Key Specifications:
  - Frost Line: Water supply and drainage pipes must be laid below the frost line (typically 0.9 m to 1.2 m in northern India).
  - Insulation: Pipes that cannot be buried must be thoroughly insulated.
  - Septic Tanks: Must be located well below the frost line. Capacity should be increased by 100% for operation at 10°C compared to 20°C, due to slower biological activity.

Visual Elements Analysis

Figure 16.1: Typical Sketch for Identification of Different Types of Water Supply Pipes

Description: A schematic diagram showing the entire water supply system from the municipal main to the building. Technical Details: The diagram labels all the key components:

- Municipal Water Main
- Ferrule: The connection tapping into the main.
- Communication Pipe: The pipe from the main to the property boundary.
- Stopcock: The main shut-off valve at the boundary.
- Consumer's Pipe (Service Pipe): The pipe from the boundary into the property.
- Underground Storage Tank
- Distributing Pipe: Pipes carrying water within the building. Relationship to Text: This diagram provides a clear visual vocabulary for all the components discussed in Part 1.

Figure 16.2, 16.3, 16.4: Details of Manhole

Description: Detailed section and plan views of manholes for different depths.
Technical Details:

- Benching: The detail view shows the semi-circular channel and the sloped "benching" on either side.
- Brickwork: Shows corbelled brickwork in the access shaft to reduce the size for the cover frame.
- Foot Rungs (Steps): The drawings show the placement and dimensions of cast iron rungs for access. Construction Notes: These drawings are standard details for civil works, crucial for any drainage system. The shape of the benching is critical to ensure smooth flow and prevent the accumulation of solids.

BOQ Implications

- Piping: Measured per linear meter (m), specifying the material (CI, GI, PVC, etc.), diameter, and class.
- Fittings: All fittings (bends, tees, valves, taps) are enumerated and priced per number.
- Excavation & Backfilling: Trench excavation is measured per cubic meter (m^3).
- Manholes: Measured per number, specifying the depth and internal dimensions. The rate is a composite one that includes excavation, concrete base, brickwork, plastering, benching, and the cast iron cover and frame.
- Insulation: Pipe insulation is measured per linear meter (m), specifying the material and thickness.

Chapter 17: Special Construction Procedures — Earthquake Effects, etc

Overview

This chapter provides essential principles and construction details for making normal buildings resistant to earthquakes. It covers masonry, timber, and precast component structures. The crux of the chapter is that earthquake resistance is not about making a building infinitely strong, but about ensuring it has continuity, lightness, and ductility, allowing it to deform and absorb energy without a sudden, catastrophic collapse.

Key Standards and Codes Referenced

- Primary Design Codes:
    - IS 1893:1984: Criteria for earthquake resistant design of structures. (The fundamental code for seismic design).
    - IS 4326:1993: Code of practice for earthquake resistant design and construction of buildings.
- Ductile Detailing: IS 13920:1993: Ductile detailing of reinforced concrete structures subjected to seismic forces. (Critical for ensuring ductility).
- Repair & Strengthening: IS 13935:1993.

Technical Specifications - CRUX & IMPORTANT INFORMATION

- General Principles:
    - Lightness: Earthquake force is a function of mass. Roofs and upper storeys should be as light as possible.
    - Continuity: The building must be tied together to act as a single, integrated unit. This is the most important principle.
    - Ductility: The structure must be able to deform significantly beyond its elastic limit without failing, to dissipate seismic energy.
- Building Configuration:
    - Crux: Simple, symmetrical building shapes are best. Complex shapes (L, T, E, Y) create torsional effects and stress concentrations during an earthquake.
    - Solution: Break up complex shapes into simple rectangular blocks using separation sections (i.e., expansion joints).
- Seismic Strengthening Arrangements (The Core of the Chapter):
    - Horizontal Bands (Crux): Continuous reinforced concrete or reinforced brickwork bands must be provided to tie the walls together.
        - Lintel Band: Provided at the lintel level of all doors and windows. This is the most critical band.
        - Roof Band: Provided immediately below the roof or floor.
        - Gable Band: Provided at the top of gable masonry.
        - Plinth Band: Provided at plinth level if the foundation is on soft soil.
    - Vertical Reinforcement: Steel bars must be placed at all corners and T-junctions of walls, and at the jambs of openings. These bars are anchored into the foundation and tied to the horizontal bands.
- Reinforcement Details (Table 17.4):

Building Category	S	No. of Bars	Dia. of Bar (Deformed)
C	7	2	10 mm
D	7	2	12 mm
E	7	4	10 mm

- Hollow Block Masonry: Vertical reinforcement is placed in the hollow cores of the blocks, which are then grouted solid.

Visual Elements Analysis

Figure 17.3 & 17.4: Overall Arrangement of Reinforcing Masonry Buildings

Description: These two isometric drawings are the key visuals of the chapter, showing how the various strengthening elements work together as a system. Technical Details:

- Fig 17.3 (Flat Roof): Clearly labels the Lintel Band, Roof/Floor Band, and Vertical Bars. It shows the lintel band running continuously over all openings, and the vertical bars at the corners.
- Fig 17.4 (Pitched Roof): Adds the Gable Band and Eave Level (Roof) Band, and shows how trusses are connected to the bands with holding-down bolts. Construction Notes: These figures illustrate the "box action" principle, where the bands act like tension rings and the vertical bars stitch the corners together, forcing the entire masonry structure to act as a rigid, continuous box that can resist lateral seismic forces.

Figure 17.5: Typical Details of Providing Vertical Steel Bars in Brick Masonry

Description: A series of plan-view details showing how vertical reinforcing bars are placed at corners and T-junctions. Technical Details: The diagrams show a pocket being created in the brickwork by leaving out a brick. The vertical bar is placed in this pocket, which is then filled solid with mortar or concrete. Construction Notes: This is a critical detail showing the practical method of incorporating vertical steel into standard masonry construction without requiring special blocks.

Figure 17.6: Reinforcement and Bending Detail in RC Band

Description: Detailed plan and section views of a reinforced concrete band. Technical Details: Shows the placement of longitudinal bars and lateral ties (stirrups).

- Stirrups: Specified as Φ6 mm @ 150 mm c/c.
- Corner Detail (Crux): Shows the longitudinal bars being bent around the corner with a proper radius, not simply lapped. This ensures continuity of tension reinforcement around the entire perimeter.

BOQ Implications

- Seismic Bands: A separate BOQ item measured per linear meter (m). The rate should be a composite one including:
  - Formwork for the band.
  - M15 concrete or 1:3 reinforced brickwork.
  - Reinforcement steel (based on Table 17.4).
- Vertical Reinforcement: Measured per linear meter (m) of bar installed. The BOQ must include the creation of pockets and grouting with concrete/mortar.
- Cost: Seismic strengthening adds a significant cost to standard masonry construction, but it is essential for life safety in seismic zones.

Chapter 18: Demolition of Buildings

Overview

This chapter covers the safety procedures and operational sequences for the demolition of buildings. The crux of this chapter is safety. Demolition is inherently more hazardous than construction, and the chapter emphasizes that all operations must be meticulously planned and executed to prevent accidents, injuries, and damage to adjacent properties.

Key Standards and Codes Referenced

- Safety: IS 3696 (Part 2):1991 (Ladders), IS 2925:1984 (Helmets), IS 4912:1978 (Railings and toe boards).

Technical Specifications - CRUX & IMPORTANT INFORMATION

- Sequence of Demolition (The Golden Rule):
    - Crux: Demolition must always proceed systematically from the top of the building downwards, storey by storey. The demolition of upper floors must be completed before any supporting members on the floor below are disturbed.
- Safety Precautions:
    - Barricading: The area must be conspicuously posted with danger signals and barricaded.
    - Protection of Public: For buildings > 7.5 m high and close to a public sidewalk, a substantial sidewalk shed must be constructed.
    - Catch Platforms: For buildings > 20 m high, catch platforms (min 1.5 m wide) must be installed not more than three storeys below the level of demolition.
- Demolition of Elements:
    - Walls: Must be removed part by part. No section with a height more than 15 times its thickness should be left unsupported.
    - Floors: Should be demolished in strips, with temporary planks and stringers used for support.
    - Jack Arches: The tie rods must not be cut until after the arches and spandrel fill have been removed.

Visual Elements Analysis

Figure 18.1: Typical Sketch of a Sidewalk Shed

Description: An isometric view of a heavy-duty timber structure built over a public sidewalk adjacent to a demolition site. Technical Details: Clearly labels the main components: Posts, Girders, Decking, and protective Planking. Construction Notes: This is a critical temporary works structure designed to protect the public from falling debris. It must be designed to sustain significant impact loads (e.g., 1460 kg/m² if material is stored on it).

BOQ Implications

- Measurement: Demolition is typically measured in one of two ways:

    - As a lump sum for the entire building.
    - Per cubic meter (m^3) of the building volume to be demolished.
- Cost Components:
    - Safety Measures: The cost of barricading, sidewalk sheds, catch platforms, and full-time watchmen is a significant part of the overall demolition cost.
    - Debris Removal: The cost of transporting and disposing of debris is a major line item.
    - Salvage: The value of salvaged materials (steel, timber, bricks) may be credited against the cost of demolition.