

STANDARD TECHNICAL SPECIFICATION

Annex I

3MDG INFRASTRUCTURE INVESTMENT

**CONSTRUCTION OF Multi Drug Resistance Tuberculosis
(MDR-TB) and OPD Facilities in Prisons**

REPUBLIC OF THE UNION OF MYANMAR

S T A N D A R D T E C H N I C A L S P E C I F I C A T I O N S



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CHAPTER 1
INTRODUCTION

1.1 Preliminaries

1.1.1. Pre-Construction Work

The Employer's Representative and Contractor shall carry out a joint condition-in survey. The use of video and/or photography will not be authorized inside prisons premises. A hand sketch description will be required to record the condition of the site upon handover to the Contractor. This will determine the state of the site that the Contractor must hand back upon completion of the works. The prison authorities may be in the position to provide support with photographic records.

The Contractor shall carry out a detailed site set out survey for the works.

A Pre-Construction Meeting will be held between the Employer's Representative and the Contractor to review the following information:

- Condition-in Survey
- Site Survey
- Work Method Statement
- Program
- Schedule of Materials and Installed Equipment

If the Employer's Representative approves the above documentation, then the Contractor will be issued with the Notice to Proceed. If the documentation is incomplete, the Contractor will have 3 calendar days to revise and resubmit the documentation for approval.

The contract period begins on the day the Notice to Proceed is issued.

The Contractor must mobilize on the project site within 7 calendar days of the date of issue of the Notice to Proceed.

1.1.2. Site Restrictions

The contractor shall comply with any restrictions on site area, access or working times as advised by the Employer's Representative. The contractor must obey the security requirements when accessing and leaving the prison. Access to and within the site, use of the site for temporary works and constructional plant, including working and storage areas, location of offices, workshops, sheds, roads and parking, shall be restricted to the areas as agreed with the Employer's Representative.

1.1.3. Occupied areas of site or buildings

The contractor must ensure that the areas where the interventions will take place will have a safe perimeter to divide the construction site from any prisoner's areas.

1.1.4. Protection of persons and property

The contractor shall provide and maintain required barricades, guards, fencing, shoring, , footpaths, signs and lighting at all times during the construction period. The contractor shall not obstruct or damage footpaths, drains and watercourses and other existing services in use on or adjacent to the site. The contractor shall identify the

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location of such services and if damage occurs, shall immediately repair it at the Contractors cost. The contractor shall not damage property which is to remain on or adjacent to the site, including adjoining property encroaching onto the site. If damage occurs, the contractor shall immediately repair it at his own cost.

1.1.5. Existing services

The contractor shall attend to existing services in the working areas if the service is to be continued, repaired, divert or relocate as required and if the service is to be abandoned, cut and seal or disconnect, and make safe. Submit proposals to the Employer's Representative for action for existing services before starting this work.

1.1.6. Adjoining property

For properties which are adjoining to the sites, the Contractor shall inspect the properties with the Employer's Representative and owners and occupants of the properties; make detailed records of conditions existing within the properties, especially structural defects and other damage or defacement; arrange for at least 2 copies of each record, including drawings, written descriptions, and photographs, to be endorsed by the owners and occupants, or their representative , as evidence of conditions existing before commencement of work; submit one endorsed copy of each record to the Employer's Representative. The Contractor shall keep the other endorsed copy for its own record.

1.2. Construction plant

1.2.1. Access

Access route and site access point shall be as shown on the drawings or as agreed by the Employer's Representative.

1.2.2. Use of existing services

Existing services may be used as temporary services for the performance of the contract subject to conditions stated in the **Existing services schedule**.

1.2.3. Contractors Facilities and Work Practices

The Contractor is required to provide adequate toilet and washroom facilities for his staff. These facilities shall be kept clean and serviceable at all times.

The Contractor is required to provide adequate first aid equipment on-site, failure of the Contractor to ensure the availability of first aid equipment on-site will result in an immediate 'stop work' order being issued. All costs and time delays resulting from any such 'stop work' order are entirely the Contractors responsibility.

A site office shall be established by the Contractor at the work site. The location of the site office will be identified by the Employer's Representative to the Contractor. The office shall have a complete set of the contract documents.

The Contractor shall maintain a safe, healthy and tidy worksite at all times and all work activities are to be performed with protective and safety equipment appropriate for the task. The Contractor is entirely responsible

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for workplace safety and unsafe work practices will be identified and recommendations made for revised work methods as appropriate.

1.2.4. Project signboards

If authorized by the prisons authorities, the Contractor shall provide, erect and maintain a signboards at the main entrances to the Site and where instructed by the Employer's Representative. There will be no separate payment for this temporary project sign board.

The boards, with suitable inscription, shall include the name of the Project, the name of the Employer, the name of the Donor, the name of the Client and the name of the Contractor etc. The boards, the layout, colours and dimensions shall be approved by the Employer's Representative, before erection.

The signboards shall be erected not later than twenty-eight (28) days prior to the date of the commencement of the Permanent Works. The Contractor shall remove the signboards at the end of the Defects Liability Period.

1.2.5. Building the works

1.2.5.1. Surveys

Prior to the commencement of any of the works, the Contractor shall carry out a detailed topographic survey of the existing site situation. The Contractor shall set out the lines and levels of the Works according to drawings or approval of the Employer's Representative. Reference pegs and batter rails clearly and indelibly marked with all the relevant information shall be provided clear of the works. These shall be maintained by the Contractor for as long as they are needed to check the work.

1.2.5.2. Contractor's representative

The contractor must employ a suitably experienced person as the Site Manager. This person must be on site during working hours, and fluent in English and technical terminology. The Contractor's Site Manager will have the authority to make all decisions concerning the project.

1.2.6 Completion of the works

1.2.6.1 Final cleaning

Before Practical Completion, the contractor shall clean throughout, including interior and exterior surfaces exposed to view of any carpeted and soft surfaces; debris from the site, roofs, gutters, downpipes and drainage systems; and remove waste and surplus materials.

1.2.6.2 Reinstatement

Before practical completion, the contractor shall clean and repair damage caused by installation or use of temporary work and restore existing facilities used during construction to original condition.

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1.2.6.3 Adjoining property

At practical completion, for properties described in the **Adjoining properties to be recorded schedule**, the contractor shall inspect the properties with the Employer's Representative and owners and occupants of the properties, recording any damage that has occurred since the pre-commencement inspection.

1.2.6.4 Post construction Works

The Contractor shall provide to the Employer's Representative the following documentation after all site construction has been completed:

- Warranty Statement
- Material Test Certificates

Defects inspection survey shall be conducted during defects liability period by the Contractor and Employer's Representative at which defects will be identified. The Employer's Representative will determine if the Contractor is to make repairs or if the damage will be deducted from the Contractor's final invoice.

1.2.6.5 Removal of plant

Within 10 working days after practical completion, the contractor shall remove temporary works and construction plant that are no longer required.

1.2.7 Payment for the works

The cost of all supervision and process control, including testing so carried out by the Contractor, shall be deemed to be included in the rates rendered for the related items of work and no separate payment shall be claimed for this purpose.

The quantities set out in the Bill of Quantities are estimated quantities and are used for the comparison of Tenders and awarding the Contract. It must be clearly understood that only the actual quantities of work done or materials supplied will be measured for payment, and that the quantities may be increased or decreased as provided in the General Conditions of Contract. In computing the final contract amount, payments shall be based on actual quantities only of authorized work done in accordance with the Specifications and Drawings. The tendered rates shall apply, subject to the provisions of the General Conditions of Contract, irrespective of whether the actual quantities are more or less than the billed quantities.

Where no rate or price has been entered against a pay item in the bill of quantities by a tenderer, it shall be understood that he does not require any compensation for such work.

The Contractor shall accept the payment provided in the Contract and represented by the prices tendered by him in the Bill of Quantities, as payment in full for executing and completing the work as specified, for procuring and furnishing all materials, labour, supervision, plant, tools and equipment, for wastage, transport, loading and

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offloading, handling, maintenance, temporary work, testing, quality control including process control, overheads, profit, risk and other obligations and for all other incidentals necessary for the completion of the work and maintenance during the Period of Maintenance.

1.2.8 Compliance with the law

The Contractor is responsible for compliance with all requirements of the laws of the country.

1.3 Inspection and Approval

Unless otherwise instructed by the Employer's Representative, the Contractor shall submit a request and obtain approval for each completed element of the Works and shall not proceed with subsequent elements until approval is granted. The Contractor shall give a minimum of 48 hours' notice in writing to the Employer's Representative to allow any inspection and testing to be carried out. Any approval given by the Employer's Representative shall not relieve the Contractor of any of his obligations under the Contract.

The Contractor shall submit to the Employer's Representative the results of all relevant tests and measurements indicating compliance with the Specification on completion of every part of the work. The contractor shall also request the Employer's Representative for inspection of all processes and materials used in the works.

1.4 Workmanship and Quality control

It is the Contractor's responsibility to produce work, which conforms in quality and accuracy of dimensions to the requirements of the Specification and Drawings. The Contractor must implement his own quality control system with experienced staff, together with all necessary facilities, to ensure adequate supervision and positive control of the Works at all times.

If the Employer's Representative has any doubt concerning the quality of any material to be used in the Works, he shall instruct the Contractor to carry out tests to prove the quality of material before it is used in the Works. The results of tests, which are carried out by the Contractor, shall be submitted to the Employer's Representative on request.

1.5. Tests

The Contractor shall carry out and attend all tests required in this specification. As a minimum, the Contractor shall carry out the following tests:

- Flatness of the sub-base (allowed tolerance is ± 2 cm using the 4 Lm bar test), to be certified on site.
- Flatness of the base of foundations (allowed tolerance is ± 2 cm using the 4 Lm bar test), to be certified on site.
- Testing of the granulometric composition and strength of all aggregates to be used.
- Testing of all concrete in accordance with the regulations and methods as stated in Concrete section of the specification.

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- Upon completion of the electrical installation a test and measurement of the earth reading for the building is to be undertaken. The results of this test are to be certified by a properly qualified electrical Employer's Representative and the results are then to be presented to the Employer's Representative for acceptance.
- Full load testing and commissioning of all components of the electrical system is to be included for the various components of the electrical system. The electrical works will not be approved until the entire system has been successfully tested and signed off in the presence of a suitable qualified UNOPS Employer's Representative.
- The Contractor will supply all necessary appliances and labor for testing of the complete water supply system at such time and as directed by the Employer's Representative. Such testing shall as a minimum require the pressurizing of the complete water supply system to a pressure of not less than 4.5bar. The pipe work and fittings shall retain this pressure for a minimum of 1 hour following the commencement of the test.
- All drains shall be hydraulically tested to a minimum of 1500 mm head and no drains shall be covered up until such test has been made and repeated as necessary until passed to the approval of the Employer's Representative. Access plugs and caps shall be removed, greased, refitted and made sound prior to the final testing.

NOTE: Alternative locally available and used testing methods and regulations may be proposed by the contractor as a part of their bid proposal, but are subject to UNOPS approval and acceptance.

1.6. Manufactured Materials and Components

All manufactured items must be new and be approved by the UNOPS Site Supervisor prior to their purchase and installation. The material provided by the Contractor will be of a suitable quality for the intended purpose. All materials used shall comply with applicable BS or ASTM standards.

Where a specific product or supplier is identified, the Contractor shall interpret the specification to read as stated or of equal quality.

1.7. Materials

Material used shall be the best of its kind. It shall conform to the relevant British Standard, and where such a Standard is not available shall conform to the Local approved standards.

1.8 Water

All water used for mixing concrete, mortar or grout shall conform to BS and be obtained from a source approved by the Employer's Representative. The water shall be fresh, clean and free from acid, alkali, oil, organic impurities, lime in solution or other matter which is deleterious to concrete or steel. In general potable water shall be used.

As a guide, the following concentrations may be taken to represent the maximum permissible limits of deleterious materials in water.

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- Suspended matter - 2,000 mg/litre
- Dissolved matter (max concentration)
- Sodium & Potassium Bicarbonate 1,000 mg/litre
- Sodium Chloride 20,000 mg/litre
- Sodium Sulphate 10,000 mg/litre
- Ca +Mg Bicarbonate as HCO₃ 400 mg/litre
- Calcium Chloride 20,000 mg/litre
- Iron Salts - 40,000 mg/litre
- Sodium Iodate, Phosphate, Arsonate& Borate 500 mg/litre
- HCL + H₂SO₄ - 10,000 mg/litre
- NaOH - 5,000 mg/litre
- pH value of water shall generally be not less than 6.

Sea water shall not be permitted for mixing or curing of concrete.

Water found satisfactory for mixing is also suitable for curing concrete; however, water used for curing shall not produce any objectionable stain or unsightly deposit on the concrete surface. The presence of tannic acid or Iron compounds is objectionable.

The Contractor shall make arrangements for and provide all the water necessary for concrete, mortar, curing or any other purpose on the work.

1.9 Cement

General

Cement shall be from an approved source and shall one of the following types of cement as specified.

Type	In accordance with
Ordinary Portland cement	BS 12
Rapid hardening Portland cement (White Portland Cement) (Colored Portland cement)	BS 12
Portland Blast furnace cement	BS 146
Low heat Portland cement	BS 1370
Sulphate resisting Portland cement	BS 4027
Low heat Portland blast (furnace cement)	BS 4246
Super Sulphated cement	

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Ultra high early strength Portland cement	The requirements for physical properties for ordinary Portland cement
Water Repellent Portland cement	Portland cement
Hydro-phobic Portland cement	BS 12
Masonry cement	BS 12

The initial setting time shall not be less than 45 minutes and the final setting time not more than 10 hours for ordinary Portland cement.

1.9.1 Supply

The cement shall be packed in bags (multiply paper, or cloth)

1.9.2 Transport, Storage and Handling

The cement needed for concrete mortar and grout shall be purchased by the Contractor to suit the construction schedule. He shall make all necessary arrangements and be responsible for transporting, storing and handling it.

Cement shall be stored on the site in such manner as to facilitate identification or inspection of each consignment. The storage sheds shall be of weather proof construction and the floors shall be free from all possibilities of flooding. Chipping up or re-using of partially set cement shall not be allowed. The bags shall be stacked at least 100 to 200 mm clear above floor level over wooden planks and joints. A spacing of 600 mm should be kept between the exterior walls and the stacks. Cement bags shall be placed close together in the stack to reduce circulation of air to the minimum. To avoid lumping under pressure, cement bags shall not be stacked more than 10 bags high. Extra precaution shall be taken during monsoons or when cement is to be stored for unusually long periods; the stack shall be enclosed completely in thick polythene sheet, canvas sheets or any other suitable water proof sheeting, with the flap closing on the top of the stack. Care shall be taken to see that the water proof sheeting, with the flap closing on the top of the stack. Care shall be taken to see that the water proof covering is not damaged at any time during use. When removing cement bags for use the 'first in, first out' rule shall be applied.

In the case of large works, the storage capacity shall be adequate to ensure uninterrupted work in accordance with construction schedule.

Storage of cement at the site of work shall be at the contractor's expense and risk.

1.9.3 Testing of Cement

The employer's representative may extract samples of consignments of cement as and when he desires for the purpose of testing. Testing shall conform to BS 12 for Portland cement and to the relevant

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British standards for other cements. If the sample fails the test, the particular consignment shall be rejected and shall be removed from the site within 24 hours of notice in writing to the contractor to do so. Any consignment of cement stored at site for more than 3 months shall be re-tested if so required by the Employer's Representative.

If the contractor provides the cement, he shall arrange for the cement to be delivered at the site in sufficient time for standard tests to be made before the cement is required for use, or provide certificates of tests from the supplier that will be acceptable to the Employer's Representative.

1.10 Lime

Lime shall be obtained from an approved source; it shall be one of the following types, as per BS depending on the raw material from which it was manufactured,

Type 1 Dolomitic Lime

Type 2 Coral lime* and sea shells

Type 3 Burnt miocene lime stone

Lime which has perished, or which has been damaged by damp, rain, or intermixture of dirt, or which has become partially air slaked shall on no account be used on the works and shall be removed from the site within 24 hours of notice to remove. Lime which gives a residue of more than 10 percent by weight when tested with hydrochloric acid shall be rejected.

The lime stored at the work site shall be protected from weather action, by being kept in a weather proof shed with impervious floor and sides.

1.10.1 Quick Lime

This shall be freshly burnt from good hard coral*, sea shells or limestone broken to a uniform size not exceeding 40mm and carefully freed from earth and other impurities.

The lime shall be delivered at the site of the mortar mill quite fresh, i.e. within 15 days of the date on which it was drawn fresh from the kiln. In cases where compliance herewith is not possible due to seasonal closure of kilns, written permission of the Employer's Representative is necessary before stored slaked lime can be used.

Note : *Government is contemplating the banning of coral lime.*

1.10.2 Hydrated/Slaked Lime

All impurities, ashes or pieces improperly or carelessly burnt shall be screened or picked out before slaking. Quick lime shall be slaked with sufficient water; slaking shall be done neither earlier than three weeks nor later than one week before being put into the mill.

The lime after slaking shall be screened through a sieve of such size as the Employer's representative may direct and all stuff that does not pass through the sieve shall be rejected. For plastering second and third coat or for any fine work, unless otherwise specified, the lime shall pass through a 1.18 mm BS

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Test sieve: for all other work, unless otherwise specified the lime shall pass a 2.36 mm BS Test sieve wire screen.

1.10.3 Lime Putty

Lime putty shall be obtained by treating either quicklime or hydrated lime with sufficient water so as to produce a plastic, sound product.

It shall be sieved to be entirely free from coarse particles and shall be thoroughly matured for not less than 16 hours before use.

1.11 Fine Aggregate for Concrete

This shall be conforming to BS 882: See chapter 4.

1.12 Coarse Aggregate

Coarse aggregate for granolithic floor finishes shall be as specified in Chapter 4.

1.13 Building Sands from Natural Sources

The sand may be naturally occurring like river sand, pit sand or crushed stone sand. It shall generally conform to BS 1198, BS 1199 and BS 1200. It shall be hard, durable, clean and free from adherent coatings such as clay. It shall not contain harmful materials like pyrites, salts, coal or other organic impurities mica, shale or similar laminated materials, or flaky or elongated particles in such a form or in sufficient quantity to affect adversely the hardening, strength or durability of the mortar. In addition to the above, the sand when used for reinforced brick work shall not contain any material which may attack the reinforcement.

The quantity of clay, silt and dust shall not exceed the following unless there is satisfactory evidence to the contrary.

In natural sand - 3 % by mass when determined by the decantation method given in BS 812.

In crushed stone sand - 15% by mass when determined by the sedimentation method given in BS 812.

1.13.1 Grading

Sand for brickwork/stone work/block work and external plastering shall pass completely through a sieve of 2.36 mm. Sand for second and third coats of plastering, pointing and fine work shall completely pass through a 1.18 mm test sieve.

1.14 Methods of Stacking

Materials normally measured in stacks are rough stone of all kinds broken stone and broken

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brick, gravel, sand, and lime. However for purpose of mixing of mortar, concrete etc. materials like sand, broken stone etc. shall be measured in properly constructed measuring boxes (or by weight as instructed by the Employer's Representative) to suit the specified proportions of those materials.

Piles shall be formed of regular shape and uniform cross section.

Materials shall not be stacked on uneven ground or in any manner which does not permit correct and ready measurement from external inspection of the piles.

Rough stone which is to be measured in the stack shall be packed so closely as to give the minimum quantity of voids possible, without actual dressing of the stones to fit the interstices

1.15 Other Materials

Materials not dealt with in this chapter will be specified in the relevant chapters.

CHAPTER 2

SITE PREPARATION, EXCAVATION & EARTH WORK

2.1 Site Work

General

The area described or shown on the relevant site plan or bill of quantities shall be cleared of all obstructions, roots and growth, vegetation of every description, trees and saplings. Unless otherwise specified, 150 mm top soil shall be removed from that part of the site to be occupied by the proposed buildings and for a distance of 3 meters around it and the area leveled. The top soil shall be preserved in stock piles if so directed by the Employer's Representative.

2.1.1 Existing Services

Particulars of over/under ground services shall be obtained from the Employer before commencing any work which may affect such services.

These services shall be maintained/diverted/plugged dismantled as specified or directed. In case the drain ends are required to be sealed off, contaminated earth shall be removed and disinfected as specified.

2.1.2 Demolition of Existing Structures

Where buildings or walls are to be demolished this shall be down to ground level, or the bottom of posts, stanchions, etc. as specified. Special care shall be taken to cause the minimum damage to the materials in the process of dismantling. The value of the materials which in the opinion of the Employer's Representative have been broken or damaged through carelessness on the part of the contractor will be recovered from the contractor. All serviceable materials shall be removed and stacked or disposed of as specified, and all debris shall be carted away by the contractor.

Refer also Chapter 10 - Dismantling & Demolition.

2.1.3 Felling and Removal of Trees

The trees shall be cut only after written permission of the Employer's representative is obtained. The roots of trees shall be removed completely and the hollows filled up with suitable earth in layers of 150 mm leveled and rammed so that the surface at these points conforms to the surrounding area.

Wood, branches of trees and other useful materials shall be handed over to the Employer's Representative. The felled trees shall be cut to such lengths as directed by the Employer's Representative, trunks and branches cleared of limbs and tops and stacked neatly, well away

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from the site of work. Other serviceable materials shall be stacked as directed and handed over to the Employer's Representative.

2.1.4 Disposal of Waste Materials

At the conclusion of the site work, the contractor shall tidy up and leave the site of the work in a clean and sanitary condition. All unserviceable material shall be removed from the area and disposed of as directed. Care shall be taken to see that the unsuitable waste materials are disposed of in such a manner that there is likelihood of these getting mixed up with materials meant for construction.

2.1.5 Waterways

All field drains and other water ways encountered during the excavation shall be temporarily diverted and reinstated, or otherwise taken care of, as directed by the Employer's Representative.

Filling of the location from which water courses have been diverted shall be commenced after clearing away all vegetable growths and soft deposits.

2.2 Excavations

***Note:** The contractor shall visit the site, inspect the trial holes or bores where available, and decide for himself the nature of the ground, subsoil to be excavated and the ground water levels. The furnishing of particulars of trial holes or bores for the information of the contractor does not absolve the contractor from his responsibilities nor does it guarantee that similar conditions apply on other parts of the site.*

2.2.1 Establishment of Levels

2.2.1.1 Bench Marks

A masonry pillar of a suitable design shall be erected at a prominent place in the site to serve as a bench mark for the execution of the work. This bench mark shall be so located that it remains undisturbed till all the works are completed. This shall be connected to a Standard Bench Mark if so directed by the Employer's Representative.

2.2.1.2 Levels

Before any excavation is commenced, the levels of the surface after removal of top soil shall be agreed by the Employer's representative and the Contractor. Such agreement shall be recorded on a drawing showing levels at predetermined intervals, and shall be signed by the contractor and the Employer's Representative. The contractor shall provide all labour and instruments to obtain and record these levels.

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2.2.2 Classification of Soils

Excavation in various types of material shall be classified under the following categories (refer Standard Methods of Measurement) No distinction shall be made whether the material is dry or wet. The decision of the Employer's representative with regard to the classification shall be final.

(a) Soft/Loose Soil

Generally and soil which yields to the ordinary application of pick and shovel, rake or other ordinary digging implements; for example vegetable or organic soils, turf, gravel, sand, silt, loam, clay, peat etc.

(b) Hard/Dense Soil

Generally any soil which requires the close application of picks jumpers or scarifiers to loosen same; for example, stiff clay, gravel and cobble stone.

Note : *Cobble stone is the rock fragment usually rounded or semi rounded having maximum diameter in any direction between 80 mm and 300 mm.*

(c) Mud -A mixture of soil and water in a fluid or weak state.

(d) Soft disintegrated rock (not requiring blasting)

This shall include rock or boulders, which can be excavated by barring, wedging and splitting manually or using pneumatic tools. It shall also include embedded boulders measuring not more than one meter in any one direction.

Note : *The mere fact that the contractor resorts to blasting to loosen the material shall not mean that it will be classified as hard rock.*

(e) Hard rock (requiring blasting)

This shall include all rock occurring in large masses which cannot be removed except by blasting. Hard varieties of rock such as granite with or without veins and secondary minerals which in the opinion of the Employer's representative requires blasting shall be considered as hard rock. Boulders of hard rock larger than one meter in any one direction lying in the overburden and requiring to be blasted for easy and efficient removal shall also be classified as hard rock. Refer clause 2.2.3

(f) Hard rock (blasting prohibited)

For hard rock requiring blasting as described in (e) but where/blasting is prohibited, the excavation has to be carried out by chiseling, wedging or any other agreed method. Refer clause 2.2.3.

(g) Common Excavation

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This shall refer to excavation in all soils except rock requiring blasting with the use of excavating and earth moving machinery.

2.2.3 Blasting

Should rock be met with, in the course of excavation, it must be removed with wedges and levers. Blasting shall not be allowed without the written permission of the Employer's Representative, who must be fully informed by the contractor as to the steps taken by him to safeguard the surrounding property: the contractor shall take all responsibility for any damage or annoyance caused by way of blasting. Blasting operations shall be carried out as per the specifications set out under rock blasting in Section XIV of BSCP 2003.

In soft rock, if the contractor wishes to resort to blasting, he can do so only with the permission of the Employer's Representative, but at no extra cost.

2.2.4 Antiquities and Useful Materials

Any finds such as relics of antiquity, coins, fossils or other articles of value which may be discovered during the excavation work shall be the property of the Employer and shall be delivered to the Employer's Representative.

2.2.5 Protection

Trenches and foundation pits shall be provided with proper caution-signals and marked with red lights at night to avoid accidents.

The contractor shall take adequate protective measures to see that the excavation operations do not affect or damage adjoining structures, services etc.

2.2.6 Reinstatement of Damages during Excavations

All materials, structures, foundations, surfaces etc. affected or damaged during excavation shall be made good by the contractor at no extra cost to the Employer.

2.2.7 Anti-Termite Treatment

The treatment may be pre-constructural or post constructural. Where specified, the work shall be carried out according to standard techniques and practices using chemicals of approved make and concentrations, and as directed by the Employer's Representative.

2.2.8 Stability of Excavation

The methods of excavation shall in every case, be subject to the approval of the Employer's Representative and the contractor shall ensure the stability and safety of the excavation, adjacent structures, services and the works.

The sides of the excavation shall be timbered and shored by a proper method previously approved by the Employer's Representative.

The contractor shall have full responsibility for the stability of the excavations and safety of workmen. If any slip occurs, the contractor shall remove all the slipped material from the excavated pit without payment. If any damage to a built up structure occurs because of the slip the contractor shall make good without any payment.

2.2.9. Excavations for Foundations

Excavation for foundations shall be taken to the natural firm ground and to the depths indicated in the drawings. Specific instructions shall be obtained from the Employer's representative if:

- (1) The natural bearing stratum occurs at a depth less/more than that indicated.
- (2) The nature of the bearing stratum vastly differs in its bearing characteristics.

In the case of sloping site, all work including foundation excavation, construction and backfilling shall be completed at the lower locations before the excavation at the higher location is commenced.

The bed of the excavation shall generally be made horizontal, and stepped in the case of sloping ground or when the bearing stratum requires such stepping.

Excavation for foundation in steeply sloping sites or sites on rock shall conform to drawings specially prepared for the purpose or approved by the Employer's Representative.

(Some guidance notes are given in Appendix 2.A)

Excavations shall be made to the correct profiles and levels shown on the drawings, trimmed to exact shape: and all disturbed material and other debris removed. Excavated material shall not be placed closer than one meter from the outer edge of the excavation.

The bed of the excavation shall be consolidated by watering and ramming. Soft/defective spots shall be dug out and filled with lean concrete or other material as directed by the Employer's Representative. In case any excavation has been made below the level shown or

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required the contractor shall, at his own expense, fill up the excavation to proper level with lean concrete or other material as directed by the Employer's Representative.

Excavations are to be inspected by the Employer's representative and the work approved before any further work or concrete or backfill is laid on them. Concrete or back fill shall be laid as soon as possible after inspection to prevent deterioration due to water or weather. The contractor shall take sufficient precautions against deterioration of excavated surfaces. If surfaces become unsuitable due to water or other causes, deteriorated surfaces shall be removed and replaced with concrete as directed by the Employer's Representative. The above shall be at the contractor's expense if it is caused by negligence or for want of precautions on the part of the contractor.

2.2.10 Disposal of Surplus Materials

All surplus material shall be carried away from the site and dumped at dumping sites selected by the Employer's representative up to the lead specified in the bill of quantities. The Employer's representative may instruct the contractor to dump the excavated materials in regular heaps, bunds, blankets, ripraps with regular slopes as directed and leveled so as to provide natural drainage. As a rule, all softer material shall be laid along the centre of heaps, the harder and more weather resisting materials forming the casing on the sides and top.

2.2.11 Dewatering

The contractor shall provide, maintain and operate sufficient pumping equipment of the required capacity to keep the area of construction free of water from rain, drains, floods springs etc. During the construction period at no extra cost to the Employer.

Method of Dewatering

The contractor shall obtain the written permission of the Employer's representative for the method he would use to keep the excavations free from water, the procedure adopted shall not result in the withdrawal of water/or soil from underneath the foundation of adjacent sites.

2.2.12 Planking and Strutting

Excavation with vertical sides shall be kept supported by planking and strutting which shall be 'close' or 'open' depending on the nature of the soil and the depth of the trench. The support required shall generally conform to section 10 of BS CP 2003.

Guideline to the type and extent of support required is given in Appendix 2B.

Support for trench excavation along a public road shall be of adequate design and to the satisfaction of the Highway Authority.

2.2.12.1 Close Planking and Strutting

Close planking and strutting shall completely cover the sides of the trench, generally with short, upright members called 'poling boards'. These shall be 250 mm x 38 mm in section or as directed by the Employer's Representative. The board shall generally be placed in position vertically in pairs, one board on each side of the cutting.

These shall be kept apart by horizontal walings of strong wood at a minimum spacing of 1200 mm cross struted as approved by the Employer's Representative. The length and girth of the struts shall depend upon the width of the trench.

Where the soil is very soft and loose, the boards shall be placed horizontally against the sides of the excavation and supported by vertical 'walings' which shall be struted to similar timber pieces on the opposite face of the trench.

The lowest boards supporting the sides shall be taken into the ground for a minimum depth of 75 mm. No portion of the vertical side of the trench shall remain exposed.

The withdrawal of the timber members shall be done very carefully to prevent collapse of the trench. It shall be started at one end proceeded with systematically to the other end. Concrete or masonry shall not be damaged while removing the planks. No claim from the contractor shall be entertained, for any timber which timber has been left permanently in position at the request of the Employer's Representative.

2.2.12.2 Open Planking and Strutting

In case of open planking and strutting, the entire side surface of the trench is not required to be covered. The vertical boards of 250 mm x 38 mm shall be spaced sufficiently apart to leave unsupported strips of about 500 mm average width. The detailed arrangement, sizes of the timber and the spacing shall be subject to the approval of the Employer's Representative. In all other respects, open planking and strutting shall comply with the clause 2.2.12.1 for close planking and strutting.

2.3 Filling around Foundations in Pits, Trenches, and Plinths Etc.

No filling in shall be done until the concrete foundations, brick footings etc. have been inspected and approved by the Employer's Representative.

All clods of earth shall be broken or removed. Material for backfilling shall generally be obtained from the soil of excavations but the Employer's representative shall have the option in case of shortage of good selected earth obtainable from excavation, to direct the contractor to get suitable filling materials from other sources.

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As soon as the work in foundations has been accepted and measured, the spaces around the foundation structures in pits and trenches shall be cleared of all debris, brick bats, mortar droppings etc. it shall then be filled with earth in layers not exceeding 150 mm in thickness, each layer being watered, rammed and properly consolidated before the succeeding one is laid. The final surface shall be trimmed and leveled to proper profile.

When the area around the building is to be filled to a height more than 600 mm above the existing ground level the filling inside and outside the building shall be carried out simultaneously in order to relieve the earth pressure on foundation walls. The contractor shall be responsible for making good at his own expense any damage occurring to any part of the building, which in the opinion of the Employer's representative is due to the neglect of this precaution. On no account will sea sand be allowed for any filling.

2.4 Excavation and Banking (or Filling)

2.4.1 Cutting

The work shall be executed true to levels, slope shape and pattern indicated in the plan or as directed by the Employer's Representative. During excavation the natural drainage of the area shall be maintain by the contractor.

Cutting shall be done from top to bottom. Under no circumstances shall undermining be allowed.

All cutting shall be done to the required levels. In case it is taken deeper by the contractor, it shall be brought to the required levels by filling with earth duly consolidated and at contractor's cost. However, in the case of hard work, where blasting operations have been resorted to cutting shall be measured to the actual levels, provided the Employer's representative is satisfied that the contractor has not gone any deeper than was unavoidable.

2.4.2 Filling/Banking

The earth from cutting shall, after approval by the Employer's Representative, be directly used for filling without claim for double handling. Filling shall be done in regular horizontal layers not exceeding 150 mm in depth. The surface of ground which is to receive filling, and having a gradient greater than 1 in 5 shall have horizontal benches cut to match the depths of compacted layers of filling. The earth shall be free from all roots, grass and rubbish and all lumps and clods exceeding 80 mm in any direction shall be broken. Each layer shall be consolidated after breaking all lumps and clods and by ramming. Watering shall be done as directed by the Employer's Representative. Where specified, the top surface of the finally finished area shall be neatly dressed to lines and levels.

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The finished formation levels of filling shall be kept higher than the required levels by making an allowance for future settlement; this may be 10% of the depth of filling in the case of ordinary consolidated fills, and 5% where the consolidation is done by heavy machinery. No allowance need be made when the consolidation is done by heavy machinery under optimum moisture conditions.

2.5 Excavation in Trenches for Pipes, Cables Etc. and Refilling

2.5.1 Cutting

Unless otherwise indicated on the drawings, trench excavation shall be by open cut. Bottom of trenches for laying of pipes, cables, etc shall be accurately graded so that the pipe or cable is uniformly supported along its length.

The excavation for underground services shall not cause instability to the foundations of the buildings. If the excavations encroach in to the stress dispersion zone bounded by the line drawn at an angle * to the horizontal from the nearest lower edge of the building foundations, specific approval of the Employer's representative shall be obtained before commencing work.

* Note: Generally = 45° for stable soils
= 30° for wet clays

2.5.2 Refilling Trenches for Pipes, Cables Etc

Normally the excavated earth shall be used for refilling unless such earth contains de-litigious salts. All clods of earth shall be broken or removed. Where the excavated material is mostly rock, the boulders shall be broken into pieces not larger than 150mm in any direction, mixed with fine material consisting of decomposed rock, lateritic soil or earth as available so as to fill up the voids as much as possible, and then the mixtures used for filling.

Filling in trenches for pipes and drains shall be commenced as soon as the joints of pipes and drains have been tested and passed. Where the trenches are excavated in soil, the filling shall be done with earth on the sides and top of pipes, in layers not exceeding 150 mm watered, rammed, and consolidated, taking care that no damage is caused to the pipe below.

In case of excavation of trenches in rock, the filling up to a depth of 300 mm above the crown of pipe or barrel shall be done with fine material such as earth, lateritic soil or pulverized decomposed rock according to the availability at site. The remaining filling shall be done with boulders or rubble of size not exceeding 150 mm mixed with fine material as available to fill up the voids, watered, rammed and consolidated in layers not exceeding 300 mm. In the event of

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any of the excavated material being deemed unsuitable for filling by the Employer's Representative, the contractor shall provide approved filling material at his own cost.

2.6 Filling under Floors

2.6.1 Earth Filling

The plinth shall be filled with earth placed in layers not exceeding 150 mm each layer watered and consolidated to the satisfaction of the Employer's Representative. The filling shall be to a height at least 75 mm above the final level; after through consolidation it shall be trimmed to the required levels and falls. Flooring work shall not be started until the filling has been inspected and approved by the Employer's Representative.

2.6.2 Sand Filling

The sand shall be clean and free from dust, organic and foreign matter.

Sand filling shall be done in a manner similar to earth filling below floors. Consolidation shall be done by flooding the filling with water. The level of the consolidated sand shall be dressed to the required level or slope. Flooring work shall not be started until the filling work has been inspected and approved by the Employer's Representative.

Appendix 2A

1.0 (a) Isolated footings at different levels

When adjacent isolated footings are to be placed at different levels the distance between the edges shall be such as to prevent undesirable overlapping of stresses and instability to the soil supporting the footing at higher levels.

The clear distance between adjacent footings shall generally be not less than the level difference between neither the two footings nor half the width of the larger footing.

(b) Foundations on slopes

In the case of sloping ground the edge of the footing shall generally not be placed at a horizontal distance from the slope less than twice the width of the footing, nor shall, the stress dispersion line intersect the slope.

(c) Stepped foundations

In the case of a continuous stepped footing on sloping ground, the height of the step and the overlap shall generally be as follows:

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Height of the step – Less than the foundation thickness

Overlap – Greater than 2 times the height of the step or foundation thickness whichever is greater.

2.1 Foundations on Bed Rock

In areas where hard sound rock is available over the whole site at or near ground level, it shall be chipped and the foundation keyed to it to the satisfaction of the Employer's Representative.

In case the rock surface is sloping, dowel rods shall be provided. Generally 16 mm diameter rods dowelled to a depth of 225 in the rock and adequately anchored into the based concrete shall be provided at a spacing of one meter or as directed by the Employer's Representative.

Support Required For Excavations with Vertical Sides

In Uniform Ground

A indicates that no support is required

B indicates that open sheeting should be employed

C indicates that close sheeting or sheet piling should be employed

Type of Soil	Up to 5 ft. (Shallow)	Depth of excavation 5 to 15ft (medium)	Over 15 ft. (deep)
Soft peat	C	C	C
Firm peat	A	C	C
Soft clays and silts	C	C	C
Firm and stiff clays	A*	A*	C

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Loose gravels and sands	C	C	C
Slightly cemented gravels and sands	A	B	C
Compact gravels and sands with or without clay binder	A	B	C
All gravels and sands below water table	C	C	C
Fissured or heavily jointed rocks (shale's, etc)	A*	A*	B
Sound rock	A	A	A

* Open or close sheeting or sheet piling may be required if site conditions are unfavorable.

Note: This table does not apply to complex ground conditions for which reference should be made to the text of BSCB 2003: 1959

Note: Ref : Table 5 of BSCP 2003 : 1959

CHAPTER 3
Mortar

3.1 Lime Mortar

The mortar shall consist of slaked lime and sand, each complying with the respective standards and mixed in the proportions specified.

Lime and sand shall be mixed dry three times on an approved platform of masonry, stone, or wood, then sprinkled with the necessary quantity of water and ground in a mortar mill. The sand and lime shall be mixed only in sufficient quantities for a day's requirements. The mortar shall be raked up continuously during the grinding process, particularly in the angles of the mill. Water may be added as required during grinding, care being taken not to add more water than will bring the mixed materials to the consistency of a stiff paste. The sides of the mill shall be maintained in good order. A satisfactory method of counting the revolutions shall be followed.

All mortar shall be used as soon as possible after grinding. As a rule it shall be used on the day on which it is made, but in no case shall mortar made 72 hours previously be permitted to be used or remain at the site of the work except mortar which is to be ground a second time for plastering work-see below. If hydrated lime is used, the ground mortar shall not be kept unused for more than 25 hours after grinding. In all cases, the mortar shall be kept damp and on no account be allowed to dry. It shall always be protected from the sun and rain. All mortar more than 72 hours old or mortar hardened or set before being used shall be removed from the work site within 24 hours of order to do so, and no second mixing will be permitted.

Mortar for plastering shall be ground a second time after storing in a damp condition for an interval of two days in the case of stone lime, and one week in the case of fat lime so as to ensure thorough slaking. The mortar shall then be used at once.

3.2 Cement Mortar

The mortar shall consist of Portland cement and sand, each complying with the respective standard and mixed in the proportions specified.

Item of work	Cement	Sand
Mortar for masonry	1	5 up to 8 as may be specified
Mortar for plastering	1	3 up to 4 as may be specified (3 for plastering of

		concrete surfaces)
Mortar for pointing	1	3

The Portland cement shall be measured by weight, a bag weighing 50 Kg. being taken as 0.035 m³ and the sand in suitable measuring boxes. Where gauge boxes are used for measurement of cement by volume the gauge box shall be 400mm x 350 mm 290 mm height while the gauge box for sand shall be 400 mm x 350 mm x 250 mm high. The sand shall be measured on the basis of its dry volume. In the case of damp sand, its quantity shall be increased suitable to allow for bulking to be determined by the method given in appendix 4C.

The mixing of mortar shall be done in mechanical mixers unless the Employer's representative permits hand mixing taking into account the nature, magnitude and location of the work.

3.2.1 Machine Mixing

The cement and sand shall be fed into the mixer in the specified proportions and shall be mixed dry. Water shall then be added gradually and wet mixing continued for at least one minute. Care shall be taken not to add more water than will bring the mortar to the consistency of a wet paste. Mixing shall be restricted to such quantities as could be utilized on the work within 30 minutes of mixing.

3.2.2 Hand Mixing

In the case of hand mixing, the measured quantity of sand shall be spread level on a clean dry platform and the cement spread over it. The cement and sand shall be mixed dry three times over. Water shall be added to the mixture only when the mortar is required for use and then only in sufficient quantity to bring the mortar to the consistency of a stiff past.

Cement mortar shall be used up on the works within two hours after mixing. Mortar remaining unused for more than two hours shall be rejected and removed from the work site.

3.3 Lime –Cement -Sand Mortara (i.e.Composite Mortar)

3.3.1 Proportioning

Cement lime putty/dry hydrated lime and sand shall be taken in the proportions specified. Commonly used proportions for internal plastering are 1 cement: 1 lime: 5 sand. In general lime should not be used in external plastering where weather proofing qualities are desired.

3.3.2 Mixing

Lime putty and sand shall be mixed and ground in the manner described in 3.1. In case where factory made dry hydrated lime powder is used prior grinding of lime and sand is not necessary, and mixing may be done in one operation in a mechanical mixer. Only a quantity of this mixture which could be used within two hours of its mixing with cement shall be taken out and mixed thorough with the specified quantity of cement in a mechanical mixer.

3.3.2.1 Hand Mixing

Hand mixing shall be permitted by the Employer's representative after taking into account the nature, magnitude and location of the work, practicability of the use of mortar mill, mechanical mixer etc. or where items involving small quantities are to be done. Cement and sand shall be mixed dry on clean water tight masonry or wooden platforms or in troughs. Lime putty shall be mixed with water to the consistency of milk of lime, which shall be added to the mixture of cement and sand, and the mixture shall be kneaded back and forth for about 10 minutes with addition of milk of lime to obtain mortar of workable consistency.

3.3.3 Precautions

Mortar shall be used within 2 hours after mixing. Mortar unused for more than 2 hours shall be rejected and removed from the work site.

CHAPTER 4
CONCRETE

The concrete shall possess the strength, durability; impermeability and resistance to abrasion required for the proposed structure. It shall be free of such defects as cracking, honey-combing, spalling of the surface, undue shrinkage etc. The concrete shall be good quality and shall be produced with careful control over the batching of materials, water cement ratio etc. Necessary care and attention shall be given to the design and preparation of formwork.

Concrete shall be produced as specified and shall meet the following requirements of each class;

(i) Non structural concrete may be a Volume Batched Mix, satisfying the following:

(i) Proportion of the Constituents by volume

(ii) Maximum size of aggregate

for ex. 1:3:6 (50 mm)

Structural Concrete may be specified as one of the types

(a) Volume Batched Mix satisfying the following:

(i) Proportion of the Constituents by Volume

(ii) Nominal Maximum size of aggregate

(iii) Grade required

for e.g. 1:2:4 (20 mm) of Grade 20.

Testing and acceptance shall be as per clause 5.4.9.2

(b) Prescribed Mix satisfying the following:

(i) The mix required from BS5328, Part 2, and Table 5.

(ii) Grade required

(iii) Nominal Maximum size of aggregate

The composition of the mix shall conform to BS5328 Part 2, Table 5(See Annexure 4 D) with the required field modifications.

Testing and acceptance shall be as per clause 5.4.9.2

(c) Designed Mix satisfying the following

(i) Grade specified

(ii) Maximum size of aggregate

(iii) Minimum cement content in Kg of cement per cubic meter and other requirements if any to ensure durability.

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Testing and acceptance shall be as per BS 5328 Part 3, Clause 3.4.2 or Part 4, Clause 3.16 where the contractor intends to use ready mixes concrete all relevant particulars detailed in BS shall be furnished for the approval of the Employer's Representative.

4.1 Materials

4.1.1 Water

Water shall conform to the specifications in Chapter 1.

4.1.2 Cement

All cement shall be from an approved source and shall comply with the latest revision of the standards noted below;

Type	In accordance with
Ordinary Portland cement	BS 12
Rapid hardening Portland Cement	BS 12
White Portland cement	
colored Portland cement	
Portland Blast furnace cement	BS 146
Low heat Portland cement	BS 1370
Sulphate resisting Portland cement	BS 4027
Low heat Portland Blast furnace cement	BS 4246
Super Sulphated cement	BS 4248
Ultra high early strength Portland cement	The requirements for physical properties for ordinary Portland
Hydro-phobic Portland cement	or BS 12

Note:

- (i) Where cements other than those complying with requirements of BS 12 are used, account shall be taken of their properties and any particular conditions of use.

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- (ii) Where Portland Blast furnace cement complying with BS 146 is used, the slower rate of hardening shall be given due consideration and adequate curing shall be ensured.
- (iii) Super sulphated cements shall not be mixed with any other type of cement.

For storage and other details see Clause 1.2

4.1.3 Aggregates

Aggregates shall be hard and not contain materials such as coal, pyrites, lumps of clay etc. that are likely to decompose or change in volume when exposed to the weather, or affect the reinforcement (where provided). Aggregates with low absorption value shall be used for all concrete that is exposed to the weather or in contact with liquids.

The aggregates shall be free from soft, friable, thin elongated or laminated pieces, coatings of dust, and from clay, alkali, organic or any foreign matter. The contractor shall wash thoroughly all aggregate or any portion of it delivered to the works if so directed by the Employer's Representative.

4.1.3.1 Dense Aggregate

These shall consist of one of the following:

Coarse & Fine Aggregates from Natural Sources (Complying with the requirements of BS 882 Part 2)

Coarse Aggregate

The coarse aggregate shall be crushed stone that is mainly retained on a 5 mm BS 410 test sieve or equivalent, and containing only so much finer material as is permitted. The stone shall be from an approved quarry and shall be clean, sharp, undecomposed gneiss or other approved metamorphic or igneous rock having clean, hard dense and durable fragments.

Note : As the quality of limestone available is variable harder types may be used only if they conform to the tests prescribed in clause 4.1.3.4

Fine Aggregate

Fine aggregate i.e. that mainly passing a 5 mm BS 410 test sieve (or equivalent) and containing only so much coarse material as is permitted shall be:

- (a) Natural sand - obtained from the natural disintegration of rock, i.e. it shall be clean, sharp, river or pit sand free of earth, silt, clay loam carbon, alkali, mica, organic matter and other deleterious substances.

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- (b) Crushed stone sand - the use of this shall be permitted only for designed mixes. Crushed stone sand shall be manufactured from hard tough durable uncoated rock.

4.1.3.2 Special Aggregates

Broken Brick Or Tile

Mass concrete with brick or tile aggregates may be specified when a high resistance to fire is required but not a high degree of impermeability not resistance to abrasion. Where specifically allowed in the plans, the brick or tile aggregate shall be of good quality and approved by the Employer's Representative. The brick shall be free from adhering mortar, plaster of dust and shall not contain soluble sulphates in excess of 1/2 %.

Heavy Aggregate

Steel shots, magnetite and barytes shall be used as specified in high density concrete required for screening radioactive sources where space is limited or for providing high sound insulation between rooms.

Light Weight Aggregate

Where light weight aggregate concrete is specified, natural aggregate such as pumice or artificial lightweight aggregate such as furnace clinker expanded clay, foamed slag. etc. of a quality approved by the Employer's representative and complying with the requirements of BS 3797 shall be used.

4.1.3.3 Storing of Aggregates

All aggregates shall be stored in scrupulously clean conditions as the presence of soil, clay or organic material can seriously impair the strength concrete or inhibit setting. Aggregate storage piles shall be built on hard paved self-draining surfaces in suitable hoppers or bins so as to avoid the inclusion of any foreign matter, soil, clay etc. The aggregates of different sizes shall be kept separate from each other. It is essential that the storage floors be sloped to facilitate drainage. Coarse aggregates shall be delivered to the mixers with the least amount of free moisture and the least amount of variation in free moisture as practicable.

Before commencing any run of concreting, it is essential that an adequate supply of aggregates is stored at the site. Reliance shall not be placed on promised delivery during mixing.

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4.1.3.4 Testing of Aggregates

Where necessary the suitability of the aggregate relevant to a particular structure shall be established well in advance by obtaining samples from sources and carrying out tests for determination of one or more of the following properties;

- (a) Particle size and shape
- (b) Clay, silt and fine dust
- (c) Specific gravity
- (d) Water absorption
- (e) Bulk density, voids & bulking
- (f) Moisture content
- (g) Organic impurities
- (h) Aggregate impact value (Note: this test is an alternative to test (j))
- (i) Aggregate Crushing value
- (j) 10% fines value
- (k) Crushing strength
- (l) Aggregate abrasion value

The tests shall conform to the relevant clauses of BS 812.

The quantity of material passing the 75 µm sieve, when determined in accordance with Clause 7.2.1 and BS 812: section 10.3.1: 1985 shall not exceed the following limits

in crushed rock aggregates	4% by weight
in Natural sand	4% “
in Crushed rock sand	16% “

The aggregate impact value shall be as follows: for,

- (i) Normal structures shall be not more than 45%
- (ii) Wearing surfaces shall be not more than 30%
- (iii) Heavy duty concrete floor finishes shall not be more than 25%

The 10% fines value shall exceed the following limits:

- (i) For normal structures shall be not less than 50 KN
- (ii) For wearing surfaces shall be not less than 100 KN
- (iii) For heavy duty concrete floor finishes shall not be less than 150 KN.

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4.1.3.5 Grading and Sizes

Coarse Aggregate

The maximum size of the aggregate to be adopted shall be as specified and will depend on the dimensions of the member being cast and the spacing of the reinforcement. As a general guide the largest particle of aggregate shall not be larger than a quarter of the least dimension of the member in which it is used, and be at least 5 mm. smaller than the least clear spacing between single bars. Generally it is an advantage to have the maximum size as larger as possible.

The continuous grading limits for coarse aggregate shown in percentage by weight are given below:

Grading Limits for Coarse Aggregates

Vide BS 882 1992, Table 3

Table 4.1

Sieve Size (BS410)	PERCENTAGE BY WEIGHT PASSING BS SIEVES							
	Nominal size of graded aggregate			Nominal size of single size aggregate				
	40mm to 5 mm	20 mm to 4mm	14mm to 5mm	40mm	20mm	14mm	10mm	* 5 mm
50.0	100	-	-	100	-	-	-	
37.5	95-100	100	-	85-100	100	-	-	
20.0	35-70	90- 100	100	0-25	85-100	100	-	
14.0	25-55	40-80	90-100	-	0-70	85-100	100	
10.0	10-40	30-60	50-85	0-5	0-25	0-50	85-100	100
5.0	0-5	0-10	0-10	-	0-5	0-10	0-25	45-
2.36	-	-	-	-	-	-	0-5	100
								0-30

* Used mainly for precast products.

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Fine Aggregate

The grading of fine aggregate, when determined by a test according to BS 812 shall be within the several limits given in Table 4.2.

Additionally not more than one in ten consecutive samples shall have a grading outside the limits for any one of the grading C, M or F given in Table 4.2. For heavy duty concrete floor finishes, the fine aggregate shall comply with C or M given in Table 4.2.

The fine aggregate shall be described as fine aggregate of the grading zone into which it falls- e.g. BS 882, Grading Zone C.

Note : *It is intended that individual zones should not be specified in contract documents relating to concrete ; the concrete mixes should be modified to make the best use of the materials readily available.*

Where fine aggregate does not fall within Table 4.2 limits, an agreed grading envelope may be used provided the materials can produce the concrete of required quality.

TABLE 4.2 Fine Aggregate (Ref Table 4 of BS 882 : 1992)

Sieve Size (BS 410)	Percentage By Weight Passing Bs Sieve			
	Overall limits	Grading Zone C	Grading Zone M	Grading Zone F
mm				
10.0	100	-	-	-
5.0	89-100	-	-	-
2.36	60-100	60-100	65-100	80-100
1.18	30-100	30-90	45-100	70-100
(Micron) μm				
600	15-100	15-54	25-80	55-100
300	5-70	5-40	5-48	5-70
150	0-15*	-	-	-

* For crushed stone sands, the permissible limit is increased to 20%, except for heavy duty floors.

4.1.3.6 Mixing of Single Sizes to obtain Graded Materials

When coarse aggregate brought to site is single sized (ungraded) it shall be mixed with single size aggregate of different size, in the proportion indicated in Table 4.3 to make it graded.

TABLE 4.3

S/No	Cement Concrete Mixture	Nominal size of graded aggregate required (mm)	Part of single size aggregate of sizes mm				
			50	40	20	12.5	10
1	1:6:12	40	-	9	3	-	-
2	1:5:10	40	-	7 1/2	2 1/2	-	-
3	1:4:8	40	-	6	2	-	-
4	1:3:6	40	-	4 1/2	1 1/2	-	-
5	1:3:6	20	-	-	4 1/2	-	1 1/2
6	1:2:4	40	-	3	1	-	-
7	1:2:4	20	-	-	3	-	1
8	1:2:4	12.5	-	-	-	3	1
9	1:1 1/2: 3	20	-	-	2	-	1

The proportions indicated are by volume. These may be varied marginally by the Employer's Representative when considered necessary after making a sieve analysis of the aggregates brought to the site. No adjustment in rates shall be allowed for any variations in the proportions so ordered by the Employer's Representative.

4.1.4 Admixtures

Additives, plasticizers or other workability agents shall not be used without the written approval of the Employer's Representative.

4.2 Lime Concrete

Lime concrete shall be prepared by mixing graded stone or brick aggregate of nominal size as specified, with wet ground lime mortar. Mortar for lime concrete generally consists of lime and sand in the proportion of 1:2 by volume.

4.2.1 Proportioning

The proportioning of wet mortar and aggregate shall be by volume. Generally the internal size of gauge boxes for measuring the materials shall be 400 x 350 x 250 mm (viz. 0.035 m³ approx.) While measuring the aggregate, shaking, ramming or heaping shall not be done.

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4.2.2 **Mixing**

The mixing shall be done by hand or in a mechanical mixer as specified. Brick aggregate shall be well soaked with water for a minimum period of 2 hours.

4.2.2.1 **Machine Mixing**

The mixing drum shall be free of hardened mortar adhering to its inner surface. Before commencing the mixing, the drum shall be flushed clean with water. A measured quantity of aggregate and wet ground mortar for one batch shall be poured in to the drum of the mixer, while it is revolving. The quantity of materials loaded in the drum shall not exceed the rated capacity of the mixer. The required quantity of water shall be added slowly and the wet mixing of a batch shall be continued for at least two minutes in the drum till a uniform mix of required consistency is obtained. The consistency of the concrete shall be such that the mortar does not tend to separate from the coarse aggregate. The entire concrete of a batch shall be discharged before the materials for the new batch are poured into the drum.

4.2.2.2 **Hand Mixing**

Hand mixing when allowed shall be done on a clean and water tight platform (of masonry, wood, or G.I Sheets) of sufficient size to provide sample mixing space. The specified wet lime mortar shall be laid on the top of the aggregate. The whole shall then be turned over and over, with addition of the necessary quantity of water by means of a sprinkler till a uniform mix of required consistency is obtained. The consistency of the concrete shall be such that the mortar shall not tend to separate from the coarse aggregate.

4.2.3 **Laying**

Lime concrete shall be laid (and not thrown) in layers while it is quite fresh. Each layer shall be thoroughly rammed and consolidated before the succeeding layer is placed. Consolidated thickness of each layer shall not exceed 150mm. Joints where necessary shall be staggered in different layers unless otherwise specified. Ramming shall be done by heavy iron rammers of 4.5 to 5.5 kg. The area of the rammer shall not be more than 0.03 m² each. Ramming shall be continued till a skin of mortar covers the surface completely. Compaction shall be done immediately on laying. Green work shall be protected from rain by suitable coverings.

4.2.4 **Curing**

After the concrete has begun to harden - i.e. about 24 hours after its laying, the curing shall be done by keeping the concrete damp with moist gunny bags, wet straw, sand or any method except water under pressure, approved by the Employer's Representative. Curing shall be done for a minimum of 7 days, after which period masonry and flooring work over the lime-concrete foundation or base concrete may be started.

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4.3 Cement Concrete

This shall be prepared by mixing graded stone of specified nominal size with fine aggregate and cement in specified proportions and the required quantity of water to give the consistency needed for proper placement and compaction.

The grading and quality of the aggregates will be as given in clause 4.1.3.5.

Sampling testing and acceptance criteria shall be as set forth in clause 5.4.9.

4.3.1 Proportioning

4.3.1.1 Proportioning By Volume

Fine & Coarse Aggregates may be measured by volume unless otherwise specified. Boxes of suitable size shall be used for measuring the sand and aggregate. The internal dimensions of the boxes recommended are 400 x 350 x 250 mm (which is 0.035m³ and corresponds to the volume of 1 bag of cement weighing 50 kg). While measuring the aggregate, shaking, ramming or heaping shall not be done. The proportioning of sand shall be on the basis of its dry volume and in case of damp sand; allowance for bulkage shall be made as given in Appendix 4C.

Cement shall be gauged by weight. The unit of measurement for cement shall be a bag of 50 kg. and this shall be taken as 0.035 m³ ; but in case the volume of cement is permitted to be gauged in a measuring box the internal dimensions of the box for cement only shall be 400 mm x 350 mm x 290 mm to account for bulking.

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The composition shall be as follows:-

TABLE 4.4.

Specified mix	Equivalent Grade where specified	Quantities per 50 Kg. bag of cement		
		Fine Aggregate	Coarse Aggregate	Approx. Water content in litres
1:1:2	30	0.035 m ³ 1 box	0.07 m ³ 2 boxes	20
1: 1 1/2 : 3	25	0.053 m ³ 1 1/2 boxes	0.105 m ³ 3 boxes	22.5
1: 2: 4	20	0.07 m ³ 2 boxes	0.14 m ³ 4 boxes	25
1: 3: 6	10	0.105 m ³ 3 boxes	0.210 m ³ 6 boxes	35
1: 4 : 8		0.14 m ³ 4 boxes	0.28 m ³ 8 boxes	40

Note : 1. The internal dimension of boxes for measuring aggregate shall be 400 mm x 350 mm x 250 mm height.

If gauging boxes are allowed to be used for cement the corresponding box shall be 400 mm x 350 mm x 290 mm internal dimensions to account for bulking.

Note: 2. Quantities required per cubic meter of concrete are given in Appendix 4A.

4.3.1.2 Proportioning By Weight

Prescribed Mix

The Employer's representative shall be informed of the nature and source of each material to be used and subsequently notified whenever a change is made. No admixtures shall be used unless specified.

The cement contents for these prescribed mixes are given in BS 5328, Part 2, Table 5 with the total weights of dry aggregate to produce approximately one cubic meter of concrete, Depending upon the specific gravity of the aggregate slight adjustments may be required to the quantity of aggregates to produce this volume of concrete having the required workability, strength and cement content. BS 5328, Part 2, Table 5 also gives the approximate proportions of fine aggregate to be used although small adjustments may be required on the site depending on the

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properties of the local materials. For grades 7, 10 and 15 a range of fine aggregate proportions is given, the lower percentage being applicable to finer material such as zone 3 sand and the higher percentage being applicable to coarser material such as zone 1 sand. Where single sized coarse aggregates are used, the proportions shall be chosen to produce a combined grading within the limits of BS 882 for graded coarse aggregate of the appropriate size.

Where weigh - batches are not available and if the necessary site control can be ensured, aggregates can be measured by volume after conducting the necessary field density tests. Cement shall be batched by weight (or in whole bags).

Designed Mix

This shall be permitted if specifically allowed in the Bill of Quantities, when the necessary weigh batches are available and the required quality control assured.

The procedure indicated in BS 5328 shall be followed.

4.3.2 Mixing

It shall be done in a mechanical mixer. Hand-mixing shall be done only with the prior permission of the Employer's Representative.

4.3.2.1 Machine Mixing

The mixer drum shall be free of hardened mortar adhering to its inner surface. Before mixing commence the drum shall be primed by washing with rich cement grout. A measured quantity of dry coarse aggregate shall be first placed in the hopper. This shall be followed with the measured quantity of fine aggregate and then cement. The skip shall be raised and the dry materials slipped into the drum. The dry materials shall be mixed for at least four turns of the drum after which the correct quantity of water shall be added gradually while the drum is in motion, to ensure even distribution of the materials. The total quantity of water for mixing shall be introduced before 25% of the mixing time has elapsed and shall be regulated to achieve the specified water cement ratio. The complete contents of the mixer shall be emptied before recharging.

When the mixer is closed down for the day or for any period, exceeding 20 minutes, the drum shall be flushed clean.

Mixing Time

The materials shall be mixed for a period of not less than 2 minutes and until a uniform color and consistency are obtained. The time shall be counted from the moment all the materials have been put into the drum.

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4.3.2.2 Hand Mixing

When permitted for Volume Batched mixes, this shall be done on a smooth, clean and water-tight platform of suitable size and in the following manner.

- (a) The measured quantity of sand shall be spread evenly
- (b) The cement shall be dumped on the sand and then distributed evenly.
- (c) The sand and cement shall be mixed intimately with shovels, turning the mixture over and over again, until it is of even color throughout and free from streaks
- (d) The measured quantity of coarse aggregate shall be spread out and the sand cement mixture shall be on top.
- (e) This shall be mixed at least three times dry, by shoveling and turning over from centre to side then back to the centre and again to the sides.
- (f) A depression shall be made in the middle of the mixed pile to receive the water
- (g) Three quarters of the total quantity of water required shall be added while the material is turned in towards the centre with shovels. The remaining water shall be added by a water-can fitted with a rose-head, while slowly turning the whole mixture over and over again at least three times until a uniform color and consistency is obtained throughout the pile.
- (h) The mixing platform shall be washed at the end of the day.

4.3.3 Consistency

The concrete shall be of such consistency as will suit the method of placement and compaction. The quantity of water shall be regulated by carrying out regular slump tests as prescribed in Appendix 4.B, for each mix using one bag of 50 Kg cement it shall not exceed that indicated in Table 4.4.

In the case of vibrated concrete, the water content may be suitably reduced to avoid segregation.

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The following slumps shall be adopted for different kinds of works.

Table 4.5

Work	Slump in mm	
	Vibrators used	Vibrators not used
Mass concrete in foundation, footings, retaining walls and pavement.	10 - 25	50 - 75
Thin sections of flooring less than 75 mm thickness	25 - 40	75 - 100
Reinforced cement concrete work	Refer chapter 5	Refer chapter 5
Under water concreting	-	100 - 180 (Actual slump to be decided by Employer's Representative)

Concrete of the higher slumps range of 75 mm and above shall be produced by using additional cement slurry and not merely water, so that the water cement ratio and compressive strength are kept reasonably constant. Generally about 10% more of cement will become necessary.

4.3.4 Laying

Sufficient notice of not less than 24 hours shall be given to the Employer's Representative prior to commencing concreting so as to enable inspection of forms, reinforcement etc. The position of all construction joints and programme of concreting shall be decided in advance. Necessary stop-boards shall be provided at construction joints.

4.3.4.1 Compaction

The entire concrete used in the work shall be laid gently (not thrown) in layers not exceeding 150 mm. It should be deposited nearly as practicable in its final position and without segregation in one continuous operation up to the movement or construction joints.

It shall be adequately compacted by means of vibrators till air bubbles cease to appear on the upper surface and a dense concrete is obtained. The vibrator will be operated in a near vertical position, and the duration of vibration limited to that necessary to produce satisfactory consolidation without causing objectionable segregation.

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The Employer's representative may however at his discretion, permit hand compaction for certain items depending upon the thickness of the members and feasibility for vibrating the same. Hand compaction shall be done with the help of tamping rods so that the concrete is thoroughly compacted and completely worked into the corners of the formwork.

The layers of concrete shall be so placed that the bottom layer does not finally set before the top layer is placed. Compaction shall be completed before the initial setting starts i.e. within 30 minutes of addition of water to the dry mixture. Re-tempering of concrete shall not be permitted.

4.3.4.2 Temperature

During cold weather, concreting shall not be done when the temperature falls below 4.50C. The concrete placed shall be protected against frost by suitable covering. Concrete damaged by frost shall be removed and the work redone. During hot weather, precautions shall be taken to see that the temperature of wet concrete does not exceed 380C

4.3.4.3 Underwater Concreting

Concrete shall not be deposited under water if it is practicable to de-water the area and place concrete in the regular manner. Where founds necessary to deposit any concrete under water, the method, equipment, materials and mix shall first be approved by the Employer's Representative.

The concrete shall be deposited under water by one of the approved methods such as Trenia Method, Drop Bottom bucket, bags etc.

If it is necessary to raise the water after placing the concrete, the level shall be brought up slowly without creating any waves or commotion tending to wash away cement or to disturb the fresh concrete in anyway. Detailed procedures recommended in BS 8004 may be followed.

4.3.4.4 Continuation of Work

When the placing of concrete is suspended, necessary removal of laitance and roughening the surface for jointing future work shall be done before the concrete sets. When the work is resumed the previous work must be thoroughly cleaned, roughened, watered and a group of neat cement slurry of the proportion 1 Kg of cement per 2 litres of water applied uniformly; The grout should not be allowed to dry prior to the placement of the fresh concrete.

4.3.5 Curing and Protection

Green work shall be protected from rain by suitable covering. The work should also be suitably protected from damage during construction.

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After the concrete has begun to harden i.e. about 1 to 2 hours after its laying, it shall be protected with moist gunny bags, or any other material approved by the Employer's representative against quick drying. After 24 hours of laying of concrete, the surface shall be cured by flooding with water of minimum 25 mm depth, or by covering with wet absorbent materials. The curing shall be done for a minimum period of 7 days. In special cases, curing may have to be prolonged as required by the Employer's Representative.

Over the foundation concrete, the masonry work may be started after 48 hours of its laying, but the curing of cement concrete shall be continued along with the masonry work for a minimum period of 7 days.

Where cement concrete is used as sub- grade for flooring, the flooring may be commenced before the curing period of sub-grade is over but the curing of sub-grade shall be continued along with the top layer of flooring for a minimum period of 7 days.

The water used for curing shall not produce any objectionable stains or unsightly deposit on the concrete surface. In special circumstances and locations, curing by other means such as sealing material, insulating blankets etc. may be adopted with the specific prior approval of the Employer's Representative.

4.3.6 Form Work

If centering and shuttering are required to be done for this work, it shall be done in accordance with the specifications for formwork under Reinforced Cement Concrete work.

4.3.7 Test and Acceptance

See paragraph 5.4.0

4.4. No Fines Concrete

Note: - No fines concrete consists of cement and coarse aggregate only. The absence of fine material results in a mass having uniformly distributed voids in it. The material is almost invariably cast in-situ and can be used for partitions and load bearing internal walls; if used for load bearing external walls it shall be rendered externally to prevent wind pressure forcing water through the voids.

The aggregate shall be crushed rock or approved light weight aggregate. Mix proportions may be in the range of 1:5 to 1:10 or as specified. The water content shall be such as to produce a continuous film of cement grout of paste consistency over the aggregate.

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Unless otherwise specified, the following proportions of water, cement and aggregates shall be adopted.

For hard dense aggregates - 0.45 : 1:10 (10 mm to 20 mm)

For light weight aggregates - 0:60 : 1:6 (10 mm to 20 mm)

The material shall be poured as soon as possible after mixing and shall not be rammed or mechanically vibrated, though it can be lightly rodded. Pouring shall be as continuous as possible to an even height since diagonal joints are a source of weakness.

4.5 Plum Concrete

'Plum Concrete' shall be of hard dense rock of approved sizes used with concrete of specified mix

A layer of concrete not less than 50 mm thick shall be placed, the first layer of plums placed upon this and the plums allowed to sink under their own weight. The concrete shall be of such consistency that the plums do not disappear completely from sight.

The thickness of each succeeding layer of concrete shall not be less than twice the maximum dimensions of plums permitted. The distance between any two plums and the face shall not be less than the maximum dimension of the plums not less than 150 mm.

APPENDIX 4A. Quantities of Ingredients per cubic meter of concrete for Volume-Batched mixes.

Nominal Mix	Equivalent Grade	Cement (Kg)	Fine Aggregate (dry sand m ³)	Coarse Aggregate (m ³)	Appropriate water cement ratio
1: 1: 2	30	552	0.38	0.76	0.40
1: 1 1/2 : 3	25	405	0.41	0.82	0.45
1: 2: 4	20	320	0.44	0.88	0.50
1: 3 : 6	-	227	0.46	0.92	0.70
1: 4 : 8	-	173	0.48	0.96	0.80

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APPENDIX 4B - Slump Test for Concrete

Apparatus: The mould shall consist of metal frustum of cone having the following internal dimensions:-

Bottom diameter	20 cm
Top diameter	10 cm
Height	30 cm

The mould shall be of a metal other than brass and aluminum of at least 1.6 mm (or 16 BG) thickness. The top and bottom shall be open and at right angles to the axis of the cone. The mould shall have a smooth internal surface. It shall be provided with suitable foot pieces and handles to facilitate lifting it from the moulded concrete test specimen in a vertical direction as required by the test. A mould provided with a suitable guide attachment may be used.

The tamping rod shall be of steel or other suitable material, 16 mm in diameter, 600 mm long and rounded at one end.

Procedure: The internal surface of the mould shall be thoroughly cleaned and free from superfluous moisture and any set concrete before commencing the test. The mould shall be placed on a smooth, horizontal, rigid and non absorbent surface, such as a leveled metal plate. The operator shall hold the mould firmly in place while it is being filled with the test specimen of concrete. The mould shall be filled in four layers, each approximately one quarter of the height of the mould. Each layer shall be tamped with twenty five strokes of the rounded end of the tamping rod. The strokes shall be distributed in a uniform manner over the cross section of the mould and for the second and subsequent layers shall penetrate into the under lying layer. The bottom layer shall be tamped throughout its depth. After the top layer has been rodded the concrete shall be struck off level with trowel or the tamping rod, so that the mould is exactly filled. Any mortar which shall leak out between the mould shall be removed from the concrete immediately after filling or raising it slowly and carefully in a vertical direction. The moulded concrete shall then be allowed to subside and the slump shall be measured immediately by determining the difference between the height of the mould and that of the highest point of specimen.

The above operations shall be carried out at a place free from vibration or shock, and within a period of two minutes after sampling.

Result : The slump shall be recorded in terms of millimeters of subsidence of the specimen during the test. Any slump specimen which collapses or shears off laterally, gives incorrect

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result. If this occurs, the test shall be repeated with another sample.

The slump test shall not be used for very dry mixes as the results obtained are not accurate.

APPENDIX 4. C

Bulking of Fine Aggregate/Sand (Field Methods)

Two methods are suggested for determining the bulking of sand/fine aggregate. The procedure may be suitably varied, if necessary. Both depend on the fact that the volume of inundated sand/fine aggregate is the same if the sand/fine aggregate were dry. Method 1: Put sufficient quantity of sand loosely into a container until it is about two third full. Level off the top of the sand and pushing a steel rule vertically down through the sand at the middle to the bottom, measure the height. Suppose this is 'X' cm.

Empty the sand out of the container into another container without loss. Half fill the first container with water. Put back about half the sand and rod it with a steel rod, about 6 mm in diameter, so that its volume is reduced to a minimum. Then add the remainder and level the top surface of the inundated sand. Measure its depth at the middle with the steel rule. Suppose this is "Y" cm.

The percentage of bulking of the sand due to moisture shall be calculated from the formula.

$$\text{Percentage bulking} = \frac{X}{Y} - 1 \times 100$$

Method 2: In a 250 ml measuring cylinder, pour the damp sand (consolidated by shaking) until it reaches the 200 ml mark.

Then fill the cylinder with water and stir the sand well (the water shall be sufficient to submerge the sand completely) It will be seen that the sand surface is now below its original level. Suppose the surface is at the mark of 'Y' m the percentage of bulking of sand due to moisture shall be calculated from the formula.

$$\text{Percentage bulking} = \frac{200}{Y} - 1 \times 100$$

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Appendix 4 D - Extracted from Table 5, BS 5328 : Part 2 : 1991

Mix proportions for standard mixes					
Standard mix and grade	Constituent	Nominal maximum size of aggregate			
		40 mm		20 mm	
		slump 75 mm	slump 125 mm	slump 75 mm	slump 125 mm
ST1 (7.5)	Cement (Kg) Total aggregate (Kg)	180 1950	200 1850	210 1900	230 1800
ST2 (10)	Cement (Kg) Total aggregate (kg)	210 1900	230 1850	240 1850	260 1800
ST3 (15)	Cement (Kg) Total aggregate (kg)	250 1850	270 1800	280 1800	310 1750
ST4 (20)	Cement (Kg) Total aggregate (kg)	300 1850	320 1750	320 1800	350 1750
ST5 (25)	Cement (Kg) Total aggregate (kg)	340 1800	360 1750	360 1750	390 1700
ST1 ST2 ST3	Fine aggregate (percentage by mass of total aggregate)	30 to 45	30 to 45	35 to 50	35 to 50
ST4 ST5	Fine aggregate (percentage by mass of total aggregate) Grading limits C Grading limits M Grading limits F	30 to 40 25 to 35 25 to 30		35 to 45 30 to 40 25 to 35	

Note 1. The cement contents together with the total masses of saturated surface dry aggregates and added water will produce approximately one cubic meter of concrete. The values given are based on typical values of the relative densities of cement and aggregates. For some aggregates having higher or lower relative densities adjustments may be required to the quantity of aggregates to produce this volume of concrete having the required workability and cement content.

Note 2. The values given for aggregate content may be adjusted to allow also for the characteristics of the aggregates.

Note 3. The aggregates for mixes ST1, ST2 and ST3 may be batched by volume.

Note 4. When standard mixes are specified with workability less than 75 mm slump, the mix proportions are to be taken from the appropriate 75 mm slump column.

CHAPTER 05
REINFORCED CEMENT CONCRETE

5.1 Reinforced Cement Concrete

Reinforced cement concrete work may be cast-in-situ or precast, and shall comprise the following which may be paid separately or collectively as per description of the item of work

- (a) Form work
- (b) Reinforcement
- (c) Concreting

5.2 Materials

This shall be structural concrete conforming to the requirements of chapter 4.

5.1.2 Steel Reinforcement

The reinforcement shall be:

- (i) Hot rolled mild steel round bars
for concrete reinforcement - BS 4449
- (ii) Hot rolled high yield steel
bars for concrete reinforcement - BS4449
- (iii) Cold worked deformed steel bars
for reinforcement of concrete - BS 4482
- (iv) Hard drawn mild steel wire for
the reinforcement of concrete - BS4482
- (v) Steel fabric for reinforcement
of concrete - BS 4449

Contractor shall produce a certificate of origin and compliance with the requirements of related BS shall be produced. Steel shall be tested in an approved laboratory and results produced to the satisfaction of the Employer's Representative.

The cost of testing etc. shall be borne by the Contractor.

Ribbed and/or Deformed steel bars shall not be assumed to be high yield steel without testing.

5.1.2.1 Properties of Reinforcing Steel

The chemical and other properties of reinforcing steel shall be complying with relevant British Standards as given in section 5.1.2.

All reinforcement when placed shall be free from dirt, oil, mud, and grease, rust, loose mill scale or any other foreign matter which can adversely affect the concrete or reinforcement chemically or reduce the bond.

5.1.2.2 Stacking and Storage

steel reinforcement shall be stored clear of the ground in a way as to prevent distortion and corrosion. Bars of different classifications shall be clearly marked/tagged and those of different sizes and lengths shall be stored separately to facilitate issues in such sizes and lengths as to minimize wastage in cutting from standard lengths.

5.2 Formwork

Formwork shall include all temporary or permanent forms/moulds required for casting the concrete in-situ and all the temporary construction required for support.

The formwork shall be designed and constructed with adequate waling struts, braces, ties and clamps so as to produce finished concrete work to the required shape and dimensions within the limits of specified tolerances if any and with the specified surface finishes vide clause 5.4.8. The formwork shall be sufficiently rigid and tight to prevent loss of grout or mortar from the concrete and shall take due account of the method of placing and compacting.

The formwork shall withstand the worst combination of the following loads.

- (i) Total weight of formwork, reinforcement and concrete
- (ii) Construction loads including dynamic effects of placing, compacting and construction traffic
- (iii) Wind loads

Formwork shall be so constructed as to be easily dismantled and removed in sections in the desired sequence from the cast concrete, without shock, disturbance or damage. Where necessary the formwork shall be so arranged that the soffit form properly supported on props only, can be retained in position for such period as may be required by the maturing conditions or specification. Screw jacks or hard board wedges shall be provided where required to make up for any settlement in the formwork either before or during the placing of concrete.

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Care shall be taken to see that no piece is keyed into the concrete.

Details of formwork shall be properly worked out, and approval obtained from the Employer's representative well in time for important works. The completed formwork shall be inspected and passed by the Employer's Representative before the reinforcement is placed in position, but the responsibility for the adequacy of the formwork remains with the contractor.

Propping and centering shall be sufficiently rigid and stable. The permissible stresses in bending, the buckling load of props, the permissible deflection of shuttering etc. Should not be exceeded. Suitable horizontal as well as diagonal braces shall be provided to resist the lateral forces due to dumping of concrete movement of construction equipment and action of the wind and to provide lateral stability.

5.2.1 Materials for Formwork

Temporary formwork shall be of timber, plywood, steel or any other material as specified.

Permanent formwork shall consist of filler blocks like clay/concrete hollow blocks, coffer units trough units etc. as specified.

5.2.1.1 Timber

The timber used for formwork shall be light weight and easily workable with nails without splitting. It shall be stiff and strong enough to avoid undue deflection when loaded; be stable and not liable to warp when exposed to sun and rain, or wetted during concreting. It shall not be so soft as to get damaged easily on the contact faces under normal condition of erecting forms, fixing steel and pouring concrete. The timber shall be free from loose knots, projecting nails, splits or other defects that may mar... the surface of the concrete. It shall not be so dry as to absorb water from concrete and swell and bulge, nor so green or wet as to shrink after erection. Species of timber which are not appreciably affected by contact with water shall be used. The sizes of timber generally used for formwork are given below:

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The following timber sizes shall be used in general:

Use	Size
Floor boarding	25 mm or 32 mm thick
Wall boarding and sides of Beams and columns	25 mm to 50 mm thick
Beam soffits	38 mm to 50 mm thick
Joists, ledges	100 x 50 to 250 x 75 mm Generally 100 x 50 mm
Raw jungle poles	Not less than 100 mm diameter at mid-length and 80 mm at thin end.
Posts	75 x 100 to 100 x 100 mm
Column yokes	50 x 50 to 75 x 75 mm
Diagonal braces	50 x 32 to 150 x 50 mm

5.2.1.2 Plywood

Phendic - resin bounded plywood shall be used as it is completely water proof and does not laminate as does ordinary plywood. Plywood panels shall be formed with 100 x 25 mm dressed timber and nailed with short, thin nails at 150 to 225 mm centers.

6 or 10 mm thick plywood shall be given a solid backing nailed at 100 to 150 mm spacing along the four edges and with at least one nail every 0.1 square meter throughout the surface. The edges of sheets shall be tacked to the same backing board to ensure the production of a smooth joint.

10 and 16 mm thick plywood shall be nailed to a skeleton backing of dressed timber before fixing to the studding. 19 mm thick plywood shall be nailed direct to studs at a maximum recommended spacing of 450 mm. For spacing greater than 450 mm skeleton backing of appropriate design shall be used.

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5.2.1.3 Steel

The contractor shall use with the approval of the Employer's representative any proprietary systems of steel formwork generally consisting of panels made up of steel sheet on light steel angle framing in sizes that can be easily handled. Special panels shall be used where curved formwork is necessary.

Special telescopic units which can be easily removed shall be provided as a simple type of joist for suspended slab formwork. Other proprietary fittings such as beam and column clamps and adjustable props designed to facilitate erection may also be used subject to the approval of the Employer's Representative in regard to their suitability for the particular work.

5.2.2. Formwork Ties

Wire ties shall generally not be recommended for fixing wall formwork as they are likely to cause rust stains or patches at the point where they are cut back. Such stains may be avoided by using bolts which should be either fitted with sleeves or well greased to enable them to be withdrawn easily from the concrete when formwork is removed. Any proprietary devices when used for supporting formwork shall have the approval of the Employer's Representative.

No metal part of any device for securing forms shall remain within the specified concrete cover.

All ties anchored against timber shall pass through a plate washer at least 50 mm x 50 mm and of sufficient thickness to transfer the load without visible deflection or penetration into the timber.

5.2.3 Top Forms

Formwork shall be provided to the top surface of concrete where the slope or nature of the work requires it.

5.2.4 Propping and Centering

Props used for centering shall be of steel, timber post round poles or any other material approved by Employer's Representative. Bamboo props or supports shall be permitted for heights or lengths not exceeding 3 meters provided they are adequately braced. In no case shall round poles be of diameter less than 100 mm measured at mid length and 80 mm at thin end. Maximum permissible spacing shall be 1.2 meters centre to centre. Poles shall rest squarely on wooden sole plates of 40 mm thickness and a minimum bearing area of 0.1 sq. meter laid on the ground. Double wedges shall be provided between the sole plates and the wooden props so as to facilitate tightening and easing of shutting without jarring the concrete.

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The details of propping and centering stated above shall be applicable for spans of 4.50 meters and height upto 3.50 meters. In case any of these limits is exceeded the formwork shall be properly designed. In case the height of centering exceeds 3.50 meters, the props shall be provided in multistage and stabilized with suitable diagonals and rakes.

Proprietary systems of props shall be erected as per manufacturer's details.

5.2.4.1 Multistoried Structures

In the case of structures with two or more floors, the normal props as per 5.2.4 shall be provided for supporting the floor to be cast on the topmost floor already cast. If necessary supports below this floor shall be provided preferably to come in line with the props of the upper floor. Planks shall be provided at the top ends of these props so as to give an even distribution of load. Formwork and concreting of the upper floor slab shall not generally be done until the concrete of the lower floor has set for at least 14 days.

In case of balconies and cantilever beams coming one above the other, the members being cast shall be supported by props on two floors below the floor where initial supporting has been done. Poles shall rest squarely on wooden sole plates of 40 mm thickness and with minimum bearing area of 0.1 square meters.

5.2.4.2 Precautions

Before the concreting is started, all the props and wedges shall be checked to see that they are intact and suitable action taken in case they are loose. While the concreting is in progress, at least one carpenter/fitter shall be readily available at the site. The carpenter shall keep a constant watch on the props and take immediate remedial measures, if any of these get loosened. Care shall be taken that props and wedges do not get loose for this minimum period specified in table 5.2.

5.2.5 Shuttering

The shuttering shall have a smooth and even surface and be appropriate to the concrete finish required. See also clause 5.4.8. For exposed concrete faces, timber for shuttering shall be treated on all faces in contact with concrete. Wooden formwork with metal sheet, plywood or other approved lining or steel plates stiffened by steel angles shall also be permitted. Undressed timber may be used for formwork for hidden faces and external faces below ground level.

When metal forms are used, all bolts and nuts shall be countersunk and well ground to provide a smooth plane surface.

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The chamfers, bevelled edges and mouldings shall be made in the formwork itself.

Provision for fan clamps and other fittings connected with services shall be made in the shuttering as directed by the Employer's Representative.

As far as practicable, clamps shall be used to hold the forms together. Where the use of nails is unavoidable the minimum possible number of nails shall be used and these shall be left projecting so that they can be easily withdrawn. Use of double headed nails shall be preferred.

Holes or openings shall be provided at suitable locations for cleaning up before placing concrete.

5.2.5.1 Surface Treatment for Shuttering

The surfaces of timber shuttering that would come in contact with concrete shall be thoroughly wetted and coated with raw linseed oil, mould oil of approved manufacture or any other approved material (such as polythene- polyethylene sheets), to prevent adhesion of concrete to formwork. Inside surfaces of forms shall be thoroughly cleaned before application of any of the materials mentioned above. Approved released agents shall be applied strictly in accordance with the manufacturer's instructions and shall not be allowed to come in contact with any reinforcement.

Re-use of the shuttering shall be permitted only after the surface has been thoroughly cleaned, and repaired if necessary.

5.2.6 Camber

Suitable camber shall be provided for the horizontal members of structures especially those of long spans, to counteract the effect of deflection. The formwork shall be so assembled as to provide for such camber. The camber for beams and slabs shall generally be 0.1% and 0.2% of the span depending upon the span and stiffness of the member in question. Cambers are not normally applied to short or very stiff cantilevers.

5.2.7 Special Formwork

Formwork locations like tall structures etc. use of special types of formwork like moving or sliding forms shall be permitted. The details of such formwork along with the sequence of working shall be approved by Employer's representative before erection.

5.2.8 Approval of Formwork

The contractor shall give the Employer's representative due notice before placing any concrete in the forms to permit him to inspect and accept the formwork as to its strength, alignment and

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general fitness; however, such inspection shall not relieve the contractor of his responsibility for safety of men, machinery, materials and the results obtained.

5.2.9 Removal of Formwork

The formwork shall be so removed as not to cause any damage to concrete due to shock or vibration.

Formwork shall normally be stripped in the following order:

- (i) Shutters to vertical faces e.g. side of columns, beams and walls
- (ii) Shutters forming soffits to roof and floor slabs, horizontal and inclined canopies etc.
- (iii) Shutters forming soffits of beams and girders.

The removal of the formwork for larger structures shall be planned and a definite scheme of operation worked out to the satisfaction of the Employer's Representative.

Re-propping of beams shall not be permitted except with the approval of the Employer's Representative.

5.2.9.1 Time of Removal

In no circumstances shall forms be struck until the concrete reaches strength of at least twice the stress to which the concrete may be subjected at the time of strike. Where possible, the formwork shall be left for as long as possible, as it would assist curing. Forms shall be eased out carefully in order to prevent the load being transferred suddenly to the partly hardened concrete. The period that shall elapse after the concrete has been laid, before easing and removal of centring and shuttering is undertaken shall be as given in Table 5.2. The Employer's Representative may however extend the periods noted where necessary by giving written instructions to the contractor.

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Table 5.2

The minimum period for removing formwork

Part of Structure	Period for Ordinary Portland Cement without admixtures
Sides of foundations, columns, beams and walls	24 hours
Under sides of slabs of up to 4.5 meter span	7 days
Under sides of slabs of above 4.5 meters span and under sides of beams and arches up to 6 meters span	14 days
Under sides of beams and arches over 6 meters span and up to 9 meters span	21 days
Cantilever slabs and beams	21 days
Domes, shells and other structures of special nature.	As per written instructions of Employer's Representative

5.3 Steel Reinforcement

The reinforcement shall be :

- (i) Hot rolled mild steel round bars for concrete reinforcement - BS 4449
- (ii) Hot rolled high yield steel bars for concrete reinforcement - BS 4449
- (iii) Cold worked deformed steel bars for reinforcement of concrete - BS 4482
- (iv) Hard drawn mild steel wire for the reinforcement of concrete - BS 4482
- (v) Steel fabric for reinforcement of concrete - BS 4482

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Contractor shall submit a certificate of origin and compliance with the requirements of related BSS shall be produced. Steel shall be tested in an approved Laboratory and results produced to the satisfaction of the Employer's Representative.

The cost of testing etc. shall be borne by the Contractor.

5.3.1 Bending Lapping and Welding

5.3.1.1 Cutting and Bending

Reinforcement shall be cut and/or bend in accordance with BS 4466. Bars shall be bend cold, correctly and accurately on an approved type of bending apparatus, to the size and shape shown on the detailed drawings or as directed by the Employer's Representative.

Where hot bending in the opinion of the Employer's representative is necessary, only hot rolled high yield or mild steel shall be allowed to be bent at a cherry red heat and allowed to cool gradually. In the case of cold worked bars, prolonged or excessive heating may reduce its properties and hot bending shall therefore be avoided.

5.3.1.2 Laps

Preferably, bars of full length shall be used. Lapping of bars where necessary, shall be done as directed by the Employer's Representative. The lapping bars shall not touch each other and shall be kept apart by 25 mm or 1 1/4 times the maximum size of the coarse aggregate whichever is greater, (but not exceeding 4 x diameter of bar). But where this cannot be done, the lapping bars shall be bound together at intervals not exceeding twice the diameter of such bars, with two strands of annealed steel wire of 0.90 mm to 1.6 mm thickness twisted tight. The laps shall be staggered for different bars and located at points along the span where neither shear nor bending moment is a maximum. Laps in secondary reinforcement shall be 30 times the diameter of the bar unless otherwise shown. Length of laps shall be as given in Appendix 5.A unless otherwise specified.

5.3.1.3 Welding

Welding may be used for (i) fixing in position between crossing or lapping reinforcement (ii) transfer of load between reinforcement. Welding on site shall be avoided if possible but where suitable safeguards and techniques are employed and provided that the types of steel (including high yield steels to B S 4449) have the required welding properties, it may be undertaken with the approval of the Employer's Representative. Welding of reinforcement shall conform to standard codes of practices and to the approval of the Employer's Representative.

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Generally however all welding shall be carried out under controlled conditions in the factory or work-shop.

5.3.1.4 Re-Bending

Where it is necessary to bend reinforcement projecting from already cast concrete, care shall be taken to ensure that the radius of bend is not less than that specified in BS 4446. Where it is necessary to re-shape steel previously bent, this should only be done with the Employer's Representative's approval and each bar should be inspected for signs of fracture.

5.3.2 Fixing in Position

5.3.2.1 Tying of Bars

Reinforcement bars shall be placed in position as shown in the drawings. The bars crossing one another shall be tied together at every intersection with two strands of annealed steel wire 0.90 to 1.6 mm thickness twisted tight to make the skeleton of the steel work rigid so that the reinforcement does not get displaced during the deposition of concrete. The ends of the binding wire shall be bent back, clear of forms and into the body of the concrete.

Note : If spacing of bars is less than 300 mm in each direction, alternate intersection may be tied. Crossing bars should not be tack welded for assembly of reinforcement unless permitted by the Employer's Representative.

5.3.2.2 Spacers and cover Blocks

The bars shall be kept in position by using spacers, chairs etc. Spacers shall be of such materials and designs as will be durable, not lead to corrosion of reinforcement nor cause spalling of the concrete cover.

The following methods shall be followed.

- (a) In the case of beam and slab construction, precast cover blocks in cement mortar 1: 11/2 about 40 x 40 mm section and of thickness equal to the specified cover shall be placed between the bars and shuttering, so as to secure and maintain the requisite cover of concrete over reinforcement.
- (b) In the case of cantilevered and doubly reinforced beams or slabs the vertical distance between the horizontal bars shall be maintained by introducing chair spacers or support bars of steel at 1.0 meter or at shorter spacing to avoid sagging.
- (c) In the case of columns and walls, the vertical bars shall be kept in position by means of removable timber templates with slots accurately cut in them or with circular blocks of

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cement mortar 1 : 1/1/2 suitably tied to the reinforcement.

- (d) In case of other RC structure such as arches, domes etc. cover blocks, spacers and templates shall be used as directed by the Employer's Representative. Projecting reinforcement shall be protected from the weather by grout washing, or special covers or wrapping, and/or subsequently cleaned until completely embedded in concrete.

Concreting shall not commence until the reinforcement has been inspected and approved by the Employer's representative . The position of reinforcement should be checked before and during concreting, particular attention being paid to the position of top reinforcement especially in cantilever sections.

5.3.2.3 Cover

The cover of concrete to the reinforcement shall be as described in the drawings and shall be provided and maintained within a tolerance of 3 mm under or over (except where specified as a minimum)

The following table shall be adopted for general guidance.

Table 5.3 - Nominal cover to all Reinforcement (Including links) to meet durability requirements

Exposure Classification	Examples of Exposure	Nominal Cover				
		mm				
Mild	Indoor and Sheltered	25	20	20*	20*	20*
Moderate	Outdoor exposed	40	35	30	25	20
Severe	Wet and Dry; Foundation	50	45	40	30	25
Very Severe	Sea Spray	-	50	45	40	35
Extreme	Abrasive	-	-	-	60	50
Maximum free water/cement ratio		0.65	0.60	0.55	0.50	0.45
Minimum cement content (Kg.m ³)		275	300	325	350	400
		(300)	(325)	(350)	(400)	(450)
Lowest grade of concrete (See note 5)		25	30	35	40	45

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Note 1 This table applies to normal -weight aggregate OPC concrete of 20mm nominal maximum aggregate size and river sand fine aggregate. In no case should the cover be less than the maximum aggregate size or diameter of main reinforcement.

Note 2 Cover values marked with asterisks () can be reduced to 15 mm provided the nominal maximum aggregate size does not exceed 15 mm subject to the conditions in Note 1. The minimum allowable cover is 15 mm.*

Note 3 The cover may be reduced by 5mm in slabs and shells, subject to the conditions in Note 1 and 2.

Note 4 The minimum cement content values in parentheses should be maintained if no water reducing admixtures are used.

Note 5 The grade requirement can be reduced by 5 if a checking regime establishes that the maximum free water/cement ratio and minimum cement content requirements are met.

Note 6 The above cover values can be reduced by 5 mm subject to the conditions in Note 1 and 2 provided a 1:3 cement : sand rendering of 10 mm 15 mm or 20 mm or equivalent is applied to concrete made to water/cement ratios of 0.65, 0.6 and 0.55 respectively.

Note 7 Cover in foundation should be treated as for 'severe' exposure conditions without any reductions in cover allowed as per Notes 3 and 6. The cover values in parentheses for the 'severe' exposure condition can be used only for foundations.

5.4 Concreting

The concrete shall be made as specified in Chapter 4 and the proportions of ingredients shall be as specified. Concrete shall be mixed by a mechanical mixer except when the Employer's Representative permits otherwise.

5.4.1 Consistency

The concrete shall be of such consistency that it will flow sluggishly into the forms and around the reinforcement without any segregation of coarse aggregate from the mortar. The consistency shall depend on whether the concrete is vibrated or hand-tamped. It may be determined by slumps of concrete for the different types of works, and shall be as given in Table 5.4 below, unless otherwise specified.

Table 5.4 Slump for Concrete

Work	Slump (in mm)	
	Vibrators used	Vibrators not used
Mass concrete in RC foundation, footings and retaining walls.	10-25	50-75
Beams, slabs and columns	25-40	75 - 100
Thin RC sections or sections with congested steel	40-50	125-150

Note: *Volume Batched Concrete of the higher slump range of 75 mm and above, shall be produced by using additional cement slurry (and not merely water) keeping the water-cement ratio and the compressive strength of concrete reasonably constant.*

The amount of water used in the concrete shall be regulated by volume or by weight as required to secure concrete of the proper consistency. Adjustment shall be made for any variation in the moisture content due to water absorbed by the aggregates and/or free water in aggregates. Addition of water to compensate for stiffening of the concrete shall not be permitted.

5.4.2 Placing of Concrete

The Employer's representative shall be kept advised sufficiently in advance as to when placement of concrete will commence. The concrete shall be transported from the mixer with the least possible delay in liquid tight containers or barrows and by methods which prevent the segregation or loss of ingredients. Slump loss in transit shall not exceed 25 mm. Compensation for excessive slump loss by allowing wetter consistency at the mixer resulting in higher water cement ratios, shall not be permitted. All concrete conveyors, barrows and chutes shall be primed by washing with rich cement grout before use. These shall be thoroughly washed and cleaned immediately after stopping concreting.

A record shall be kept of the time and date of all concrete pours and the subsequent removal of formwork

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- 5.4.2.1** Concreting shall be commenced only after the Employer's representative has inspected the formwork and reinforcement as place and passed the same.

Shuttering shall be cleaned of all shavings, saw dust, pieces of wood, or other foreign material by the use of air and water pressure hoses. All accumulation of water or debris shall be flushed out through the holes or opening provided for the purpose. These holes shall be neatly plugged before concreting.

- 5.4.2.2** In the case of concreting of slabs and beams, wooden plank or cat-walks supported directly on the centering by means of wooden blocks or lugs shall be provided to take the concrete to the place of deposition without disturbing the reinforcement in any way. Traffic shall not be allowed over the reinforcement or freshly placed concrete.

- 5.4.2.3** The concrete shall be deposited in its final position in such a manner as to preclude segregation of ingredients. In deep trenches and footings, concrete shall be placed through chutes as directed by the Employer's Representative. In the case of columns and walls, the shuttering shall be so adjusted that the vertical drop of concrete is not more than 1.5 meters at a time. The progress of concreting in the vertical direction shall be restricted to one meter per minute.

The mix shall be such that there will be no excess water on the top surface on completion of compaction. In the case of deep lifts, the water content of batches at the top may have to be reduced to compensate for water gain from lower levels.

- 5.4.2.4** During cold weather, concreting shall not be done when the temperature falls below 4.5 °C. The concrete placed shall be protected against frost by suitable covering. Concrete damaged by frost shall be removed and work redone.

- 5.4.2.5** The time between mixing and placing of concrete shall not exceed 30 minutes so that the initial setting process is not interfered with.

5.4.3 Compaction

Concrete shall be compacted into a dense mass immediately after placing by means of mechanical vibrators designed for continuous operation. The Employer's representative may however relax this condition at his discretion for certain items, depending on the scope of the work, on the thickness of the members and feasibility of vibrating the same, and permit hand compaction instead.

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Hand compaction shall be done with the help of tamping rods. Concrete shall be thoroughly compacted and completely worked around the reinforcement, embedded fixtures, duct formers and into corners of the formwork.

Compaction shall be completed before the initial setting starts, i.e. within 30 minutes of addition of water to the dry mixture.

Concrete shall be deposited continuously in layers of such thickness that no concrete is deposited on concrete which had hardened sufficiently to cause the formation of seams and planes of weaknesses within the section. If a section cannot be placed continuously, construction joints shall be located at points provided for in the plans or approved by the Employer's Representative. If a delay exceeding one hour occurs in placing, no fresh concrete shall be placed on that already deposited until the Employer's Representative's approval is obtained. The surface of the hard concrete is then to be prepared as specified in 5.4.4.

5.4.3.1 Use of Vibrators

The contractor shall inform the Employer's representative of the number and type of vibrators to be used. Stand by vibrators shall always be provided before commencement of work. External vibrators shall not be used without the approval of the Employer's Representative.

The vibrators shall maintain the whole of concrete under treatment in an adequate state of agitation, such that de-aeration and effective compaction are attained. The rate of the supply of concrete from the mixtures shall be commensurate with this. The vibration shall continue, throughout the whole duration of the placing of concrete, the vibrators being adjusted so that the centre of vibration approximates to the centre of the mass compacted at the time of placing.

The full depth of fresh concrete shall be compacted without damaging adjacent partly hardened concrete.

Concrete shall be considered as properly compacted when the air bubbles cease to appear on the upper surface and mortar fills the spaces between the coarse aggregate and begins to cream up to form an even surface.

When this condition has been attained, the vibrator shall be stopped if using vibrating tables or external vibrators, while needle vibrators shall be withdrawn slowly so as to prevent formation of loose pockets. In case both internal and external vibrators are being used, the internal vibrators shall first be withdrawn slowly after which the external vibrators shall be stopped so that no loose pocket is left in the body of the concrete. The specific instructions of the makers

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of the particular type of vibrator used shall be strictly complied with. Over vibration shall be avoided.

Shaking of reinforcement for the purpose of compaction should not be restored to. Likewise, all precautions shall be taken to prevent displacement of the reinforcement during the placing and compaction of concrete.

5.4.4 Construction Joints

Concreting shall be carried out continuously upto construction joints, the position and details of which shall be decided in advance and approved by the Employer's Representative. Such joints shall be kept to the minimum and shall not be located in valleys. The joints shall be located taking into account the shear and other stresses. They shall be straight and at right angles to the direction of main reinforcement. Immediately prior to re-commencement of concrete on a joint, the surface of the concrete against which new concrete will be cast shall be freed from laitance and shall be roughened to the extent that the largest aggregate is exposed but not disturbed. Care shall be taken that the joint surface is cleaned immediately before the fresh concrete is placed against it. A coat of neat cement slurry at the rate of 2.75 kg of cement per sqmeter shall then be applied on the roughened surface before fresh concrete is laid.

Particular care shall be taken in the placing of the new concrete close to the joint. This concrete shall be well compacted and if possible a vibrator shall be used.

Where the Employer's representative considers that special preparation is necessary, e.g. for an in-situ structural connection preparation shall be carried out preferably when the concrete has set but not hardened, by spraying with a fine spray of water or brushing with a stiff brush to remove the outer mortar and expose the larger aggregate without its being disturbed.

Where this treatment is impracticable sand blasting or a needle gun shall be used to remove the surface skin and laitance. Hacking of hardened surfaces shall be avoided.

5.4.4.1 Columns

In the case of columns, the joints shall be horizontal and located 100 to 150 mm below the bottom of the beam running into the column. The portion of the column above this joint shall be concrete with the beam. If a kicker (i.e. a starter stub) is used, it should be at least 70 mm high and carefully constructed. It is preferable for the kicker to be incorporated with the previously placed concrete. Where possible, the formwork should be designed to facilitate the preparation of the joint surface, as the optimum time for treatment is usually two to four hours after placing.

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5.4.4.2 Slabs and Beams

When stopping the concrete on a vertical plane in slabs and beams, an approved stop-board shall be placed with necessary slots for reinforcement bars. The construction joints shall be keyed by providing a triangular or trapezoidal fillet nailed on the stop-board. Inclined or feather joints shall not be permitted. Any concrete flowing through the joints of stop-boards shall be removed soon after the initial set.

5.4.5 Movements Joints

Movement joints shall generally be straight and conform to approved plans. The joints shall be formed with rigid formwork and stop ends suitably designed to cast the structurally separate components or parts. Filling of these joints with resilient joint fillers and the provision of copper or brass plates shall be as specified or directed.

A note on movement joints given in appendix 5B.

5.4.5.1 Contraction Joints

An interval of not less than 48 hours shall be allowed between casting of adjacent bays separated by formed contraction joints or construction joints.

5.4.5.2 Expansion Joints

Concrete shall not be placed on both sides of the joints at the same time unless otherwise approved.

5.4.6 Curing and Protection

5.4.6.1 Curing

After the concrete has begun to harden i.e. about 1 to 2 hours after its laying, it shall be protected from quick drying with moist gunny bags, sand or any other suitable material approved by the Employer's Representative. After 24 hours of laying of concrete, the surface shall be cured by flooding with water of minimum 25 mm depth, or by covering with wet absorbent material, e.g. damp hessian or jute, coconut or straw matting, or a layer of sand about 50 mm thick. The curing shall be done for a minimum period of 7 days.

5.4.6.2 Protection

It shall be the responsibility of the contractor to prevent damage to the fresh concrete surfaces from rain indentation and physical damage. Immature concrete shall be protected from physical shock or movement and thermal shock particularly from cold weather. Exposed concrete surface shall be protected from rust marks and other disfigurement.

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5.4.7 Finishing

5.4.7.1 Immediately on removal of forms, the reinforced concrete work shall be examined by the Employer's Representative, before any defects are made good.

- (a) Work that has sagged or contains honey-combing to an extent detrimental to structural safety or architectural concept shall be rejected.
- (b) Surface defects of a minor nature accepted by the Employer's representative shall be rectified as given below. Surface defects which require repair when forms are removed usually consist of bulges due to movement of forms, ridges at form joints, honey-combed areas, damage resulting from the stripping of forms and bolt holes.
 - (i) Bulges and ridges shall be removed by careful chipping or tooling and the surface shall then be rubbed with a grinding stone.
 - (ii) Honey-combed and other defective areas shall be chipped out, the edges being cut as straight as possible and perpendicularly to the surface, or preferably slightly undercut to provide a key at the edge of the patch.

Shallow patches shall first be treated with a coat of thin grout composed of one part of cement and one part of sand and then filled with mortar similar to that used in the concrete. The mortar shall be placed in layers not more than 10 mm thick and each layer shall be given a scratch finish to secure bond with the succeeding layer. The last layer shall be finished to match the surrounding concrete by floating, rubbing or tooling on formed surface by pressing the form material against the patch while the mortar is still plastic.

Holes left by bolts shall be filled with mortar carefully packed into place in small amounts. The mortar shall be mixed as dry as possible, with just enough water so that it will be tightly compacted when forced into place.

Tiered holes extending right through the concrete may be filled with mortar using a pressure gun (similar to the gun used for greasing motor cars).

Normally, patches appear darker than the surrounding concrete, possibly owing to the presence on their surface of less cement laitance. Where uniform surface color is important, this defect shall be remedied by adding 10 to 20 percent of white Portland cement to the patching mortar, the exact quantity being determined by trial.

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Care shall be taken to cure the material in the patches as taken with the whole structure. Curing shall be started as soon as possible after the patch is finished to prevent early drying. Damp hessian may be used but in some locations it may be difficult to hold it in place. A membrane curing compound will be most convenient in these cases.

5.4.7.2 Surface Preparation for Plastering

The surface which is to receive plaster or where it is to be joined with a brick masonry wall, shall be properly roughened immediately after the shuttering is removed, taking care to remove the laitance completely without disturbing the concrete. The roughening shall be done by hacking. Before the surface is plastered, it shall be cleaned and wetted so as to give good bond between concrete and plaster.

The reinforced concrete work shall be done to such tolerances that the thickness of plaster required for finishing the surface does not exceed 10 mm.

5.4.7.3 Surface Preparation for Floor Finishes

The surface of a reinforced concrete slab on which a screed or other finish is to be laid shall be roughened with brushes while the concrete is green. This shall be done carefully without disturbing the concrete.

5.4.7.4 Preparation for Roof Slabs

In case of roof slabs the top surface shall be finished even and smooth with a wooden trowel, before the concrete begins to set. When required, a brushed finish shall be obtained by brushing the surface with a stiff broom or wire brush while still green. This provides a slightly coarse surface.

5.4.8 Surface Finishes

This sub clause on finishes to in-situ concrete covers formed finishes, worked finishes on plastic concrete and worked finishes on hardened concrete.

The contractor shall provide form work appropriate to the required formed finish and to the dimensional tolerance it any specified.

Control samples shall be provided for the specified finish and approval of the appearance of each sample obtained from the Employer's representative in advance of construction.

The surface of plastic concrete shall not be wetted to assist surface working to obtain the specified finishes.

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All adjacent work shall be protected from damage when finishes are worked on plastic or hardened concrete particularly when working with power driven floating, toweling or grinding.

5.4.8.1 Formed Finishes

Formed finishes shall consist of one of the following;

- (1) Basic finish
- (2) Plain finish
- (3) Fine finish
- (4) Special finish

5.4.8.1.1 Basic Finishes

A basic finish shall be appropriate for areas which are not exposed in the finished work e.g. foundations, backs of retaining walls, areas to be subsequently clad, plastered or rendered. There are no special requirements for this finish except those for dimensional tolerances. The concrete shall be fully compacted and shall be sound.

5.4.8.1.2 Plain Finish

A plain finish shall be appropriate for plain concrete surfaces exposed in the finished work. E.g. Car parks subways, circulation areas and areas to be subsequently painted.

The general requirements for plain finish shall be as follows:

- (1) The surface shall have an even finish by use of a sheet material e.g. plywood.
- (2) Panels shall be arranged in a regular pattern as a feature of the surface.
- (3) The concrete surface shall be free from voids, honey combing and other large defects. Blow holes shall not be more than 10 mm diameter.
- (4) The concrete surface shall be free from discoloration due to contamination or grout leakage but variation in color resulting from the use of an impermeable form lining may be permitted.

The tolerances for the concrete surfaces shall be as follows;

- (a) Abrupt irregularities not more than 5 mm.
- (b) Gradual irregularities expressed as maximum permissible deviation from a meter straight edge shall be not more than 5 mm.

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- (c) The arises to columns, walls etc. Shall be chamfered or rounded as specified in the drawings or as directed by the Employer's Representative.

Plain finish shall be left as struck unless otherwise specified. Making good of small defects will normally be permitted but only after inspection by the Employer's representative Blowholes shall be filled with mortar to an approved sample.

5.4.8.1.3 Fine Finish

Fine finish shall be adopted for areas of high aesthetic importance and generally only for internal work. The contractor shall provide the control sample of fine finish in an approved location in advance of construction.

The general requirement for fine finish shall be as follows;

- (i) A smooth even finish shall be produced with an impervious sheet material e.g.plastic faced plywood.
- (ii) Panels shall be mad as large as practicable and arranged in an approved regular pattern as a feature of the surface.
- (iii) Blow-holes less than 5 mm will be permitted but otherwise the surface shall be free from voids, honey combing and other defects.
- (iv) Variation in color resulting from the use of impermeable form lining will be permitted but the surface shall be free from discoloration due to contamination or grout leakage.
- (v) Cover spacers shall not be used without the approval of the Employer's Representative.

Tolerances for the fine finished surfaces shall be as follows;

- (a) Abrupt irregularities in the surface shall not be more than 3 mm.
- (b) Gradual irregularities expressed as maximum permissible deviation from a one meter straight edge shall not be more than 3 mm
- (c) Arises of columns, walls etc shall be chamfered/rounded as detailed in the drawing or as specified by the Employer's Representative.

Formwork ties shall not be used except with the permission of the Employer's Representative.

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Making good of fine finished concrete will not be permitted and the surface shall be left as struck.

Blow holes shall be filled with mortar to an approved sample.

5.4.8.1.4 Special Finish

Special finishes to concrete surfaces like rough board finish, ribbed finish, coffered/Troughed etc. shall be provided by the Contractor to the specific requirements and tolerances indicated in the drawings.

5.4.8.2 Worked Finishes: Plastic Concrete

Worked finishes (normally to horizontal surfaces) shall be produced by working the concrete when still in the plastic condition.

The worked finishes on plastic concrete shall be one of the following:

- (a) Tamped Finish
- (b) Scored Finish
- (c) Floated Finish
- (d) Trowel led Finish

5.4.8.2.1 Tamped Finish

The surface of plastic concrete shall be stamped with the edge of a board or beam of adequate size and weight to give an even texture of parallel ribs. The concrete surface shall thus be given an overall ribbed affect. It shall be noted that the tamping shall be started with very little bleeding water present on the surface.

5.4.8.2.2 Scored Finish

This type of finish which gives an overall roughened surface to the concrete and shall be obtained by scoring (scratching) the concrete surface at the appropriate time with a stiff brush, metal comb, trowel or a length of mesh reinforcement.

5.4.8.2.3 Floated Finish

The surface shall be floated with a wooden float to give an even, slightly coarse texture with no ridges or steps. Alternatively skip float or power float may be used to give the required finish. Floating has to be timed properly to achieve the best results.

5.4.8.2.4 Trowel led Finish

After obtaining an initial finish using a wooden float/power float a fine smooth finish shall be given to concrete surfaces by hand troweling or power troweling. Power troweling shall be adopted for large unbroken areas with few ducts, recesses etc. The timing of power troweling in relation to the ambient condition of concrete shall be such that the concrete shall be sufficiently stiff to take the weight of the machine and the operator, yet sufficiently workable for the troweling to be effective. Vacuum dewatering may be adopted to overcome this timing problem, if so directed.

5.4.8.3 Worked Finishes: Hardened Concrete

Hardened concrete shall be given the following surface finishes as specified.

- (a) Abrasive blasted Finish
- (b) Tooled Finish
- (c) Power ground floor Finish

Finishes on hardened concrete noted above shall be worked over a formed finish or worked finish on plastic concrete.

5.4.8.3.1 Abrasive Blasted Finish

Abrasive blasted finish shall be carried out over a plain/fine/floated finish. These shall conform to approved samples and shall be carried out within 7 days of striking of formwork. The surface shall be blasted with an approved abrasive to even texture and to the depth of exposure specified. The minimum depth of exposure shall be 1 mm for light plastered finishes. Abrasive blasting shall be stopped short of arises with regular margin of 40 mm or as otherwise directed.

5.4.8.3.2 Tooled Finish

Tooled finishes shall be obtained over an initial plain finish surface or a ribbed finish surface by using a snub-nose tool/Disc head bush hammer/combed chisel or other approved tools. Tooling shall be carried out only on a concrete which is at least 21 days old and has a compressive strength of not less than 20 N/mm² when tooling is carried out. Tooling shall be stopped short of arises with a regular margin of 40 mm or as otherwise directed.

5.4.8.3.3 Power Ground Floor Finish

Power grinding shall be used to produce a hard wearing surface suitable for the direct application of thin sheet or tile covering. Grinding shall be used as a finishing technique and shall not be used to correct gross irregularities in the surface. The objective shall be to remove the thin, weak surface layer of concrete (about 1 mm thick) to produce a surface which is less prone to dusting and wear, more coarse and slip resistant.

STANDARD TECHNICAL SPECIFICATION

A sample shall be provided by the Contractor in an approved location. Power grinding shall be carried out on a floated finish obtained with specified tolerances. (The normal gradual irregularities of the surface shall be not more than 2 mm on a 1 meter straight edge.) Power grinding shall normally be done dry and within 7 days of concreting. After grinding, all dust shall be swept away and the surface thoroughly washed down. To reduce dusting, a surface hardening solution may be applied to the specification of the manufacturer, if so directed by the Employer's Representative.

5.4.9 Sampling and Compliance Criteria For Strength of Concrete

5.4.9.1 General

Sampling and testing of concrete shall be as per B.S. 1881.

The characteristic strength of concrete on which the structural design is based is that 28 day cube strength below which not more than 5% of the test results may be expected to fall.

Compliance with the specified characteristic strength should generally be judged by tests made on cubes at an age of 28 days. In order to get an idea of the quality of the concrete sooner, compressive strength test at 7 days may be used to test compliance with the specified characteristic strength.

For this purpose the 7 days strength may be taken to be 75% of the 28 day cube strength. The rate of sampling shall generally be as given below unless otherwise decided by the Employer's Representative.

One sample shall be taken from any one batch selected randomly to represent an average volume of not more than 20 cubic meters, 20 batches or 1/4 of the total quantity of concrete under consideration for testing whichever is the lesser volume, but not at a rate less than 1 sample per day per grade.

5.4.9.2 Testing Plan and Compliance Criteria

Three test specimens shall be prepared for compliance and all the specimens shall be cured as follows:

- (a) for 28 days
- (b) by any other regime of curing agreed between the producer and the purchaser (e.g. 7 days normal curing or accelerated curing at an elevated temperature) that is capable of predicting the strength of 28 days.

STANDARD TECHNICAL SPECIFICATION

To assess compliance as regards compressive strength, the first result alone cannot be used to judge compliance with the specified characteristic strength.

Compliance with the characteristic strength is based on groups of four consecutive test results. Compliance with the specified characteristic strength may be assumed if the average strength determined from any group of four consecutive test results and if each individual test result complies with the appropriate limits in columns A and B of Table 5.5 respectively.

When there are less than four results, i.e. at the start of a job or on small jobs, the average of the first 2 or first 3 results, and the individual results should comply with the appropriate limits in columns A and B of Table 5.5 respectively.

For a test result, the difference between the strength of two specimens prepared from the same sample shall not exceed 5 N/mm².

Table 5.5 - Compressive Strength Compliance Requirements

A			B		
Specified Grade	Test Results	Average of first 2 of first 3, or of 4 consecutive test results exceeds the specified characteristic strength by at least	Specified Grade	Test Results	Any individual test result is not less than the specified characteristic strength minus
C 20 and above	first 2 first 3 Consecutive 4	1 N/mm ² 2 N/mm ² 3 N/mm ²	C 30 and above	first 2 first 3 Consecutive 4	3N/mm ² 3 N/mm ² 3 N/mm ²
Below C 20	first 2 first 3 Consecutive 4	0 N/mm ² 1 N/mm ² 2N/mm ²	Below C 30	first 2 first 3 Consecutive 4	2N/mm ² 2N/mm ² 2N/mm ²

Note 1 If the work is of minor nature or when the total volume of concrete is small, the following alternatives may be used

STANDARD TECHNICAL SPECIFICATION

- (a) the average value of 3 cubes made from the same sample shall equal or exceed the characteristic strength
- (b) the lowest individual strength of any cube shall not be lower than 0.85 of the characteristic strength, and
- (c) the allowable range (maximum minus minimum value) of the strength of the 3 cubes made from the same sample shall not exceed 20% of the average value of the 3 cubes

Note 2 The quantity of concrete represented by a group of 4 consecutive test results shall include the batches from which the first and last samples were taken together with all intervening batches. Similarly the first 2 or 3 results shall be taken as representing all the intervening batches. For the individual test results requirements given in column B of Table 5.5 only the particular batch from which the sample was taken shall be at risk.

5.4.9.3 Compliance Criteria for prescribed and volume batched mixes

The testing plan and compliance criteria can be as for designed mixes above, based on the equivalent grades specified for the prescribed and volume batched mixes. If compliance is based on strength in the manner, the cement content and water/cement ratio requirement can be deemed to have been satisfied.

On the other hand, compliance can be assessed, without strength testing, by either observation of the batching or examination of the autographic records of the batch weights used. Such an individual assessment of the mix proportions shall be within + 5 % of the values specified, and the mean of any 4 consecutive assessments of cement content shall not be less than the specified value. Account shall be taken of the adjustments permitted in Note 2 of Appendix 4 D.

STANDARD TECHNICAL SPECIFICATION

Appendix 5 A

REINFORCED CEMENT CONCRETE

Maximum Anchorage Length of Single Bars					
Concrete Grade	Code used	Tension		Compression	
		Mild Steel	TOR Steel	Mild Steel	TOR Steel
20 (i.e. 1:2:4 mix)	BS 8110	44	45Ø	36Ø	36Ø
25	BS 8110	39Ø	40Ø	32Ø	32Ø

Average Anchorage Stress

fy.	Tension		Compression	
	Con.Gr.20	Con. Gr. 25	Con.Gr. 20	Con.Gr. 25
460 N/mm ²	2.24	2.50	2.82	3.15
250 N/mm ²	1.25	1.4	1.57	1.75

Note : Lapping (as per clause 3.11.6.5 BSCP 110) When bars are lapped, the length of the lap should at least equal the anchorage length required to develop the stress in the smaller of the two bars lapped, except that for deformed bars in compression the length of the lap should be 25% greater than the anchorage length required for the smaller bar.

The length of lap provided however, should be less than 15 Ø or 300 mm whichever is greater.

Appendix 5 B

Movement Joints - shall be as specified or directed.

In general movement joints in the structure should pass through the whole structures in one plane. Movement joints may be of the following types

- (a) Contraction Joint - This has a deliberate discontinuity but no initial gap between the concrete on both sides of the joints as it is intended to permit contraction of the concrete.

STANDARD TECHNICAL SPECIFICATION

- In a complete contraction joint - both concrete and reinforcement are interrupted.
- In a partial contraction joint - only the concrete is interrupted while the reinforcement runs through.
- (b) Expansion Joint - A joint with complete discontinuity in both reinforcement and concrete intended to accommodate either expansion or contraction of the structure. Generally a wide gap between the adjoining parts of the structure is provided.
- (c) Sliding joint - a joint with complete discontinuity in both reinforcement and concrete at which special provision is made to facilitate relative movement in the plane of the joint.
- (d) Hinged joint - a joint specially designed and constructed to permit relative rotation of the members at the joint.
- (e) Settlement joint - a joint permitting adjacent members or structures to settle or deflect relative to each other.

A joint may be designed to fulfill more than one of the above requirements.

CHAPTER 6
Brick Work and Block Work

Definitions

Bat

A portion of a brick either especially manufactures or formed on site by cutting a whole brick across its length.

Bond

A disposition of units in a wall usually designed to ensure that the cross joints in each course are not less than one quarter of the length of a unit from those in adjacent courses.

Bricks

A masonry unit not exceeding 337.5 mm (13-1/2") in length, 225 mm (9") in thickness or 112.5 mm (4-1/2") in height. (The height is taken to be the vertical dimension perpendicular to the base when the unit used in its normal aspect. The height of a brick shall not less than 38 mm (1 dimension, it shall be classified as a tile)

Blocks

A masonry unit which when used in its normal aspect exceeds the length or width or height specified for bricks.

Solid Blocks

In which small holes passing through or nearly through the brick do not exceed 25% of its volume or in which frogs (depressions in the bed faces of a brick) do not exceed 20% of its volume.

Hollow Blocks

In which holes passing through the unit exceed 25% of its volume.

Coordinating size: The size of a coordinating space allotted to a masonry unit including allowances for joints and tolerances.

Work size: The size of a masonry unit specified for its manufacture, to which its actual size should conform within specified permissible tolerances.

Compressive Strength: The average value of the crushing strengths of ten masonry units tested in accordance with BS.

STANDARD TECHNICAL SPECIFICATION

Common: Suitable for general building work but having no special claim to give an attractive appearance.

Facing: Specially made or selected to give an attractive appearance when used without rendering or plastering or other surface treatment for the wall.

Brick work & Block work

As assemblage of units (brick or blocks) bonded together with mortar to form a wall including piers or columns.

Closer

A portion of a unit used to maintain bond, either specially manufactured or formed on site by cutting a whole unit along its length.

Corbel

A unit cantilevered from the face of a wall to form a bearing.

Cornice

A projection, generally continuous, from the facade of a building or part of a building or wall.

Course

A layer (e.g. a course of brickwork or blockwork) which includes a layer of mortar as well as a layer of units.

Over Sailing Course

Brick course projecting from a wall for the sake of appearance only as distinct from corbels which are load carrying.

Damp-proof Course

A layer, or layers, of materials laid or inserted in a structures to prevent the passage of water.

Efflorescence

An encrustment of salt left by evaporation.

STANDARD TECHNICAL SPECIFICATION

Flashing

A sheet of impervious material fixed to a structure and dressed to cover an intersection or joint where water would otherwise penetrate.

Footings

A projecting course or courses formed below the base of a wall to distribute the load.

Frog

A purpose-made indentation in either or both of the two largest faces of a brick.

Header

A unit with its end showing on the face of the wall.

Indenting

The omission of units to form recesses into which future work can be bonded.

Jamb

That part of a wall at the side of an opening (see reveal).

Joint

A junction between walling units.

Bed joint - The mortar layer upon which walling units are set.

Cross joint - A joint, other than a bed joint, normal to the face of a wall.

Wall joint - A joint parallel to the face of a wall.

Masonry Unit

A block, a brick or a fixing unit.

Pad stone (Template)

A strong block bedded on a wall to distribute a concentrated load, sometimes known as a template.

Parapet

Top section of a wall where it conceals the gutter of the roof.

Partition wall

Any internal wall primarily intended for sub-division of space

Pier

A thickened section forming an integral part of the wall, placed at intervals along the wall primarily to increase the stiffness of the wall or to carry a vertical concentrated load.

STANDARD TECHNICAL SPECIFICATION

Pilaster

Attached pier.

Pillar or Column

A detached masonry support, rectangular, circular, or elliptical in shape.

Plinth

A projecting base of an external wall which gives additional stability.

Pointing

The refilling and finishing of joints from which mortar has been raked out.

Quoin

An external corner.

Reveal

The visible part of each side of a recess or opening in a wall (see 'jamb')

Scaffolding

A temporary erection of bamboo, timber, or steel work, used in the construction, alteration, demolition or repairs of a building to support or to allow the hoisting or lowering of workmen, their tools and materials.

Sill

Work forming the lower boundary of door or window opening.

Stretcher

A unit laid with its length in the direction of the wall.

String Course

A distinctive course or band in a wall, usually horizontal and sometimes projecting and molded.

Template

A pattern, usually of sheet material, used as a guide for setting out particular work.

STANDARD TECHNICAL SPECIFICATION

Toothing

Units left projecting to bond with future work.

Weathering

This term is used to describe both :-

- (i) the cover applied to, or the geometrical form of, a part of a structure to enable it to show rain water.
- (ii) the effect of climatic and atmospheric conditions on the external surfaces of material.

6.1 Materials

6.1.1 Common Burnt Clay Bricks

General

Bricks shall be hand or machine moulded. They shall be regular in shape with good clean arises, free from lumps of unslaked limestone, etc.

Their surface shall be free from striations, laminations, pitting, cracks etc. They shall be uniform in color and must be well burnt so as to give a clear ringing sound when struck. When broken, the fracture shall give a close grained uniform texture and color and shall be free from black core or any sign of being imperfectly burnt.

The dimensions of bricks shall be 220 mm x 105 mm x 65 mm (8.7" x 4.1" x 2.6").

The general and specific requirements are tabulated below in Table 6.1

Description	Type I	Type II	
		Grade I	Grade II
Method of manufacture	Wire-cut, machine made	Hand-made	Hand-made
Average compressive strength not less than	10 N/mm ² (1450 p.s.i.) storeyed	4.8 N/mm ² (700 p.s.i.)	2.8 N/mm ² (410 p.s.i.)
Use in locations (unless otherwise specified)	Load bearing multi storeyed	Two-storeyed construction	Single storey construction
Maximum water absorption	18%	28%	28%
Efflorescence	Slight	Moderate	Moderate

STANDARD TECHNICAL SPECIFICATION

Nominal dimension of individual bricks	220 mm x 105 mm x 65 mm (8.7"x4.1"x2.6")	
Overall dimension of 24 Bricks	L 5280 \pm 75 mm (207.93 \pm 3.0 in) B 2520 \pm 40 (99.2 \pm 1.6 in) D 1560 \pm 40 (61.4 \pm 1.6 in)	
Other features	The bed faces shall be provided with grooves, frogs (depressions) or holes to ensure adequate bonding.	

6.1.1.1 Sampling and testing of bricks

The bricks shall be sampled and tested for dimensions, general requirements, compressive strength, water absorption and efflorescence as per BS. Acceptance criteria shall be as set out in the same standard. The testing methods are given in appendix 6A.

6.1.2 Pre-cast blocks/bricks

General

These shall be composed of cement mortar/cement concrete in specified proportions, or the proportions needed to achieve the specified compressive strength. These shall generally conform with B.S. 6073 Part I and Part 2.

6.1.2.1 Materials

Cement - shall be Ordinary Portland Cement conforming to BS 12.

Aggregates - shall be natural aggregates conforming to BS 882 except that the fine and/or coarse aggregates need not be graded.

Admixtures - Use of admixtures shall be not permitted without the prior approval of Employer's Representative.

STANDARD TECHNICAL SPECIFICATION

6.1.2.2 Sizes and shape

The blocks/bricks shall be true to shape with good, clean arises. The minimum thickness of the external shell of hollow and cellular blocks shall be not less than 15 mm or 1.75 times the nominal maximum size of the aggregate whichever is the greater.

The maximum size of bricks shall be 337.5 mm x 225 mm x 112.5 mm. The size of bricks shall generally conform to the work sizes in B.S. 6073 Part 2, Table 2 given below :

Work sizes of Bricks;

290 x 90 x 90 mm

215 x 103 x 65 mm

190 x 90 x 90 mm

190 x 90 x 65 mm

The size of blocks shall generally conform to the work sizes in BS 6073 Part 2 Table 1 given below :

Table 6.2 - Work sizes of blocks (ref. Table No. 1 of BS. 6073: Part 2: 1981)

Thickness mm		60	75	90	100	115	125	140	150	175	190	200	215	220	225	250
Length mm	Height mm															
390	190	x	x	x	x	x		x	x		x	x				
440	140	x	x	x	x			x	x		x	x			x	
440	190	x	x	x	x			x	x		x		x	x		
440	215	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
440	290	x	x	x	x			x	x		x	x	x			
590	140		x	x	x			x	x		x	x	x			
590	190		x	x	x			x	x		x	x	x			
590	215		x	x	x		x	x	x	x		x	x		x	x

6.1.2.3 Strength requirements

Bricks/Blocks of thickness 75 mm or more when tested for compressive strength shall comply with the followings:

- (a) the average crushing strength of 10 bricks shall be not less than 7.0 N/mm²
- (b) the average crushing strength of 10 blocks shall be not less than 2.8 N/mm²
- (c) the coefficient of variation for the sample shall not exceed 20%

STANDARD TECHNICAL SPECIFICATION

Blocks less than 75 mm shall be tested for transverse strength in accordance with the code and the average transverse strength of 5 blocks shall be not less than 0.65N/mm^2

6.1.2.4 Manufacture

Cement mortar used for manufacture of bricks shall be 1:6 or other proportion needed to achieve the specified compressive strength and the mortar shall be of stiff consistency.

Cement concrete for blocks/bricks shall be 1:3:6 (14 mm) or other proportions needed to achieve the strengths specified. Concrete shall be of the required consistency to suit the moulds and the methods of compaction.

The units shall be manufactured by machines of approved make. In the absence of machines, they shall be cast in properly designed rigid steel moulds or wood moulds lined with galvanized steel sheets. The mould surfaces shall be cleaned and smeared with a suitable oil after each casting. Hand tamping shall be with 16 mm diameter steel rods and shall be continuous after filling the first 25 mm. The units as cast, shall be dense and solid as they come from the block making machines or moulds. The units showing cavities of any kind must be broken up immediately however, the concrete may be re-used the time since mixing has not exceeded 30 minutes. Under no circumstances shall the units be plastered at any stage to cover up defects.

Units which are too smooth to provide a key for the final plaster coating may be bristle brushed to provide a slightly rough surface after they have hardened for 6 hours.

Curing shall be carried on for 14 days. The units shall be cured for the first seven days by immersion in water commencing not earlier than 16 hours after casting they shall thereafter be kept wet by stack curing for a further period of seven days, the units being stacked to a height of not more than 1.2 meters. In the case of hollow blocks the cavities shall be filled with sand and water shall be supplied as required to ensure their being wet throughout the day and night. On sunny and windy days, the top and side faces of stacks shall be protected with cadjans or hessian canvas which shall be removed at frequent intervals for watering.

The units shall be built into the work not earlier than 4 weeks from casting.

6.1.2.5 Sampling and testing of blocks

This shall be as per clause 13 of BS 6073 Part I.

The units shall be made in batches, and from each batch of 1,000 not more than 15 units will be selected at random for testing the compressive strength and drying shrinkage.

STANDARD TECHNICAL SPECIFICATION

In the case of blocks less than 75 mm thick, 10 blocks shall be selected for testing the transverse strength and drying shrinkage. The further preparation of the selected units for testing as described in the British Standard is to be done at the site, by the contractor who shall in the presence of the Employer's Representative, pack the units in approved packing cases with suitable packing material to ensure the units remaining damp during transit and deliver them at the approved testing station at his own expense. The cost of the actual test shall be borne by the owner. In the event of the units tested failing to meet the specified strength requirements, they shall be (at the discretion of the Employer's Representative) relegated to some lesser category or condemned. In the former case they shall be suitably marked to avoid confusion and in the latter case they shall be removed from the site without delay.

6.2 Brickwork (Clay Brick)

6.2.1 Mortars for Brickwork

These shall conform to Chapter 3.

Mortar for brickwork shall be generally as given below in Table 6.3 unless otherwise specified.

Type of Mortar	Mortar Designation	Mix by volume Masonry				Location
		Cement	Cement	Lime	Sand	
Cement-sand	iv	1	-	-	8	All walls above ground level except 4 1/2" brick work -do- -do-
cement-lime sand	iv	1	-	2	9	
Masonry cement sand	iv	-	1	-	5	
Cement-sand *	iii	1	-	-	5	in 4 1/2" brick and in walls below ground level where specified. -do-
cement -lime sand	iii	1	-	1	5	
Masonry cement	iii	-	1	-	4	
Cement-sand * -	ii	1	-	-	3	-do-
cement-lime sand	ii	1	-	1/2	4	-do-
masonry cement	ii	-	1	-	2 1/2	-do-
cement -sand *	i	1	-	-	3	-do-

Note : (1) * Plasticizer of approve manufacture shall be used if directed by the Employer's Representative.

(2) The gauge box for cement shall be 400 x 350 x 290 mm or 300 x 300 x 350mm

The corresponding gauge box for lime and sand shall be 400 mm x 350 mm x 250 mm or 300 x 300 x 300 mm respectively

STANDARD TECHNICAL SPECIFICATION

6.2.2 Handling of Bricks and Preparation

Bricks shall not be handled in baskets, thrown from a height or in other manner that would destroy the sharpness of the edges. In no case shall bricks of different dimensions be used in the same-work except when specially permitted by the Employer's Representative.

In exposed brick work, selected bricks of the specified class shall be used for the face work.

The bricks shall be wetted with water (immersed in water) before use on works. Bricks required for masonry with mud or fat lime need not be wetted. The tops of walls left off shall be wetted before the work is recommenced.

6.2.3 Laying and Jointing

Bricks shall be laid in English bond unless otherwise specified. Half or cut bricks shall not be used except where necessary to complete the bond; Closers in such cases shall be cut to the required size and used near the ends of walls. In all load bearing walls the bricks shall be laid with frogs upwards and the frogs shall be filled with mortar.

A layer of mortar shall be spread on full width over a suitable length of the lower course. Each brick shall be properly bedded and set home (in position) by gentle tapping with the handle of a trowel or wooden mallet inside faces of the set bricks shall be buttered with mortar and the next brick to be laid shall be pressed against it. All bricks in every course shall be grouted full with mortar using the trowel for chasing in for this purpose.

The thickness of mortar joint shall not exceed 10 mm.

6.2.4 Raising of Walls

The quoins shall be set out and built up in advance of the main body of the brick walling.

The walls shall be carried up uniformly in all cases where the nature of the work admits it. No part shall be left more than one meter below the rest of the work. The work shall not be built higher than 1.5 m in one day. The courses shall be kept perfectly horizontal and every fourth course shall be checked for level and plumb. Courses shall be break joints. At the end of the day's work and where it is not possible to raise the adjoining portion uniformly and in gable walls, the work shall be raked back according to the bond, at an angle not steeper than 45°.

All Perpendics, Quoins etc. shall be kept strictly true and square and the whole properly bonded together and brought to final levels at each floor. Over hand laying shall not be used without approval. Panel walls or non load bearing walls shall not but against the concrete beams or slabs.

STANDARD TECHNICAL SPECIFICATION

The lateral stability of walls which are free standing during construction shall be ensured by adequate shoring and scaffolding until the roof or floor providing the necessary stability is constructed.

6.2.5 Curing and Protection

Brick work shall be protected from rain by suitable covering when the mortar is green. Brickwork in cement/composite/lime mortar (except fat lime mortar) shall be kept constantly moist on all faces for minimum period of seven days. In the case of masonry with fat lime mortar, curing shall commence two days after laying and shall continue at least for seven days thereafter.

6.2.6 Fixtures Etc.

All iron fixtures like hold fasts, pipes, etc. which are required to be built in to the wall shall be embedded in their correct positions in cement mortar or cement concrete as specified.

6.2.7 Raking of Joints for Plaster

When the face work is to be plastered or joints alone pointed upon, the joints shall be raked to a minimum depth of 12 mm by a raking tool during the progress of work or when the mortar is still green. When plastering or pointing is not required to be done, the joints shall be struck flush and finished at the time of laying. The face and top of courses of the brick work shall be cleaned thoroughly of all mortar droppings on the same day.

6.2.8 Brick on Edge Coping

The top course of all plinths, the top of walls below reinforced concrete parapets, steps etc. shall be brick on edge with extra fine vertical joints not exceeding 3 mm in thickness. Bricks forming the corners of all such courses are to be properly radiated and keyed in to position.

6.2.9 Treatment at Ends of Beams Etc.

The ends of steel beams and roof trusses shall rest in recesses having 15 mm space for free circulation of air and provided with perforated zinc sheeting.

6.2.10 Corbelling

Corbelling shall be effected by a one fourth brick projection (in every course) for ordinary work and a one eighth brick projection where greater strength is required.

STANDARD TECHNICAL SPECIFICATION

6.2.11 Damp-Proof Course

This shall conform to clause 11.1

6.2.12 Scaffolding

For all exposed brick work, double scaffolding having two sets of vertical supports shall be provided. The supports shall be sound and strong and tied together with horizontal pieces over which scaffolding planks shall rest. Alternatively steel scaffolding may be resorted to, in which case the arrangements shall be approved by the Employer's Representative.

For all other brick work in buildings single scaffolding shall be provided. In such cases, the inner end of the horizontal scaffolding pole shall rest in a hole provided only in the header course for this purpose. Only one header for each pole shall be left out. Such holes for scaffolding shall however, not be allowed in pillars/columns less than one meter in width, or immediately near the skew back of Arches. The holes left in masonry work for scaffolding purposes shall be completely packed and made good before plastering.

Note: - In the case of special type of brick work, scaffolding shall be got approved by the Employer's representative in advance.

6.2.13 Half Brick Masonry

The work shall be done in the same manner as specified in 6.2.4 except that all courses shall be laid as stretchers. The proportion of cement mortar shall generally be one part of cement to 5 parts of sand.

6.2.14 Reinforced Brickwork

In special cases such as long unsupported partition walls where reinforcement is considered necessary, 2 numbers of 6 mm diameter rods shall be provided at every alternate course unless otherwise specified. The rods shall be straight and free from rust and loose flakes. They shall be placed over cement mortar beds of 1:3 composition. 10 mm thickness of mortar shall first be laid, the rods laid and then covered with a bed of 10 mm mortar immediately. The rods shall be fully embedded in the mortar. At the ends, the rods shall be bent up for half the thickness of the course.

6.2.15 Honey-Comb Brickwork

Standard or specified bricks shall be used for this class of work and they shall be laid on cement mortar 1:3 or as otherwise specified.

STANDARD TECHNICAL SPECIFICATION

The thickness of brick honey-comb shall be half brick or one brick as specified. Openings shall be equal and alternate in every course and the bearing width, on each side shall be 20 mm minimum. The bond used shall be heading throughout in one brick thick honey-comb, and stretchers throughout in half brick thick honey-comb work. The bricks shall be thoroughly bedded in mortar and jointed and the edges struck flush and finished smooth as the work proceeds.

6.2.16 Brickwork in Arches

Bricks for Arch work shall be specially selected and shall be free from defects of any sort.

The bricks shall be laid in concentric half brick rings with break joints (i.e. staggered joints). The arch work shall be carried out from both ends simultaneously and keyed in the centre. The bricks shall be buttered with mortar and well pressed in to their positions so as to squeeze out a part of the mortar and leave the joints thin and compact. All joints shall be full of mortar and the thickness of joints shall neither be less than 5 mm nor more than 15 mm in all arches; the voussoir joints shall be normal to the curve at these points.

Bricks forming skew back joints shall be specially moulded or cut so as to radiate thinly, and defects in this particular case shall not be remedied by the extravagant use of mortar nor shall any parthing by chips be allowed.

Joints in any two consecutive rings shall not come in the same radial plane.

The arch work shall be quickly and evenly done and kept moist so that no portion of the arch hardens or sets before the whole arch is completed.

6.2.16.1 Centering for Arches

In all centers the upper bearing surface shall be very correctly formed to the curve of the intrados of the arch. The centering shall be strong enough to bear the dead load and live load coming upon it during construction without any appreciable deflections. For spans longer than 2 meters, timber centers shall be used and shall be provided with hard wood wedges for slackening. For larger span arches special plans for centering shall be prepared and prior approval of the Employer's Representative obtained.

In all centers the arrangement shall be such that the slackening can be effected without any vibration being transmitted to the arch, and in the case of a series of arches that the centers can all be slackened simultaneously. The time after which this slackening has to be done shall be carefully decided.

STANDARD TECHNICAL SPECIFICATION

When lime mortar is used, centers will ordinarily be slackened within 24 hours of the completion of the arch. Care however, shall be taken to see that the centering is not eased while the mortar in the last joint is so soft that it will be squeezed out, but at the same time centers will be slackened while the mortar in the joints is still moist so as to allow the arch to compress itself and bring all the joints to fair bearing.

In the case of a segmental arch, care shall be taken to see that the skew backs are secure, and they shall be given a week's time to set.

In the case of semicircular, elliptical or other arches springing from a horizontal joint, the adjacent wall shall be built up to two thirds of the height of the arch before slackening centers.

6.2.17 Joining Old Work with New Work

New work shall be bonded carefully to existing work by cutting pockets into existing walls; the pockets shall not be less than 10 mm deep, with a width equal to the full thickness of the new work. The spacing and height of each pocket shall be as follows; for joining of

Brick to Brick - 4 courses high and at 8 course centers.

Brick to Block,

Block to Brick - every alternate block course. Block to Block

The new walling shall be bonded well into the pockets with all voids filled solid with mortar.

6.3 Masonry With Cast Block/Brick

Unless otherwise specified, the blocks shall be built in cement mortar 1:5, with joints not exceeding 10 mm in thickness. The blocks shall not be wetted before use.

Concrete Blockwork and brickwork shall be reinforced for construction in cyclone-prone areas.

Where concrete is to be laid over hollow block masonry, this shall be done over a specially cast hollow block course with the top of the cavities filled with concrete to a depth of at least 25 mm.

Where the space between the block course and reinforced or plain concrete above that course is less than the height of a block, the same shall be filled with cement concrete 1:3:6 (20 mm) or as specified.

The cavities between the reveal of any opening and the block work shall be filled up with cement concrete 1:3:6 (20 mm) for the length of a block.

STANDARD TECHNICAL SPECIFICATION

Appendix 6A - Test for Bricks

1. Checking the Dimensions

The bricks selected in accordance with BS shall be grouped into one or more sets of 24 bricks. The overall dimensions shall be measured by placing each set of 24 bricks in contact in a straight line on a level surface. Any blisters or other small projection together with any loose particles of clay shall be removed before the bricks are assembled for measurement. The overall length of each set of assembled bricks shall be measured with a steel tape, or other suitable inextensible measure long enough to measure the whole row at once. Measurement by repeated application of a short rule or measure shall not be permitted. If the measured dimensions of each set of 24 bricks falls within the limits specified below the bricks shall be considered to have passed this test.

$$L = 5280 \pm 75 \text{ mm (207.9} \pm 3\text{")}$$

$$B = 2520 \pm 40 \text{ mm (99.2} \pm 1.6\text{")}$$

$$D = 1560 \pm 40 \text{ mm (61.4} \pm 1.6\text{")}$$

2. Determination of Compressive Strength

Each brick to be tested shall be rubbed down as necessary to obtain a smooth plane surface on each face to receive the load. The bricks shall be immersed in water at room temperature for 72 hours. The bricks shall be removed and allowed to drain at room temperature, wiped free of surplus moisture and subjected to the test within 90 minutes of immersion. They shall be placed between two 3 - play plywood sheets 4 mm thick, and carefully centered between the platens of the machine.

One of the platens of the testing machine shall have a ball seating in the form of a portion of a sphere the centre of which coincides with the centre of the face of the plate. The load shall be applied in the direction of the thickness of the brick at a rate of 14 Mpa (2.0×10^3 1 bf/in) per minute until failure occurs. The compressive strength shall be calculated by dividing the maximum load on failure by the area of the face on which the load is applied and shall be expressed in Mpa (1bf/in²). If the arithmetic mean of the compressive strengths of the bricks tested does not fall below the relevant value specified in Cl. 6.1.2.3 the bricks shall be considered to have passed this test.

Note : For the purpose of this test the brick shall be deemed to have failed when there is a momentary decrease in the rate of advance of the indicator of the testing machine, combined with fracture of the brick.

STANDARD TECHNICAL SPECIFICATION

3. Determination of Water Absorption

The bricks shall be dried to constant mass in a well ventilated oven at 100°C. They shall then be cooled to approximately room temperature and weighed.

Note : In a ventilated room bricks properly separated require about four hours for cooling unless an electric fan passes air over them continuously , in which case about two hours may suffice.

The dry bricks shall be totally immersed without preliminary partial immersion, in clean water at room temperature for 24 hours. As far as possible, the water shall have free access to all surfaces of the bricks. Each brick shall then be removed, the surface water wiped off with a damp cloth, and the brick weighed in a balance sensitive to about 0.1 per cent of the weight of the brick. The weighing of each brick shall be completed within three minutes after its removal from the water.

The percentage of water absorption by mass shall be calculated as

$$\text{The percentage of water absorption} = \frac{M_2 - M_1}{M_1} \times 100$$

where M_1 = mass of the dry brick and

M_2 = mass of the brick after 24 hours immersion in cold water.

4. Test for Efflorescence

Place the ends of the bricks in a shallow flat bottom dish having an area of approximately 0.10 m² (160 in²), containing distilled water, the depth of immersion in water being 25 mm (1.0 in) . Place the whole arrangement in a well ventilated room until all the water in the dish evaporates. When the water has been absorbed and bricks appear to be dry, place a similar quantity of water in the dish and allow it to evaporate as before. Examine the bricks for efflorescence when the bricks are dry and report the results.

The liability to efflorescence shall be reported as 'nil' , 'slight' , 'moderate' heavy or 'serious' in accordance with the following definitions.

- (a) Nil - When there is no perceptible deposit of efflorescence.
- (b) Slight - When not more than 10 per cent of the area of the brick is covered with a thin deposit of salts.
- (c) Moderate - When there is a heavier deposit than 'slight' and covering up to 50 percent of the area of the brick surface but unaccompanied by powdering or flaking of the surface.

STANDARD TECHNICAL SPECIFICATION

- (d) Heavy - When there is a heavy deposit of salts covering 50 percent or more of the brick surface but unaccompanied by powdering or flaking of the surface.

- (e) Serious - When there is a heavy deposit of salts accompanied by powdering and/or flaking of surfaces and tending to increase with repeated wettings of the specimen.

CHAPTER 07
STONE WORK

7.1 Definitions

Ashlar

Stone masonry using dressed stone blocks of given dimensions having faces perpendicular to each other and laid in course, with fine joints not exceeding 5 mm thick.

Bed Joint

The joint where one stone presses on another for example, a horizontal joint in a wall or a radiating joint between the voussoirs of an arch.

Bond

An interlocking arrangement of structural units in a wall to ensure stability

Bond stone (through stone)

Selected long stones used to hold a wall together transversely.

Corbel

Cornice See chapter 6

Courses

Cramp

A small piece of metal or the hardest or toughest stone procurable, sunk in mortices and fixed across joints as additional ties. The ends of metal cramps are bent at right angles and stone cramps are dovetailed.

Dowels

Dowels are small section of metal, stone or pebbles bedded with mortar in corresponding mortice in bed or side joint of adjacent stones.

Hammer Dressing

Rough surfacing to a stone by means of a spall hammer.

Jamb

See Chapter 6

Natural Bed

The plane of stratification that occurs in sedimentary rocks.

Parapet

Quoin See chapter 6

Random

Of irregular size and shapes

Reveal

See chapter 6

Rubble Masonry

Masonry built of stones either irregular in shape as quarried or squared and only hammer dressed and having comparatively thick joints. Stones for rubble masonry are as far as possible, angular.

String course

See chapter 6

Template or bed block

See chapter 6

7.2 Cabook Work

Cabook for masonry shall be of the best quality and obtained from an approved source. This shall be regular in size true in shape and cut to standard sizes of at least 365 x 125 x 125 mm and shall be thoroughly seasoned before using for masonry.

All cabook masonry shall be in lime mortar, 1 lime, 2 1/12 sand, unless otherwise specified.

7.3 Random Rubble Masonry

Random rubble masonry work shall be constructed as follows:

- Provide one bond or through stone per 0.5m² of wall surface.
- Chips shall not be greater than 20% of the quantity of stone masonry.
- Plastered face bushing shall not be greater than 10.
- Exposed face bushing shall not be greater than 40.
- Width of all joints in the face of the random rubble masonry walls shall not be more than 25mm.

STANDARD TECHNICAL SPECIFICATION

7.2.1 Materials

7.2.1.1 Stone

Stone shall be of the type specified. It shall be hard, sound, free from decay, weathering and defects like cavities, cracks, flaws, sand holes, veins patched of soft or loose materials etc. It shall be obtained from an approved quarry. Stone with a rounded surface shall not be used.

Samples

The contractor shall submit samples of stones representing the range of variations to be used in the work and obtain the approval (of appearance) from the Employer's Representative.

Size of Stone

Normally stones used shall be small enough to be lifted and placed by hand.

The lengths of the stone shall not exceed three times the height and the breadth on base shall not be greater than three - fourth of the thickness of wall (except for through stones) nor be less than 150 mm. The height of a stone may be 300 mm maximum.

Dressing

Stone shall be hammer dressed on the face, the side and the beds, to enable it to come into close proximity with the neighboring stone. The 'bushing' in the face shall not project more than 40 mm on an exposed face and 10 mm on a face, to be plastered.

7.2.1.2 Mortar

The mortar used for jointing shall be as specified and conform to requirements in Chapter 3.

7.2.2 Laying

All stones shall be clean and free of dust and shall be wetted before use. Chips, spalls etc. shall be washed clean with water to ensure a clean surface for the mortar to adhere to.

The stone shall be laid on their natural bed on a full even bed of mortar. Every stone shall be carefully fitted to the adjacent stones, so as to form neat and close joints. Stones may be brought to level courses at plinth, window sills and roof level. Leveling up at plinth level, window sills and roof level shall be done with concrete comprising one part of the mortar a used for the masonry and two parts of graded stone aggregate of 20 mm nominal size. The bond shall be obtained by fitting in the adjacent stones closely, and by using bond stones.

Face stones shall extend and bond well into the backing. These shall be arranged to break joints as much as possible and to avoid long vertical lines of joints.

STANDARD TECHNICAL SPECIFICATION

The hearting or interior filling of the wall shall consist of rubble stones which may be of any shape but shall not pass through a circular ring of 150 mm inner diameter. The thickness of these stones in any direction shall not be less than 100 mm. These shall be carefully laid, hammered down with a wooden mallet into position and solidly bedded in mortar, chips and spalls of stone being used wherever necessary to avoid thick mortar beds or joints and at the same time ensuring that no hollow spaces are left anywhere in the masonry. The hearting will be laid nearly level with facing and backing, except that at about one meter intervals, vertical 'Plums' projecting about 150 mm to 200 mm shall be firmly embedded to form a bond between successive courses.

The chips shall not be used below the hearting stone to bring these upto the level of face stones. The use of chips shall be restricted to the filling of interstices between the adjacent stones in hearting, and these shall not exceed 20% of the quantity of stone masonry.

The wall shall be carried up truly plumb or to the specified batter. The masonry in a structure shall be raised uniformly. Where the masonry of one part has to be delayed, the work shall be raked back at an angle not steeper than 45° . Tothing in stonework shall not be allowed.

7.2.2.1 Bond Stones/Through Stones

A sufficient number of bond stones or through stones shall be used in building the wall. At least one through stone shall be built into the wall at intervals of 1.8 m horizontally and 0.6 meter vertically. Such stones shall be at least 150 mm square at the face and shall run through the full thickness of the walls upto 600 mm in thickness. In case of walls exceeding 600 mm in thickness more than one stone may be used to run through the full thickness of the wall with overlaps of not less than 150 mm.

In case of highly absorbent types of stones (porous lime stone and sand stone etc.) the bond stone shall extend about two-third into the wall. Through stones in such cases may give rise to damp penetration. Therefore, for all thicknesses of such walls, a set of two or more bond stones overlapping each other by at least 150 mm shall be provided.

Where bond stones of suitable lengths are not available cement concrete blocks of 1:3:6 mix (1 cement : 3 sand 6 graded stone aggregate 20 mm nominal size) conforming to the sizes mentioned above shall be used.

All bond stones in stone masonry shall be marked suitably for identification as directed by the Employer's Representative.

STANDARD TECHNICAL SPECIFICATION

7.2.2.2 Quoins

The quoins shall be of selected stones neatly dressed with the hammer or chisel to form the required angle, and laid header and stretcher alternately. The quoins shall be set out and built up in advance of the main body of the rubble walling.

7.2.2.3 Joints

Stones shall be so laid that all joints are fully packed with mortar and chips. Face joints shall not be more than 20 mm thick.

When plastering or pointing is not required to be done, the joints shall be struck flush and finished at the time of laying. Otherwise, the joints shall be raked to a minimum depth of 20 mm by a raking tool during the progress of work, when the mortar is still green.

7.2.3 Scaffolding

Single scaffolding having one set of vertical supports shall be allowed. The supports shall be sound and strong, tied together by horizontal pieces over which the scaffolding planks shall be fixed. The inner end of the horizontal scaffolding member may rest in a hole provided in the masonry. Such holes, however, shall not be allowed in pillars under one meter in width or near the skew-back of arches. The holes left in masonry work for supporting scaffolding shall be filled with a proper sized stone and packed completely, or if allowed made good with cement concrete 1:3:6 (20mm).

7.2.4 Curing

Masonry work in cement or composite mortar shall be kept constantly moist on all faces for a minimum period of seven days. In the case of masonry with fat lime mortar curing shall commence two days after the laying of masonry and shall continue for at least seven days thereafter.

7.2.5 Protection

Green work shall be protected from rain by suitable covering. The work shall also be suitably protected from damage, mortar dropping and rain during construction.

7.3 Coursed Rubble Masonry

7.3.1 Materials

7.3.1.1 Stone

Shall be as specified in 7.2.1

STANDARD TECHNICAL SPECIFICATION

Size of Stone

Shall also be as specified in 7.2.1.1

Dressing

Face stones shall be hammer dressed in all beds and joints, so as to give them an approximately rectangular block shape. These shall be squared on all joints and beds.

The bed joint shall be rough chisel dressed for at least 80 mm back from the face, and side joints for at least 40 mm such that no portion of the dressed surface is more than 6 mm from a straight edge placed on it. The bushing on the face shall not project more than 40mm on an exposed face or 10 mm on a face to be plastered. The hammer dressed stone shall also have a rough tooling for a minimum width of 25 mm along the four edges of the face of the stone, when stone work is to be exposed.

7.3.1.2 Mortar

The mortar for jointing shall be as specified and conform to the requirement of Chapter 3.

7.3.2 Laying

All stones shall be clean and free of dirt and shall be wetted before use. They shall be laid on their natural bed on a full and even bed of mortar. The walls shall be carried up truly plumb or to the specified batter. All courses shall be laid truly horizontal and all vertical joints shall be truly vertical. The height of each course shall not be less than 150 mm nor more than 300 mm.

Face stones shall be laid as headers and stretchers alternately. No pinning shall be allowed on the face. No face stone shall be less in breadth than its height and at least one third of the stones shall tail into the work for a length not less than twice their height or full thickness minus 150 mm whichever is less.

The hearting or the interior filling of the wall shall consist of stones carefully laid on their proper beds in mortar, chips and spalls of stone being used where necessary to avoid thick beds of joints of mortar and at the sometime ensuring that no hollow spaces are left anywhere in the masonry. The chips shall not be used below the hearting stone to bring these upto the level of face stones. The use of chips shall be restricted to the filling of interstices between the adjacent stones in hearting and these shall not exceed 10% of the quantity of stone masonry.

The masonry in a structure shall be carried up regularly but where breaks are unavoidable, the joints shall be raked back at an angle not steeper than 45⁰. Tothing shall not be allowed.

STANDARD TECHNICAL SPECIFICATION

7.3.2.1 Bond Stones

These shall be as specified in 7.2.2.1 and a bond stone or a set of bond stones shall be inserted 1.5 to 1.8 meters apart, in every course.

7.3.2.2 Quoins

The quoins shall be of the same height as the course in which these occur. These shall be at least 450 mm long and shall be laid stretchers and headers alternately.

These shall be laid square on the beds, which shall be rough-chisel dressed to a depth of at least 100 mm. In case of exposed work, these stones shall have a minimum of 25 mm wide chisel drafts at four edges, all the edges being in the same plane.

The quoins shall be set out and built up in advance of the main body of the rubble walling.

7.3.2.3 Joints

All bed joints shall be horizontal and all side joints vertical. All joints shall be fully packed with mortar and face joints shall not be more than 10 mm thick.

When plastering or painting is not required to be done, the joints shall be struck flush and finished at the time of laying. Otherwise, the joints shall be raked to a minimum depth of 20 mm by a raking tool during the progress of work when the mortar is still green.

7.3.3 Curing and Scaffolding

Those shall be as specified under 7.2

7.4 Ashlar Masonry

This is a fine chisel dressed or sawn stone work built to very close tolerances and shall be built only by masons specially skilled in this type of work.

For detailed specifications on Ashlar masonry refer Indian Standard 1597 pt. II Code of Practice or equivalent standard for construction Ashlar Masonry.

7.5 Stone Veneering Work

Stone lining up to 80 mm shall be treated as stone veneering work and lining of greater thickness as plain Ashlar Masonry.

In this work, the stones are cut into slabs of required thickness along planes parallel to their natural bed, dressed to very close tolerances, laid and secured to the backing masonry of brickwork or other work by cramps of adequate design and with high resistance to corrosion.

CHAPTER 08
WOOD WORK

8.1 Definitions

General

Conversion

The process of sawing timber from the log.

Hardwood

Conventionally, the timber of broad-leaved trees belonging to the botanical group-Angiosperms.

Softwood

Conventionally, timber of coniferous trees belonging to the botanical group Gymnosperms. Commercial timbers of this group are practically confined to the class Coniferae or conifers.

Structural Timber

Timber used in framing and load-bearing structures where strength is the major factor in selection and use.

Veneer

A thin sheet of wood produced by rotary-cutting or slicing.

Seasoning and Conditioning

Oven Dry

A state of timber when it does not lose moisture when placed in a ventilated oven at $(103 \pm 2)^{\circ}\text{C}$.

Seasoning/Drying

The process of drying timber to a moisture range appropriate to the conditions and purposes for which it is to be used.

Air Seasoning

The process of drying timber by exposure to natural atmospheric conditions.

Kiln Seasoning

The process of drying timber in a kiln.

Defects, Blemishes and Imperfections

STANDARD TECHNICAL SPECIFICATION

Blemish

Any features that mars the appearance of timber or other product without affecting its technical quality.

Bow (Camber)

A curvature of a piece of timber in the direction of its length.

Cup (Ping)

A curvature occurring in the cross section of a piece.

Decay / Rot

Decomposition by fungi and other micro-organisms resulting in softening, progressive loss of strength and weight and often a change of texture and color.

Decay / Fault

Any feature that lowers the technical quality or commercial value of timber or other material and may therefore lead to its rejection or to its relegation to a lower grade.

Dry Rot

A type of decay of timber in buildings, caused by the true dry rot fungus, *Merutiuslacrymans* (a brown rot).

Imperfection

Any feature that mars the appearance or lowers the technical quality of timber or other product, but does not make it unacceptable in relation to the relevant specification or grading rules or make it unacceptable for its immediate purpose where there is no specification or rule on which to base a decision.

Knot

A portion of a branch enclosed in the wood by the natural growth of the tree.

Shake

A separation of the fibers along the grain due to stresses developing in the standing tree, or in felling or in seasoning.

STANDARD TECHNICAL SPECIFICATION

Split

A separation of the fibers along the grain forming a crack or fissure that extends through the piece from the surface to another.

Termite Damage

Damage characterized by irregular honey combing or wide channels; bore-dust (frass) is usually present; that of the subterranean termite is cemented together with mud, whereas the bore-dust of drywood termites is granular and dry. The damage may affect standing trees, logs or stored timber mostly when in contact with the ground; it occurs mainly in tropical climates.

Twist/Winding

Spiral distortion.

Warping

Distortion in converted timber causing departure from its original plane, usually developed during seasoning.

Balanced Construction

A construction such that the forces induced by changes in moisture content will not cause warping. In practice this means that corresponding veneers or layers on either side of the centre line are of the same species and thickness and are laid with the grain in the same direction.

Blackboard

A composite board having a core made up of strips of wood each not more than 30mm wide, laid separately or glued or otherwise joined together to form a slab to each side of which is glued one or more outer veneers with the direction of the grain of the core strips running at right angles to that of the adjacent veneers.

Core

The inner layer or layers of a piece of plywood, batten board blackboard or laminated board.

Face

The surface of plywood, battenboard, blackboard or laminated board by which the grade or quality is chiefly judged.

Where both surfaces are of the same quality both are described as faces.

STANDARD TECHNICAL SPECIFICATION

Faced Plywood

Plywood faced with a material other than wood e.g. metal or plastics.

Gluing/Bonding

The process of uniting by means of an adhesive, two or more pieces of wood. When used without qualification the term implies a process characterized by continuity of the union over the whole area of contact.

Laminated Wood

An assembled product made up of layers of wood and adhesives in which the grain of adjacent layers is parallel.

Ply

An individual layer in plywood. Usually a ply is a single veneer.

Plywood

A product of balance construction made up of plies assembled by gluing; the chief characteristic is the crossing of alternate plies to improve the strength properties and minimize movement in the plane of the board.

Multi-Ply

Plywood formed of more than three plies.

Veneered Plywood

Plywood faced with a decorative wood veneer.

Fiber Building Board

Fiber building board sheet material usually exceeding 1.5 mm in thickness manufactured from fibers of lignocelluloses material with the primary bond derived from the felting of the fibers and their inherent adhesive properties. Bonding, impregnating or other agents may be added during or after manufacture to modify particular properties of the board.

Hardboard

See standard hardboard and tempered hardboard.

STANDARD TECHNICAL SPECIFICATION

Wood Chip Board and other Particle Boards

Particle Board

Panel material manufactured under pressure essentially from particles of wood and/or other ligno-cellulosic fibrous material (for example, woodchips, sawdust, flax chivers etc.) with or without the addition of an adhesive, hydraulic binders being excluded.

Wood Chipboard

Particle board made from particles of wood bonded with synthetic resin and/or other organic binder.

Carpentry

Permanent carpentry other than roofs.

Boarding

Wooden covering to a floor, wall, roof etc.

Carcassing Timber/Framing Timber.

Timber used in the structural work of a building.

Cleat

A block fixed to a main member to provide a bearing or to resist a thrust.

Laminated Member

A solid member built up of comparatively thin boards connected together by nails, screws, bolts connectors or adhesives.

Match boarding

Tongued and grooved boarding with a 'V' or beaded (see bead) edge.

Roofs

Laminated Roof Truss

A roof truss in which the members are built-up from several thicknesses nailed or bolted together at their intersections.

Sprocket

An additional piece fixed to the top or side of rafter at the eaves to give an inclination less than that of the roof.

STANDARD TECHNICAL SPECIFICATION

Verge

The overhanging edge of the roof covering at a gable.

Joinery

Architrave

Moulding or fillet round an opening fixed to the face to cover the joint between joinery and the adjoining work.

Doors

Flush Door

A door having two plane faces which entirely cover and conceal its structure.

Framed And Ledged Door

A door having rails and stiles framed together and filled in one face with vertical boarding of lesser thickness than the surrounding framing. The vertical boarding overruns the middle and bottom rails which are of less thickness than the top rail and stiles.

Framed Ledged And Braced Door

A framed and ledged door fitted with diagonal brace or braces.

Ledged Door

An unframed door composed of vertical boards fixed to horizontal ledges.

Ledged and Braded Door

An unframed door composed of vertical boards fixed to horizontal ledges and diagonal brace or braces.

Paneled Door

A door having stiles, rails and (some-time) muntins framed together with the space filled in with panels.

Grounds

A sawn or wrote member on which another finishing for example a skirting, is fixed.

Lipping

A strip of wood or other material applied to the edge of a flush door, table top, etc.

STANDARD TECHNICAL SPECIFICATION

Mortice

A hole or slot to receive a lock.

Note :- This term applies only when the lock is let in from the edge into the middle of the thickness of the member, not when it is recessed from one face of the member.

Moulding

1. A contour cut upon a member for ornament.
2. A moulded member.

Mullion

An intermediate vertical member of a window frame, door frame or similar structure.

Muntin

An intermediate framed vertical member of a paneled door or other piece of framing.

Nosing

The projecting edge of a tread or board, often rounded.

Panel

A filling to a space surrounded by framing.

Rail

A framed horizontal member of a sash, door or other such piece of framing.

Rebate

A step-shaped reduction formed on the edge of a member.

Stile

A framed vertical outer member of a door or sash.

- Aclosing stile - The stile of a door or sash which
- Locking stile - closes against the jamb or mullion
- Striking stile - of the surrounding frame and against which the opening appears when the door or sash is opened.

Hanging stile

A stile by which a door or sash, is hung.

STANDARD TECHNICAL SPECIFICATION

Meeting stile

The abutting stiles of a pair of doors or sashes.

Transom

An intermediate horizontal member of a window frame door frame or similar structure.

Wrot

Planned on one or more surfaces.
joints used in carpentry and joinery.

Built Joint

a plain square joint between two members.

Cogged Joint

A joint where one member is supported upon another which it crosses, with part of its width housed into the other.

Combed Joint or Corner Locked Joint or Laminated Joint

An angle joint in which the parts of the meeting sections of the respective members are cut away so that the remaining projections on each fit into the slots formed in the other.

Dovetail

A splayed shape cut in the end of a member where it is joined to another, wider at the extreme end than at the shoulder, so that when fitted into a recess of corresponding shape it will resist withdrawal by tension in the direction of its length.

Dowel

A cylindrical piece of wood used for positioning and fixing one member to another.

Finger Joint

A heading joint, joined by interlacing tapered projections on the ends of members.

Key

1. A wedge passing through a hole in a projecting tenon.
2. A piece of wood inserted in a joint to prevent movement between adjacent surfaces.

Keyed Joint

A joint that is located or secured by a key. Keys are used in various types of joints such as keyed tenons, keyed scarged joints, keyed heading joints, keyed lapped joints etc.

Lapped Joint

A joint in which one member overlaps the other, and is secured by nails, bolts, adhesives, or other means.

Mitred Joint

A built joint between two members meeting at an angle with the respective ends cut to complementary angles.

Mortice

A hole or slot to receive a tenon of corresponding size which may or may not penetrate the full width or thickness of the member in which it is formed.

Mortice and Tenon Joint

A joint in which a tenon on the end of one member is fitted into a mortice cut in the other member.

Notched and Cogged Joint

A joint in which a notched member is supported by another member in which a cog has been formed.

Tenon

A projection at the end of a framed member, of lesser cross section than the member, intended to fit into a corresponding mortice in the other member to which it is thereby joined.

8.2 Materials

8.2.1 Timber

General

Timber for constructional purposes shall be of the specified species and of the best quality, thoroughly seasoned, sawn square, and free from sap, shakes, cracks and waney edges. It shall be free from decay and insect attack. It shall not contain loose or dead knots and other defects. Sound knots if they exist, shall be of such size and location as will be permissible for the relevant structural or joinery work.

The density of timber used for building purposes should not, in general, be less than 640 kg/m³ (40 lb/ft³) at 12% moisture content.

STANDARD TECHNICAL SPECIFICATION

In general, the quality of building timber shall conform to BS 5268. The sizes of structural and non-structural timber components shall be as specified.

Any timber brought to the site, which in the opinion of the Employer's representative does not conform to the required standard shall be rejected and shall then be removed from the site by the contractor at his own cost within 24 hours of notice to do so.

Tolerances

The tolerance for dimensions of timber both sawn (unplaned) and finished (planed) shall conform BS 5268 which is reproduced below:-

a. Sawn (unplaned)

Nominal dimension (mm.) (mm)	Maximum permissible variation	
Upto 25	- 0	+ 2
Over 25 to 50	- 2	+ 3
Over 50 to 150	- 3	+ 6
Over 150	- 6	+ 6

b. Finished (planed)

Nominal dimension (mm.) (mm)	Maximum permissible variation	
Upto 25	- 0	+ 1
Over 25 to 50	- 1	+ 2
Over 50 to 150	- 2	+ 3
Over 150	- 3	+ 3

Grain Slope

In structural timber, the slope of the grain shall not exceed 1 in 8. Slope shall be measured over the worst face and over a distance of not less than 200mm.

STANDARD TECHNICAL SPECIFICATION

For timber to be used for door and window frames and shutters, the slopes shall not exceed 1 in 8. In paneling however, sloping grain may be permitted to any extent.

8.1.1.1 Moisture Content and Seasoning of Timber

Timber seasoned under controlled conditions shall be used, as green timber is liable to shrinkage and warping and is easily affected by wood destroying and sap-staining fungi. The moisture content of the timber at the time of fabrication shall be within 3% of the moisture content likely to be attained by the timber in service.

Seasoning of green timber in air, kiln or both, shall conform in all respects to BS 5268. Seasoning techniques shall be such that seasoning defects like endsplits, surface cracks warping etc. are minimized. The moisture content of air seasoned timber shall be not more than 15% and that of kiln seasoned timber not more than 12%.

8.1.1.2 Preservative Treatment

Special preservative treatment such as Pressure Diffusion, vacuum or immersion treatment shall be carried out where necessary in consultation with the Forest Department. Guidance may be obtained from BS 5268 : Part 5 for structural timbers and BS 5589 for joinery work.

Coats of hot tar which shall be applied without disfiguring exposed faces. 40 mm wide recesses shall be left for free circulation of air around the ends of all beams, and the recesses protected with perforated zinc sheet.

Timber buried in the ground shall be tarred. No timber shall be tarred, oiled or painted before inspection and approval by the Employer's Representative.

8.1.2 Adhesives

Adhesives used for joinery work shall conform to one of the following :

- B.S. 745 Animal glues for wood
- B.S. 1444 Cold setting casein glue for wood
- B.S. 1203 Synthetic resin adhesive (phenolic and aminoplastic for plywood)
- B.S. 1204 Synthetic resin adhesive (phenolic and amino plastic for wood)

For structural gluing one of the latter three glues shall be used as specified.

Regarding storage, mixing and use of adhesives, the instructions of the manufacturer shall be followed.

STANDARD TECHNICAL SPECIFICATION

8.1.3 Fasteners

Wire Nails

Wire nails (oval, chequered head, lost head, round or panel pins) shall conform to the following standards.

Steel nails - BS 1202 : Part I

Copper nails - BS 1202 : Part II

Where not specified, the gauge of the nails shall be suited to the timber being used and their length shall give a sound and secure fixing. Nails or screws used with reactive timbers shall be of nonferrous metal.

Nails used in wood work likely to be subjected to moist conditions (as in the case of external work) shall have the specified protective coating.

Wood Screws

These shall be made of steel wire or brass wire and shall conform to BS 1210. The finish (oxidized, anodized, galvanized etc.,) shall be as specified.

Coach Screws

These shall conform to BS 1494 Part 2. The finish shall be as specified.

Black Bolts, Screws And Nuts

These shall conform to BS 4190 with the specified finish.

Washers

These shall be made of steel or brass and shall conform to CS 238 or BS 4320.

Steel Gussets

These shall be manufactured to the profiles shown on the drawings and made from steel plates conforming to BS 4360. Thickness of plates and the finish shall be as specified.

Mild Steel Connectors

These shall conform to BS 1579

Other Fixing Devices

STANDARD TECHNICAL SPECIFICATION

Expanding bolts and nuts, joist hangers, framing anchors, tie down straps, anchor bolts etc. shall be as specified in respect of materials, size, gauges and the finish.

Plugs

These shall be of durable timber like teak of specified sizes.

Dowels

These shall be Mild Steel rods of 16 mm diameter and of adequate length.

Holdfasts

These shall be of mild steel flats 25 mm x 6 mm x 250 mm long, turned up and with 2 Nos. 3mm holes drilled at one end, and finish tailed at the other end.

8.1.4 Plywood, Hardboard, Block Board, Chip Board etc.

These shall conform to the relevant British Standards as noted below:

1. Plywood for general purpose	-	BS 1455
2. Plywood for exterior use	-	BS 1455 bonding
W.B.P. (Grade 1	-	where varnished,
Grade 2	-	where painted,
Grade 3	-	where hidden.
3. Block board	-	BS 3444
4. Wood chipboard	-	BS 5669
5. Hard board	-	BS 1142

8.2 Structural Timber and Timber Roof Work

General

Structural timber and timber roof work shall be fabricated in accordance with detailed drawings and shall generally conform to BS5268 : Part 2 in regard to workmanship.

The contractor shall provide details of the work as necessary to help ensure co-ordination with related building elements and services. He shall provide fabrication/installation drawings and obtain approval before starting fabrication. Where directed he shall provide samples for intended connection before commencing actual fabrication.

Proprietary products shall be used to manufacturers' recommendations.

Fabrication

The sizes of timber sections unless otherwise stated are basic (nominal) sizes. Tolerance on sizes shall be as per Section 8.1

STANDARD TECHNICAL SPECIFICATION

All timber shall be sawn, planed, drilled or otherwise machined to the correct size and shape in accordance with drawings and specifications. Dimensions and spacings shall not be scaled from the drawings. Pieces damaged by splitting or bruising shall not be used.

Mating and bearing surfaces shall be finished to ensure close contact over the whole area. These surfaces shall have a good sawn or planed finish and treated with the specified preservative. Bearing surfaces of notches and other cuttings shall be true and smooth and in appropriate relation to the other surfaces of the piece.

8.2.1 Joints

8.2.1.1 Nailed Joints

Wire nails shall be of the gauge shown in the drawings and at least 20 mm. longer than the full thickness of the assembly to be secured; the projecting portion shall be clinched over at right angles to the grain to resist withdrawal.

All nails shall be soaked in hot boiled linseed oil and allowed to drain immediately before fitting. All nails shall be driven, unless the nails are of large gauge or the timbers are likely to be split in which case holes shall be drilled in one operation through all the members held in position. The holes shall be approximately 20 percent smaller in diameter than the nails.

8.2.1.2 Screwed Joints

Lead holes shall be used in making screwed joints; the diameter of the hole for the shank shall be equal to the diameter of the shank; for the threaded portion, the diameter of the hole shall not exceed the diameter of the root of the screw thread adjacent to the shank defined in clause 42.1 of BS 5268 : Part 2. Care shall be taken to avoid placing screws in an end split.

8.2.1.3 Bolted Joints

Bolt holes shall be drilled to diameters as close as possible to the nominal diameter of the bolt but not more than 2 mm larger than the bolt diameter. Care shall be taken to avoid placing a bolt in an end split. At least one complete thread shall protrude from the nut.

A washer shall be fitted under the head of each bolt and under each nut. The minimum sizes of washers are given in the Table 8.1 below:

STANDARD TECHNICAL SPECIFICATION

Diameter of bolt washed	Minimum thickness of washer	Minimum side of square or dia. of washer
mm	mmmm	
9.5		
12.7	3	51
15.9		
19.0	5	64
22.2		
25.4		
28.6		
31.8	6	76

Structural connections using steel plates. Split rings etc. shall be as per BS 5268 : Part 2.

Note : - Laminated Roof trusses
Unless otherwise specified, all members of laminated roof trusses shall be connected with wire nails with a washer at each end of the nails.

8.2.2 Preservative Treatment of Cut Surface

Cutting of timber after preservative treatment shall be avoided. However, when it is unavoidable, a liberal application of preservative shall be made to the cut surfaces.

8.2.3 Assembly of Structural Units

Assembly of structural units shall be done on a level bed and in such a way as to avoid damage to any of the members. The finished structural units shall conform to drawings and specifications. Twisted or damaged members shall be replaced before erection on the site.

Before proceeding with bulk production, a complete assembly of each type of framed truss or other structural unit shall be checked for accuracy. A similar check shall be carried out from time to time to control the wear and tear on templates and gauges.

Timber members of built up units shall be marked in accordance with a marking diagram.

8.2.4 Storage

Timber components shall not be exposed to high humidity and all materials and assemblies shall be protected against exposure to the weather, wetting, damage, decay and insect attack.

STANDARD TECHNICAL SPECIFICATION

8.2.5 Painting

Where painting of the timber is specified, all parts of assemblies or individual pieces shall be protected with a priming paint complying with BS 2521 or BS 2522 and one undercoat before one undercoat before leaving the factory.

Steel components other than bolts, connectors and washers shall be thoroughly cleaned to remove all loose scale and rust and painted with one coat of genuine red lead paint before dispatch to the site.

8.2.6 Transport

All materials and assemblies shall be protected from the weather, and suitable measures shall be taken to protect the surfaces during hoisting and fixing.

8.2.7 Handling, Hoisting and Fixing

The over-stressing of members during handling shall be avoided. In the case of framed arches, portal frames, trusses etc. special care shall be taken to avoid distortion in hoisting from the horizontal to the vertical position. Where lifting points or methods of lifting are not indicated on the drawing guidance shall be sought from the Employer's Representative. On completion of erection, all joints shall be inspected and care taken to ensure that all bolts are tightened without crushing the wood under the washers.

8.2.8 Testing and Acceptance

When testing of a timber structure or component becomes necessary due to doubt about the adequacy in designing, quality of material, etc. the test and acceptance criteria shall be as per Section 8 of BS 5268 : Part 2.

8.3 Joinery

General

Joinery work shall consist of the manufacture, delivery to the site and fixing in the building of all joinery described in the specification and shown on the drawings including the supply and fixing of -

- (a) Metal straps, lugs and dowels
- (b) Priming and application of preservative
- (c) All iron mongery specified or shown in the drawings.

The joinery work shall be of the workmanship conforming generally to BS 1186 : Part 2.

The joinery work shall be completed ready for the respective finishes.

STANDARD TECHNICAL SPECIFICATION

8.3.1 Dimensions

All wrot timber is to be sawn, planed, drilled or otherwise machined or worked to the correct sizes and shapes shown in the drawings or specified. Tolerance on timber sizes shall be as per Clause 8.1.1

8.3.2 Exposed Faces

All timber that is to be exposed in the finished surfaces of joinery works shall be wrot on the appropriate faces unless otherwise specified.

8.3.3 Natural Finish

When natural finish or finish for staining, clear polishing, or varnishing is specified, the timber in adjacent pieces shall be matched for color and grain. The surface finish shall be as specified.

8.3.4 Shrinkage

The arrangement, jointing and fixing of joinery works shall be such that shrinkage in any part and in any direction shall not impair the strength and appearance of the finished work, and shall not cause damage to contiguous materials or structures.

8.3.5 Fabrication

All necessary mortising, tenoning, grooving, matching, tonguing, housing, rebating, and all other works necessary for correct jointing, shall be in conformity with BS 1186. All metal plates, screws, nails and other fixing that may be directed by the Employer's representative or that may be necessary for the proper execution of the joinery works specified shall be the responsibility of the contractor. All works necessary for the proper construction of all framings, linings, etc and for their support and fixing in the building shall be carried out to approval.

8.3.6 Joints

The joinery shall be constructed as shown in the detail drawings. Where joints are not specifically indicated they shall be the recognized forms of joints for each position. The joints shall be made so as to comply with BS 1186: Part 2. Glued joints shall be used where provision need not be made for shrinkage or other movements in the connections, and where sealed joints are required. All glued joints shall be cross-tongued or otherwise reinforced. All nails, springs, etc. shall be punched and puttied. Surfaces in contact shall have a good sawn or planed finish. All cutting edges of tools shall be sharp to avoid burnishing. The surface of plywood to be glued shall be lightly dressed with sand or glass paper. The sand or glass paper must not be allowed to clog and cause burnishing.

STANDARD TECHNICAL SPECIFICATION

Members to be joined by gluing are to be of similar conversion. All surfaces to be glued shall be kept clean, free from dirt, dust, sawdust, oil and any other contamination. Adequate pressure shall be applied and maintained whilst the glue is setting.

8.3.7 Moulding

All moulded work shall be accurately worked to the full size details shown in drawings. All mouldings shall be worked on the solid timber except where otherwise stated.

8.3.8 Bent Work

Where bending is specified, the work shall be performed by saw-kerfing, keying, backing-a-veneer, laminating or steaming and shall be carried out to the satisfaction of the Employer's Representative.

8.3.9 Circular Work

When circular work is specified, it shall be built up with an appropriate number of pieces out to the required shapes. The pieces shall be put together in two (or three) thicknesses so that they break joint, and shall be secured with hardwood keys and wedges or with hardwood pins (whichever is more appropriate).

8.3.10 Veneering

This shall be carried out in an approved manner, and to the entire satisfaction of the architect.

8.3.11 Scribing

All skirtings, architraves, plates and other joinery works shall be accurately scribed to fit the contour of any irregular surface against which they may be required to form a close but connection.

8.3.12 Weathering

All weathering surfaces, throatings, grooves and joints, etc. and all open connections in external joinery works shall be properly executed so as to provide a reasonable degree of weather resistance.

All reasonable measures shall be taken to check or prevent capillary penetration of water in the joints and open connections of external joinery works, and in all other positions where joinery works may be exposed to water.

8.4 Door and Window Frames

General

The frames shall be wrot, framed and fixed in position as specified in drawings. The scantling of specified timber, shall be planed smooth and accurate to the dimensions shown in

STANDARD TECHNICAL SPECIFICATION

drawings. Rebates, roundings, and mouldings shall be made before assembly patching or plugging of any kind shall not be permitted except as specified. Tolerance on sectional dimensions of timber shall

In general joinery work shall conform to requirements of Section 8.3

8.4.1 Joints

These shall be of mortice and tenon type, simple neat and strong. Tenons shall be formed on the posts of frames. Mortice and tenon joints shall fit in fully and accurately without wedging or filling. The joints shall be glad and the frames put together and kept pressed in position by means of a press and pinned with hardwood pins of at least 10 mm diameter.

8.4.2 Surface Treatment

Wood work shall not be painted, oiled or otherwise treated before it has been approved by the Employer's Representative. All portions of timber abutting against masonry or concrete or embedded in ground shall be painted with approved wood primer or preservative.

8.4.3 Fixing in Position

Before fixing, the backs and ends of frames shall be coated with 2 coats of boiling tar or solignum. When frames are to be built into masonry these shall be braced and protected as necessary to prevent distortion and damage during construction of the brick-work.

The frames shall be positioned accurately, plumbed, leveled and aligned as necessary. The timber frames, unless otherwise specified, shall be fixed at centres not exceeding 600 mm with at least one fixing located 150 mm from each end of jambs and one adjacent to each hanging point of doors/window shutters. Generally at least 3 fixings per side of each door frame and 2 fixings per side of each window frame shall be provided. The fixing device shall consist of a hold fast as described in Clause 8.1.3 embedded in concrete, or stout steel screws driven into hard wood plugs embedded in the walls, or other approved cramps of a suitable design.

The feet of all door frames and posts shall not be buried into the concrete floor but shall be fitted to specially cast cement spur block projecting above the floor. 16 mm dia iron dowels shall be provided connecting the spur stone and the frame. The spur stone shall be such that the architraves if any, and the coved floor finishes shall be accommodated producing a neat clean finish with no corners which can hold dust or vermin.

8.5 Sashes for Doors, Windows, Fanlights Etc.

General

The specified timber shall be planed smooth and accurate to the full dimensions rebates, roundings mouldings shall be made before assembly. Patching or plugging of any kind shall not be permitted except as specified. The sashes shall be wrot, framed and fixed in position as per detailed drawing and as directed by the Employer's Representative.

Note:- Joinery work for doors and windows etc. shall be started immediately after commencement of the building work. The components shall be stored clear off the floor in a dry and covered area allowing for free circulation of air. Pressing and securing of joints shall be carried out at the time of fixing frames or shutters.

(a) Joinery Work

All members of the door sashes shall be straight without any warp or bow, and shall have smooth well planed faces at right angles to each other.

The corners and edges of panels shall be finished as shown in drawings, and these shall be feather-tongued into stiles and rails. Sash bars shall have mitred joints with the stiles. Stiles and rails shall be properly and accurately mortised and tenoned. Rails which are more than 180 mm in width shall have to tenons. The thickness of each tenon shall be approximately one third the finished thickness of the members and the width of each tenon shall not exceed five times its thickness. The tenons shall pass through stiles for at least 3/4th of the width of the stile. Muntins and glazing bars shall be stubtenoned to the maximum depth which the size of the member would permit or to a depth of 25 mm, whichever is less. When assembling a leaf, stiles shall be left projecting as a horn. The stiles and rails shall have 12 mm grooves in the paneled portion for the panel to fit in.

The depth of rebate in the frames for housing the sashes shall in all cases be 12.5 mm; the rebate in the sashes, for closing in double sash doors or windows shall be less than 20 mm. In the case of double leaved sashes the meeting of the stiles shall be rebated 20 mm and the rebate shall be splayed.

In general, the joinery work shall conform to the requirements of Clause 8.3

The joinery work shall be assembled and passed by the Employer's representative before the joints are pressed and secured by hard wood or bamboo pins of about 6-10 mm diameter. The horns of stiles shall be sawn off.

STANDARD TECHNICAL SPECIFICATION

(b) Gluing of Joints

The contact surfaces of tenon and mortice joints shall be treated before putting together with bulk type synthetic resin adhesive of a make approved by the Employer's Representative. Sashes shall not be painted, oiled or otherwise treated before they are fixed in position and passed by the Employer's Representative.

(c) Bending

Timber, plywood, hardboard and particle board panels shall be fixed only with grooves but additional beading may be provided either on one side or on both sides.

In so far as glass panels are concerned, beading shall always be provided without grooves. Where beading is provided without grooves the beading shall only on one side, the other side being supported by a rebate from the stiles.

For external doors and windows beading shall be fixed on the outside.

(d) Fittings

Fittings shall conform to the requirements of Chapter 10. Details of fittings shall be as specified.

(e) Wooden Cleats and Blocks

Wooden cleats and blocks shall be fixed to doors and windows as specified or as directed by the Employer's Representative. The size and shape of cleats and blocks shall be as approved by the Employer's Representative.

(f) Tolerance

A tolerance of ± 1.5 mm shall be allowed on heights and widths of sashes.

8.5.1 Ledged, Braced and Battened Sashes

The thickness of the doors shall be the thickness of the battens only and not the combined thickness of battens and braces.

Planks for battens shall be 75 mm to 100 mm wide and 20 mm thick unless otherwise specified. These shall be planed smooth and provided with rebated joints rebated at least 12 mm. The tolerance on sizes of battens ledges and braces shall conform to Sub Section 8.1.1.

STANDARD TECHNICAL SPECIFICATION

Ledges and Braces

The battens shall be fixed together by 25 mm thick ledges and braces fixed to the inside face of door shutters with screws. The ledge shall be 175 mm wide and brace 125 mm wide unless otherwise specified. The braces shall incline downwards towards the side on which the door is hung. Edges and ends of ledges and braces shall be chamfered. Tee hinges shall be provided for these doors.

Wooden cleats, blocks and fittings shall be as specified.

8.5.2 Paneled, Glazed or Paneled And Glazed Sashes

Paneling

The following types of paneling shall be used for door/window sashes as specified.

- (a) Plywood
- (b) Hardboard
- (c) Block board
- (d) Sheet glass

These shall conform to the relevant BS.

The panels shall be framed into grooves to the full depth of the groove, leaving an air space of 1.5mm and the faces shall be closely fitted to the sides of the groove. Mouldings to the edges of panel openings shall be scribed at the joints.

8.6 Wooden Floors

Wood floors and landings shall be of specified timber. These shall be 30mm thick unless otherwise specified, with grooved and tongued planks in equal widths not exceeding 150 mm, with well broken and splayed heading joints. They shall be fixed to the joints with 62 mm screws the heads shall be counter sunk and the holes filled with wax, two screws being used for each 150 mm plank wherever it crosses or ends be planed in both directions and made perfectly smooth and even. Where the underside of the floor is exposed the flooring is to be wrot on both side.

8.7 Skirtings, Picture Rails, Mouldings, Etc.

All skirtings, picture rails, mouldings, and similar items shall include for all necessary grounds, backings or splayed fillets and for forming all mitres, scribing, fitted ends.

All such features shall be secured by screws driven in to holes fitted with rawl plugs or equivalent.

8.8 Wooden Stairs

- (a) All wood stairs unless otherwise specified shall be framed up in the timber specified and

STANDARD TECHNICAL SPECIFICATION

to the design and sizes shown in the drawings.

- (b) All stringers shall be framed and pinned to newels and wall stringers plugged to walls. The feet of newels on a concrete ground floor shall have special cast concrete blocks as described in Sub Section 8.4.3. On upper floors, the newel feet shall be notched to wood joists and /or R.S.J bearers in the concrete floor.
- (c) Where bull nose steps are shown, they shall be properly formed and the riser blocked, screwed, glued and wedged.
- (d) Handrails shall be framed and pinned to newels with all the bends, ramps and wreaths etc. required, and heading joints shall be framed with handrail screws.
- (e) Joinery work shall conform to the requirements of Clause 8.3 and shall be as specified. Handrails shall be French-polished. Other surfaces shall be stained/wax polished/decorated as specified. All finished surfaces shall be protected with rough timber or boarding until completion.

8.9 Shelving

All shelving shall be of the widths and thicknesses specified. Timber shelving shall normally consist of 25 mm thick boarding screwed to 100x50 mm timber brackets fixed to the wall at approximately 1.2 m centre.

Note :- The contractor's rate shall provide for treating both the top and bottom with two coats of approved wood preservative.

8.10 Trellis Work

8.10.1 Plain Trellis

This shall consist of wooden strips or laths 35x10 mm section, unless otherwise specified, planed and nailed together at every alternate crossing. The strips shall be spaced 35mm apart so as to form 35x35 mm openings, or as shown in the drawing. These shall be fixed with nails to the frame. To cover the ends of strips, 50x12 mm beading shall be fixed to the frame with screws. Finished work with a tolerance of ± 1 mm may be accepted.

8.10.2 Trellis Door and Window Sashes

The sash frame shall consist of two styles and the top, lock and bottom rails, each of section 75x35 mm unless otherwise specified. The styles and rails shall be properly mortised and tenoned. The tenons shall pass through the styles for at least 3/4th of the width of the style.

STANDARD TECHNICAL SPECIFICATION

The sash and frame shall be assembled and passed by the Employer's representative before jointing. The joints shall be pressed and secured by hard wood pins of about 6 mm diameter. To this frame, plain trellis work as described in Clause 8.10.1 shall be fixed as shown in the drawings or as directed by the Employer's Representative. The fittings, wooden cleats and blocks shall be provided as specified.

8.11 Pelmets

The sides, front and top of the pelmets shall be of 12 mm thick planks or boards of specified width unless otherwise stated.

These shall project from the wall face by 150 mm or as specified, and shall be securely fixed to walls with wood screws by means of wooden plugs and 100 mm long dia. 25 x 3 mm mild steel flats bent in the form of an angle or by any other device approved by the Employer's Representative. The pelmets shall be provided with curtain rods and brackets or curtain rails with rollers, stop ends and brackets as specified. Intermediate wooden brackets shall be provided if the front length of pelmets exceeds 1.5 meters.

8.12 Mild Steel Bars or Grills in Wooden Frames

These shall be of the pattern and details specified.

8.12.1 Fixing of Mild Steel Bars in Wooden Frames

Through holes shall be drilled in one frame, and 50 mm deep in the other frame. The bars shall be passed into the frame from one side and shall be of the correct length to fit in at one end and to end flush with outside of the frame at the other end.

Where there are mild steel flats provided along with the bars, these shall be fixed to the wooden frame with wood screws. Holes for passing M.S. bars shall be punched in the flats at proper positions.

8.12.2 Fixing of Steel Grills

The grills shall be fabricated as per design and fixed to the frame using round headed bolts and nuts in new work, and wood screws in the case of old work.

Appendix - 8A

Not applicable

Appendix 8B

Table - B1

Imperial measure sizes most closely corresponding to the recommended Metric sizes of structural timber.

STANDARD TECHNICAL SPECIFICATION

Component	Standard Metric Sizes (Imperial size in inches)	Standard Metric Sizes (Imperial sizes in inches)
Ridge Plates	175 x 25 [7 x 1] 175 x 50 [7 x 2]	- -
Rafters	75 x 50 [3 x 2] 100 x 50 [4 x 2]	- -
Wall plates	100 x 75 [4 x 2] 100 x 75 [4 x 3] 50 x 50 [2 x 2] 75 x 38 [3 x 1 1/2] 100 x 50 [4 x 2] 125 x 50 [5 x 2] 150 x 50 [6 x 2] 175 x 50 [7 x 2]	- - - - - - - -
Reepers (Battens)	50 x 25 [2 x 1] 50 x 13 [2 x 1/2]	- 200 x 22(8 x 7/8)
Eaves boards (Valance Boards)	200 x 25 [8 x 1]	200 x 19 (8 x 3/4) -
Principal rafters	125 x 25, 32 , 38 (5 x 1, 1 1/4, 1 1/2) 150 x 25, 32, 38, 50 (6 x 1, 1 1/4, 1 1/2, 2) 175 x 25, 32, 38, 50 (7 x 1, 1 1/4, 1 1/2, 2)	- - - - -
Tie beams	125 x 25, 32, 38 (6 x 1, 1 1/4, 1 1/2) 175 x 25, 32, 38 (6 x 1, 1 1/4, 1 1/2) 175 x 25, 32, 38	- - - - -

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Braces	(7 x 1, 1 1/4, 1 1/2)	-
	75 x 50 (3 x 2)	-
Ceiling bearers	100 x 50 (4 x 2)	-
	100 x 50 (4 x 2)	-
	75 x 50 (3 x 2)	-
	50 x 50 (2 x 2)	-

Table - B2

Imperial measure sizes most closely corresponding to the recommended Metric sizes of non-structural timber.

Component	Standard Metric Sizes (Imperial size in inches)	Standard Metric Sizes (Imperial sizes in inches)
Ceiling boards	115 x 22 [4 1/2 x 7/8]	100 x 19 (4 x 3/4)
	150 x 16 [6 x 5/8]	140 x 13 (5 1/2 x 1/2)
Ceiling beadings	38 x 13 [1 1/2 x 1/2]	-
	50 x 13 [2 x 1/2]	-
Cornice mouldings	50 x 50 [2 x 2]	-
Window frames		
Jambs & Heads	100 x 50 [4 x 2]	95 x 44 (3 3/4 x 1 3/4)
	100 x 63 [4 x 2 1/2]	95 x 57 (3 3/4 x 2 3/4)
Mullions	100 x 63 [4 x 2 1/2]	95 x 60 (3 x 2 3/8)
Sills	125 x 50 [5 x 2]	120 x 44 (4 3/4 x 1 3/4)
	125 x 63 [5 x 2 1/2]	120 x 57 (4 3/4 x 2 1/4)
Stops	40 x 16 [1 5/8 x 5/8]	38 x 13 (1 1/2 x 1/2)
Window Sashes	36 [1 x 3/8] thick	32 x (1 1/4) thick
	44 x [1 3/4] thick	40 x 1 5/8) thick
Door frames		
Jambs & Heads	100 x 50 [4 x 2]	95 x 44 (3 3/4 x 1 3/4)
	100 x 63 [4 x 2 1/2]	95 x 57 (3 3/4 x 2 1/4)
Stops	40 x 16 [1 5/8 x 5/8]	38 x 13 (1 1/2 x 1/2)
Door Sashes	36 [1 3/8] thick	32 (1 1/4) thick

CHAPTER 09
METAL WORK

9.1 Definitions

Bead

A single run of weld metal deposited on a surface.

Butt Weld

A weld in which the weld metal lies substantially within the extension of the planes of the surfaces of the parts joined or within the extension of the planes of the smaller of the two parts of differing size. The edges of the metal pieces shall be bevelled or chiselled to the required shape at the throat.

Crater

A depression left in weld metal where the arc was broken or the flame was removed.

End Crater

A crater at the end of a weld or at the end of a joint.

Fillet Weld

A weld of approximately triangular cross-section joining two surfaces approximately at right angles to each other in lap joint, tee joint or corner joint. It is of two types (1) Continuous, (2) Intermittent.

Fusion Welding

Any welding process in which the weld is made between metals in a state of fusion without application of pressure.

Fusion Penetration

(a) In fusion welding - The depth to which the parent metal has been fused.

(b) In spot, seam or projecting welding. - The distance from the interface to the edge of the weld nugget, measured in each case on a cross-section through the centre of the weld and normal to the surface.

Non Fusion Welding

A term applied to the deposition, by the Oxy-Acetylene process, of filler metal on parent metal without fusion of the latter.

Oxy-Acetylene Pressure Welding - Pressure welding in which an Oxy-Acetylene flame is used to make the surface to be united plastic. No filler metal is used.

STANDARD TECHNICAL SPECIFICATION

Run

The metal deposited during one passage of the electrode or blow pipe in the making of a joint.

Throat Thickness

The minimum thickness of weld metal in a fusion weld measured as follows:

- (a) For a fillet weld or a V.U.J. or a bevel butt weld -
along a line passing through the roof.
- (b) For a close square-butt weld - In the plane of the abutting faces.
- (c) For an open square-butt weld - At the centre of the original gap in a plane parallel to the fusion faces.

Weld

A union between two pieces of metal at faces rendered plastic or liquid by heat or by pressure, or both. Filler metal may be used to effect the union.

Weld Metal

All metal melted and/or made plastic in making a weld and retained in the weld.

9.2 Materials

Materials	Standards	Remarks
Hot rolled-Mild steel sections excluding angles and hollow sections.	BS 4 Part - 1 BS 4848 - Part 2	To be hot rolled from weldable steel for structural purposes conforming to BS 4360
Hot-rolled MS hollow sections.	BS 4848 - Part 4	To be hot rolled from weldable steel for structural purposes conforming to BS 4360
Hot-rolled MS angles	BS 4360	
M.S. bars	BS 1775	- do -
Steel tubes	BS 4360	

STANDARD TECHNICAL SPECIFICATION

M.S. Plates	BS 2989	
Galvanized steel sheet	BS 1449 - Part 1	
Steel plate & sheet	BS 3014	
Stainless Steel - Tubes	BS 1449- Part 2	
Stainless Steel (plate, sheet & Strip)		
Aluminum alloy	BS 1161 or BS 1474	
Extruded section	BS 1471	
Drawn tube	BS 1470	
Plate, Sheet & Strip		
Copper alloy	BS 2874	
Sections		

Materials	Standards	Remarks
Tubes	BS 2871 : Part 2	
Sheet, Strip & Foil	BS 2870	
Plate	BS 2875	
Fastenings		
Wood screws - Iron	BS 1210	
Wood screws - Brass	BS 1210	
Bolts, screws & nuts	CS 97	
Rivets	BS 641 & VS 4620 or as specified.	
Expanding bolts & nuts	As specified.	
Plugs	- do-	
Adhesives	- do-	
Electrodes for manual arc welding	BS 639	

STANDARD TECHNICAL SPECIFICATION

Note 1: Steel supplied to site shall come with evidence to show that it conforms to the relevant British Standards and shall furnish to the employer's representative to his satisfaction. For steel conforming to the Specifications for Structural Steel of any other country, the relevant specifications shall be forwarded to the Employer's Representative for prior approval.

9.3 Fabrication and Erection - Shop work

9.2.1 Preliminaries

9.2.1.1 Quality of Work

Metal work shall be fabricated carefully and accurately to ensure compliance with design and performance requirements, using types and grades of metal as specified for the purpose. The finished work must be free from distortion and cracks. Proprietary products shall be used to the recommendations of the manufacturers.

Steel work shall be fabricated and erected by competent, experienced persons and shall generally conform to B.S. 449 - Part 2 - "Specifications for the use of structural steel in buildings".

9.2.1.2 Co-ordination

The work shall be carried out in co-ordination with the work on related building elements and services. The fabrication/installation drawings showing complete details of the work shall be furnished by the contractor well in advance for checking by the Employer's representative necessary modifications shall be made and sufficient number of corrected copies shall be furnished to the concerned parties.

9.2.1.3 Samples

Where directed, the contractor shall furnish samples of the components and obtain approval for the same before proceeding with the fabrication.

9.2.1.4 Inspection

The Employer's Representative shall have access at all reasonable times to all places where the work is being carried out, and shall be provided by the contractor with all the necessary facilities for inspection during construction.

9.2.2 Shop Preparation

9.2.2.1 Straightness

All material before and after fabrication, shall be straight unless required to be of curvilinear form, and shall be free from twists.

STANDARD TECHNICAL SPECIFICATION

9.2.2.2 Clearances

Care shall be taken to ensure that the clearances specified are adhered to. The erection clearance for cleared ends of members connecting steel to steel shall be not greater than 2 mm at each end. The erection clearance ends of beams without web cleats shall be not more than 3 mm at each end, but where for practical reasons this clearance has to be increased, the seating shall be suitably designed.

Where black bolts are used the holes may be made not more than 2 mm greater than the diameter of the bolts unless otherwise specified.

9.2.2.3 Cutting

Cutting may be shearing, cropping, sawing or machine flame cutting. Hand flame cutting may be adopted subject to the approval of the Employer's Representative. If thermal cutting is permitted for plates which will be subjected to dynamic or fatigue loading, the edges shall be machined. In the case of highly stressed welded joints, thermal cutting shall be controlled to prevent excess hardening. Sheared or cropped edges shall be dressed to a neat workmanlike finish and be free from distortion where parts are to be in metal-to-metal contact.

9.2.2.4 Holing

Holes through more than one thickness of material for members such as compound stanchion and girder flanges shall where possible; be drilled after the members are assembled and tightly clamped or bolted together. All matching holes for rivets and black bolts shall register with each other so that a gauge 2 mm less than the required diameter of hole will pass freely through the assembled members in a direction at right angles to such members.

Finished holes shall be not more than 2 mm larger in diameter than the diameter of the rivet or black bolt passing through them unless otherwise specified.

When holes are drilled in one operation through two or more separable parts, shall be separated after drilling and the burrs removed.

Punching may be permitted before assembly when the thickness of material punched is less than 15 mm. The holes punched shall be 2 mm less in diameter than the required size and reamed after assembly to the full diameter.

Holes in connecting angles and plates other than splices, as also in roof members and light framing, may be punched full size through material not over 12 mm thick. This shall not be permitted for close tolerance or barrel bolts.

STANDARD TECHNICAL SPECIFICATION

Where a connection is subject to impact or vibration or to reversal of stress (unless such reversal is solely due to wind) or, where for some special reason such as continuity in rigid framing or precision in alignment of machinery, slipping of bolts is not permissible, then rivets, close tolerance bolts, high strength friction grip bolts or welding shall be used. Holes for close tolerance and barrel bolts shall be drilled to a diameter equal to the nominal diameter of the shank or barrel subject to a tolerance of +0.15 mm and -0 mm. Parts to be connected with close tolerance bolts or barrel bolts shall preferably be firmly held together by tacking bolts or clamps, the holes drilled through all the thicknesses in one operation and subsequently reamed to size. All holes not drilled through all thicknesses in one operation shall be drilled to a smaller size and reamed out after assembly. Where this is not practicable the parts shall be drilled and reamed separately through hard bushed steel jigs.

Holes for rivets or bolts shall not be formed by a gas cutting process.

9.2.2.5 Flattened Ends of Tubes

For welded, riveted or bolted connections, the ends of tubes may be flattened or otherwise formed provided the methods adopted are such as not to injure or deface the material. The change of section shall be gradual.

9.2.3 Shop Assembly

The component parts shall be assembled in such a manner that they are neither twisted nor otherwise damaged, and shall be so prepared that the specified cambers if any are provided.

All tubular members shall be sealed so as to prevent, the access of moisture to the inside of the members. (See also Clause 9.5.2)

9.2.4 Riveting

Rivets shall be heated uniformly throughout their length, without burning or excessive scaling, and shall be of sufficient length to provide a head of standard dimensions. They shall when driven, completely fill the holes and if countersunk, the countersinking shall be fully filled by the rivet, and proudness of the countersunk head being dressed off flush if required.

Riveted members shall have all parts firmly drawn and held together before and during riveting, and special care shall be taken in this respect of all single-riveted connections. For multiple riveted connections, a service bolt shall be provided in every third or fourth hole.

Wherever practicable machine riveting shall be carried out by using machines of the steady pressure type.

All loose, burned or otherwise defective rivets shall be cut out and replaced before the

STANDARD TECHNICAL SPECIFICATION

structure is loaded, and special care shall be taken to inspect all single-riveted connections.

Special care shall be taken in heating and driving long rivets.

9.2.5 Bolting

Bolts shall be of sufficient length to have at least one complete thread projecting beyond the outer face of the nut when tightened up.

Washers shall be provided in all cases. Where necessary, washers shall be tapered or otherwise suitably shaped to give the heads and nuts of bolts a satisfactory bearing.

In all cases where the full bearing area of the bolt is to be developed, the bolt shall be provided with a washer of sufficient thickness under the nut to avoid any threaded portion of the bolt being within the thickness of the parts bolted together.

Where a tubular member is drilled to take bolts or studs, provision shall be made to prevent the access of moisture to the interior of the tube. For example, a transverse sleeve can be inserted where a bolt passes through a tube or grommets can be used under the heads and nuts.

9.2.6 Welding

General

Steel shall normally be welded by the metal arc process conforming to B.S. 5135. Other methods shall be subject to the approval of the Employer's Representative.

Welding of stainless steel, aluminum alloys, copper alloys, bronze etc. and brazing shall conform to the appropriate British Standard where specified, approval and testing of welders, and welding procedures shall be as per BS. 4870, BS 4871 and BS 4872. Surfaces to be welded shall be dry. When rain is falling off during periods of high wind, necessary precautions shall be taken to protect outdoor welding areas.

Welding shall be so carried out as to ensure that;

- (1) Welds will be of good clean metal deposited by a procedure which will ensure uniformity and continuity of work.
- (2) The surfaces of the weld will have an even contour and regular finish and will indicate proper fusion with the parent metal.

All slag shall be removed after making each run by light hammering followed by wire brushing.

STANDARD TECHNICAL SPECIFICATION

Weld metal shall not be allowed to spatter on surfaces which will be visible in the completed work.

Butt-weld which will be visible in the completed work shall be dressed off smooth and flush with adjacent surfaces.

9.2.6.1 Equipment for Welding of Steel

Equipment

The contractor shall be responsible for ensuring that the capacity of welding plant, instruments, cables and accessories is adequate and suitable for the welding procedure to be used and for maintaining all welding plant and ancillary equipment in good working order. The contractor shall also take all necessary safety precautions in connection with work. All electrical plant in connection with the work shall be adequately earthed. The welding return lead from the work shall be adequate in cross section and shall be correctly connected and earthed.

Adequate means of measuring the current shall be available with the welding plant or a portable ammeter shall be provided.;

the risk of cracking, but in no case shall the gap exceed 3 mm.

9.2.6.6 Tack Welds

Tack welds shall be not less than the throat thickness or leg length of the root run to be used in the joint and shall be subject to the same welding conditions as those specified for the root run. The length of the tack weld shall not be less than four times the thickness of the thicker part or 50 mm whichever is the smaller.

Where a tack weld is incorporated in a welded joint its shape shall be suitable for incorporation in the finished weld and it shall be cleaned and fused thoroughly with the final weld. Cracked, broken or otherwise defective tack welds shall be removed before final welding.

9.2.6.7 Identification

When specified by the Employer's representative adequate means of identification, either by an identification mark or other record, shall be provided to enable each weld to be traced to the welder (s) by whom it was made.

9.2.6.8 Inspection and Testing

The Employer's Representative shall have access to the contractor's work at all reasonable times, and the contractor shall provide him with all facilities necessary for inspection during manufacture and on completion.

STANDARD TECHNICAL SPECIFICATION

Welds showing cavities or in which the weld metal tends to fall over the parent metal without proper fusion shall be cut out and re-welded to the satisfaction of the Employer's Representative. Care shall be taken to avoid under cutting of the base metal along the weld edges and where serious undercutting occurs the reduction shall be made good to the satisfaction of the Employer's Representative.

Where specified for important works, radiographic or ultrasonic testing procedures shall be carried out to the satisfaction of the Employer's Representative.

Finished welds and adjacent parts shall be protected with clean boiled linseed oil after all slag has been removed.

Welds shall not be painted or otherwise obscured until they have been accepted by the Employer's Representative.

Quality of Welds

Welds joints shall be free from defects that would impair the service performance of the construction.

9.2.6.9 Correction of Faults Welds

Where welds do not comply with the requirements of the clause above, the defective portions shall be cut out they shall then be rewelded and reinspected in accordance with this standard. Where serious undercutting of the base metal along the weld edges is noticed, the reduction shall be made good to the satisfaction of the Employer's Representative.

9.2.7 Machining of Butts, Caps and Bases

Stanchion splices and butt joints of compression members dependent on contact for the transmission of compressive stresses, shall be accurately prepared to butt so that the permitted stress in bearing is not exceeded nor eccentricity of loading created which would induce secondary bending in the members. Stanchion caps and bases shall be prepared in a similar manner to the above, and where this is obtained by machining, care shall be taken that any attached gussets, connecting angles or channels are fixed with such accuracy that they are not reduced in thickness by more than 2 mm.

9.2.8 Slab Base and Caps

Slab bases and slab caps, except when cut from material with true surfaces, shall be accurately machined over the bearing surfaces and shall be in effective contact with the end of the stanchion. A bearing face which is to be grouted direct to a foundation need not be machined if such face is true and parallel to the upper face.

STANDARD TECHNICAL SPECIFICATION

To facilitate grouting, holes shall be provided where necessary in stanchion bases for the escape of air.

9.2.9 Marking

Each piece of steel work shall be distinctly marked before delivery in accordance with a marking diagram, and shall bear such other marks as will facilitate erection.

9.2.10 Painting

All surfaces which are to be painted, oiled or otherwise treated shall be dry and thoroughly cleaned to remove all loose scale and loose rust; all other steelwork shall be given one coat of red oxide of iron paint at the earliest possible opportunity. During the process of erection and subsequently until the work is completed, these protective coats shall be maintained.

Shop contact surfaces need not be painted unless specified. If so specified, they shall be brought together while the paint is still wet.

Surfaces not in contact, but inaccessible after shop assembly, shall receive the full specified protective treatment before assembly. This does not apply to the interior of sealed hollow sections.

All faces to be riveted or bolted together shall be painted before assembly.

In the case of surfaces to be welded, the steel shall not be painted or metal coated within a suitable distance of any edges to be welded if the paint specified or the metal coating would be harmful to welders or impair the quality of the welds.

Welds and adjacent parent metal shall not be painted prior to de-slugging, inspection and approval.

Parts to be encased in concrete shall not be painted or oiled. See also Clause 18.1

9.3 Erection - Site Work

9.3.1 Plant and Equipment

The suitability and capacity of all plant and equipment shall be decided prior to commencement of erection.

9.3.2 Storing And Handling

All structural steel at the site shall be stored and handled so that members are not subjected to excessive stresses, damage deformation etc.

STANDARD TECHNICAL SPECIFICATION

9.3.3 Permission

The erection of steel work shall be started only after obtaining the permission of the Employer's Representative.

9.3.4 Setting Out

The positioning and leveling of all steelwork, the plumbing of stanchions and the placing of every part of the structure with accuracy shall be in accordance with the approved drawings and to the satisfaction of the Employer's Representative.

9.3.5 Security During Erection

The work may be erected in suitable units as may be directed by the Employer's Representative. Fabricated members shall be lifted at such points as will avoid the deformation or excessive stress in members.

The structures or part of it placed in position shall be secured against overturning or collapse by suitable means.

During erection the work shall be securely bolted or otherwise fastened and if necessary temporarily braced, so as to make adequate provision for all erection, stresses and conditions, including those due to erection equipment and its operation. Neither rivetting, permanent bolting nor welding shall be done until proper alignment has been obtained.

9.3.6 Modification to Fabrication

Modification to fabricated steel work which would involve cutting, welding etc. must not be made without the prior approval of the Employer's Representative.

9.3.7 Painting after Erection

All surfaces to be painted shall be dry and thoroughly cleaned from all loose scale and rust.

The specified protective treatment shall be completed after erection. All rivet and bolt heads and site welds after deslagging shall be cleaned. Damaged or deteriorated paint surfaces shall first be made good with the same type of paint as the shop coat. Where specified, surfaces which will be in contact after site assembly shall receive a coat of paint (in addition to any shop priming) and shall be brought together while the paint is still wet.

Where the steel has received a metal coating in the shop, this coating shall be completed on site so as to be continuous over any welds and site rivets or bolts protection may be completed by painting on site in lieu of metal coating subject to the approval of the Employer's Representative. Bolts which have been galvanized or similarly treated are exempted from this requirement. Site painting should not be done when humidity is such as to cause

condensation on the surface to be painted. Please also see clause 18.8

9.3.8 Bedding of Stanchion Bases and Bearing of Beams and Girders on Stone, Brick or Concrete (Plain or Reinforced)

Bedding shall be carried out with Portland cement grout or mortar or fine concrete.

For multi-storeyed buildings this operation shall not be carried out until a sufficient number or bottom lengths of stanchions have been properly line, leveled and plumbed and sufficient floor beams are in position.

Whatever method is adopted, the operation shall not be carried out until the steel work has been finally leveled and plumbed, the stanchion bases being supported meanwhile by steel wedges; and immediately before grouting the space under the steel shall be thoroughly cleaned.

The bolt holes and space beneath column base plates shall be filled with grout or mortar of specified below:

- (a) Space not deeper than 25 mm: neat cement slurry to as thick a consistency as possible and poured under a suitable pressure head.
- (b) Spaces between 25 mm and 50 mm deep: A mortar of cement and fine aggregate in the proportion of 1:1, just fluid enough to pour, poured under a suitable head and tamped as filling proceeds.
- (c) Spaces over 50 mm deep: A damp dry mortar of cement fine aggregate 1:2, well tamped against properly fixed forms as filling proceeds.

9.3.9 Encasing of Steel work in Foundations and Filling between Grillage Beams

Grillage beams and all steel in foundations shall be solidly encased in dense concrete of structural Gr. 20 (10 mm) with a minimum cover of 100 mm.

9.3.10 Erection of Trusses

Trusses shall be lifted only at nodes. The trusses above 10 mm in span shall not be sligned at the apex, as this will develop compression stresses in the bottom tie member. They shall be lifted by slinging at two mid points of rafters, which shall be temporarily braced by a wooden member of a suitable section. After the trusses are placed in position, purlins and wind bracings shall be fixed as soon as possible.

STANDARD TECHNICAL SPECIFICATION

The end of the truss which faces the prevailing winds shall be fixed with holding down bolts, and the other end kept free to move. In case of trusses of spans upto 10 m the free end of the truss shall be laid on lead sheet or steel plate as per design, and the holes for holding down bolts shall be made in the form of oblong slots, so as to permit the free movement of the truss end. For larger spans, the truss shall be provided with bearing as per design.

9.4 Rolling Shutters

General

Rolling steel shutters shall be the product of an approved and recognized manufacture regularly engaged in the production of the type of shutter required. Standard commercial products, which meet the general requirements of the specifications and vary only in non-essential details shall be accepted subject to the approval of the Employer's Representative. These shall include necessary locking arrangements and handles etc. These shall be suitable for fixing in the specified location and position i.e. outside or inside on or below lintel or between jambs of the opening. The doors shall be either push and pull type or operated manually or mechanically with a suitable gear mechanism.

9.4.1 Shutters

These shall consist of mild steel laths 121 mm thick (18 G) and 80 mm wide or as specified. The laths shall be machine rolled from a continuous strips into an easy curve free from crimps or sharp bends and with an effective bridge depth of 16 mm. These shall be interlocked together throughout their entire length and jointed at the ends with end locks designed in such a way as to maintain alignment and protect the slats against abrasion in the guides. All joints shall be completely air and weather tight.

The shutters shall be supported by means of spring barrels which in turn are supported by cast iron or steel brackets. The shutter slats shall coil on the spring barrel. A galvanized steel sheet hood not lighter than 18 G reinforced form the end closure.

The spring shall be preferably of coiled type and shall be manufactured from high tensile spring steel wire or strip of adequate strength to balance the shutters in all positions.

9.4.2 Guide Channels

The guide channel shall be a mild steel deep channel section of rolled, pressed or built up (fabricated) construction. The thickness of the sheet used shall not be less than 3 mm. The minimum depth for guide channels shall be as follows:

Clear width of shutter	Depth of Guide Channel
Under 3.5 m	60 mm
3.5 m and above	75 mm

STANDARD TECHNICAL SPECIFICATION

The gap between the two legs of the guide channel shall be sufficient to allow the free movement of the shutter and at the same time close enough to prevent the rattling of the shutter due to wind.

Each guide channel shall be provided with a minimum of three fixing cleats or supports for attachment to walls or columns by means of bolts or screws. The spacing of cleats shall not exceed 750 mm. Alternatively the guide channels may be provided with suitable dowels, hooks, or pins for embedding in the walls.

9.4.3 Fixing

The installation shall be mounted plumb, square and true on the vertical surface of lintels and/or masonry when completed, the door shall completely fill the opening for which it was designed and shall not obstruct the opening when in the open position. The shutters shall operate easily and smoothly under all conditions.

9.5 Tubular Roofs and Columns

9.5.1 Structural Steel Tubes

These shall conform to B.S. 1775 and shall be one of the following types:

1. Hot finished welded (HFW) type
2. Hot finished seamless (HFS) type
3. Electric resistance welded (ERW) type

The steel shall contain:

not more than 0.06 percent sulphur

not more than 0.06 percent potassium

The steel shall have an yield strength of 209 N/mm^2 or as specified. The sizes of tubes and wall thickness shall be as specified. Standard sizes of tubes are reproduced from BS 1775 in Appendices 9A to 9D.

Tolerances

These shall be in conformity with BS 1775 for each type of tube. The tubes shall not deviate from straightness by more than $1/600$ of any length.

Tubes shall be cleanly finished and reasonably free from scale. They shall be free from cracks, surface flaws, lamination and other defects. The ends shall be cut clean and square with the axis of the tubes unless otherwise specified. Where Galvanized tubes are specified these shall be hot dip galvanized and in conformity with the requirements of BS 1775.

STANDARD TECHNICAL SPECIFICATION

Minimum Wall Thickness of Tubes

Structural tubes shall have the minimum wall thickness indicated below depending upon the exposure.

Construction not exposed to weather	3.2 mm
Construction exposed to weather	4.0 mm
Structures not readily accessible for maintenance	5.0 mm

9.5.2 Fabrication

This shall conform to the requirements of clause 9.2.

Caps and Bases for Column

The ends of all the tubes for columns, transmitting loads through the ends, shall be true and square to the axis of the tube and shall be provided with a cap or base accurately fitted to the end of the tube and screwed, welded or shrunk on. The cap or base plate shall be true and square to the axis of the column.

Sealing of Tubes

When the end of a tube is not automatically sealed by virtue of its connection by welding to another member, the end shall be properly and completely sealed. Before sealing the inside of the tube shall be dry and free from loose scale.

Flattened Ends

In tubular construction the ends of tubes may be flattened or otherwise formed to provide for welded, rivetted or bolted connections provided that the methods adopted for such flattening do not injure the material. The change of sections shall be gradual.

9.5.3 Hoisting And Fixing

Shall conform to 9.3

9.6 Steel Doors, Windows, Ventilators And Composite Units

General

The type, overall sizes and location of steel door window and ventilators shall be either as shown on the drawings or as per details given by the Employer's Representative. For doors, the provision of the threshold or the tie-bar at the bottom of the door frame shall be as specified or as directed (usually external doors are provided with threshold and the internal doors with tie bars).

The actual sizes of doors, windows and ventilators shall not vary by more than 1.5 mm from

STANDARD TECHNICAL SPECIFICATION

the dimensions given in the drawings. Where these are not built into the wall construction, the openings shall allow 12 mm clearance around to facilitate easy installation later on.

9.6.1 **Materials**

Cold rolled steel sections made from steel sheet conforming to BS 1449: Part I

9.6.2 **Protection**

Rust proofing and protective finishes shall be as specified.

9.6.3 **Workmanship**

The fabrication, erection, glazing and finishing shall conform to the following standards.

BS 1245	-	Metal door frames (steel)
BS 990: Part 2	-	Steel windows generally for domestic and similar buildings
BS 1787	-	Steel windows for industrial buildings
BSCP 152	-	Glazing and fixing of glass for buildings

9.7 **Aluminum Framed Sliding Glass Doors**

These shall be made of extruded Aluminum alloy sections anodized to Grade AA 25 as per BS 1615 or as specified, mechanically jointed and erected and finished conforming in all respects to BS 5286.

9.8 **Aluminum Windows**

These shall be made of extruded aluminum alloy sections anodized to Grade AA 25 as per BS 1615 or as specified, mechanically jointed, erected and finished conforming in all respects to BS 4873.

CHAPTER 10
DEMOLITION

Demolition work shall be carried out by experience workmen and generally comply with BS 6187. It includes basic consideration and recommended method of demolition of different types of structure , provides a basic for logical approach to safe procedures and offers advice on safety precaution and statutory requirement.

Before any works of demolition are started, a detailed survey and examination of the building or structure and its cartilage should be made, and recommended and kept available for inspection.

All available plans of the building or buildings should be examined, where the nature of the construction is uncertain, a special site investigation should be carried out where there is a doubt concerning the design of structural arrangements, the opinion and advice of an Employer's Representative experienced in such work should be sought.

It is also necessary to consider the after and protection of adjoining buildings and other sensitive elements during demolition.

SCAFFOLDING AND SHORING

General

Any scaffolding required should be designed and erected in accordance with the recommendation given in BS 5973 and should be provided by a competent scaffolder.

Where scaffolding is required it should normally be an independent tied scaffold situated on the outside of the building or structure. The demolition contractor should arrange for the scaffolder to visit the site as necessary and make any adjustments required to the scaffolding as the work proceeds, to ensure its stability.

Care should be taken that the load of any debris collecting on a scaffold does not exceed the loading assumed for the design of scaffold. Measures should be taken to prevent debris from being accidentally dislodged from the platform.

Progressive dismantling. Scaffold that are to be dismantled progressively during the demolition of a building should not be left projecting above residual height of the walls more than necessary.

Stabilizing ties should be maintained, especially with sheeted scaffolds. Compliance with the statutory regulations.

STANDARD TECHNICAL SPECIFICATION

Scaffolds when completed should be left in a condition suitable to perform the duty for which they were intended, and should comply with the requirement of the statutory regulations and with any Local Authority requirement.

Scaffolds should be inspected by the constructor before being taken into use. The user should inspect them weekly or at more frequent intervals if necessary to see that they remain in compliance with the statutory regulation and should sign the Records of weekly inspections to record his findings.

Shores and shoring . When required, shores and shoring should be designed and erected in accordance with the recommendation given in CP 2004. Shoring should be so designed and constructed that it is adequate for its purpose, and an experienced person should ensure that it is placed in position at the appropriate time. Provision should be made for the erection of adequate shoring before the existing lateral support is disturbed.

The layout of the shores should be designed to enable any new building to be constructed with the least possible interference. The shoring should be checked for effectiveness as the demolition proceeds.

10.1 SAFETY OF PERSONNEL ON SITE

Plant and equipment. Care should be taken to ensure that plant equipment is:

- (a) Of an appropriate type and stranded having regard to the location and type of work involved ,
- (b) In the charge of a competent operator , and
- (c) Maintained in good working condition at all times .

The equipment should be fitted to machines and adequate power and stability for the use intended.

The operator should be experienced in the use of the equipment and there should be a high standard of inspection and maintenance.

Where appropriate, plant and equipment should comply with the requirements of the relevant British Standards.

Protection of site personnel. During demolition work all operators should wear adequate protective clothing and, where appropriate, protective equipment such as safety helmets, goggles, ear defenders and respirators.

STANDARD TECHNICAL SPECIFICATION

High levels of noise can cause permanent hearing damage to workers. Attention is drawn to the Health and Safety for reducing the exposure of employed persons to noise, which contains advice on the levels of noise that are a serious hazard and the precautions that can be taken. When noisy machinery is used, ear defenders may be necessary.

For specific operations such as work on building where chemicals have been stored or used or where lead paint, asbestos, dust or fumes may encountered, which may prejudice the health of persons using the site, special precautions should be taken regarding protective clothing, goggles and the use of suitable respirators.

Projecting nails in timber should be removed or hammered flat; they should not be allowed to remain as a source of danger.

Precautions against uncontrolled collapse. The removal of certain parts of the building or structure during demolition can result in other parts becoming unsafe and it is necessary to pre-determine where temporary support will be needed. The advice of a competent Employer's Representative may be required .

10.2 Other Precautions

General

Every working place and approach and all openings dangerous to persons employed and others should be properly illuminated and protected .

Overloading of any part of the building by debris or materials should be avoided.

Before carrying out any part of the work the demolition contractor should consider prevailing weather conditions and weather forecast. Particular attention should be paid to the effects of adverse wind.

When materials and debris are lowered, care should be taken to prevent the material from swinging in such a manner that it creates a danger to the safety of either personnel or the surrounding structure.

Prior to and during enter into confined spaces effective steps should be taken to establish and maintain an atmosphere fit for respiration. Standby men may be necessary during such operations as may be the provision, and training in the use, of rescue equipment.

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Electrical Hazards

When mechanical plant, especially cranes and pusher arms, is used for demolition purposes, care should be taken to ensure that no part of such machines can come into direct contact or in close proximity to overhead or underground electricity or telephone wires or cables. Where such a possibility exists, the local electricity or telephone authority should be informed in order that they may assess the degree of risk and offer advice accordingly. Precautionary measures may include physical barriers, disconnection, recovery or diversion of the affected wires or cables.

Fire or Explosion Risks

Precaution should be taken to prevent the risk of fire or explosion caused by gas or vapour. When thermal reaction or thermal lancing methods are used, consideration should be given to the prevention of oxygen enrichment and the attendant risk of explosion or ignition of flammable vapour. Containers of oxygen, acetylene or liquefied petroleum gas should be handled with care and stored and used in accordance with good practice.

The use of thermal cutting tools in close proximity to timber and other flammable materials should be avoided unless suitable precautions are taken against the risk of fire or explosion.

Attention is drawn to the increasing use of foam plastics and the like in building construction, including its use as insulation between wall leaves. This material may constitute both a fire hazard and a health risk due to toxic combustion products and methods of demolition likely to cause ignition should be avoided. Similarly, when burnt, timbers treated with copper /chrome/ arsenic rot preventatives give off poisonous fumes, and where such timbers are known to be present it should be disposed of in a safe manner.

Explosives should be handled and used in accordance with the recommendations given in BS 5607.

Flooding

Care should be taken to guard against the risk of flooding, especially where the method of demolition being used employs water in volume.

Safety and Convenience of Third Parties

A Person carrying on demolition operations should make sure that any building that is partly demolished and its site is, so far as is reasonably practicable, properly secured or closed against entry at all times when demolition operations are not in progress and that the building or structure is left in a safe condition at the close of each day's work. All reasonably practicable steps should also be taken to prevent the exposure of third parties to substances hazardous to health that are or could be present during demolition work.

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When a building is to be partially demolished it should be ensured that at no time during the process of demolition is the safety of any occupant of the remaining portion put at risk. If necessary the occupants of the remaining portion should be evacuated.

Where works of demolition are likely to result in the discharge of materials or debris on to the public highway or private property not a part of the demolition site, protective covering or fans should be erected or a temporary closure applied to the highway. Fans should be of adequate strength for the purpose and, if need be, waterproofed and laid to fall so that there is no likelihood of water or drips falling on persons using the highway.

Every effort should be made to minimize any nuisance to the public; the following precautions should be observed.

- 10.3** Dust. The demolition works should be periodically sprayed with water to reduce the amount of dust. It should be borne in mind that some dusts are flammable, particularly if there are residues contained within silos, plant, etc.
- (a) Noise. Noise should be minimized as far as possible, in particular by limiting the use of compressors and other plant to stated hours and by the fitting and use of silencing devices wherever practicable.

Where partial demolition or alterations are carried out to an occupied building or to a building structurally linked to an occupied building, the use of non - percussive methods should be considered in order to minimize the structural - borne transmission of noise and vibration.

Fire and Smoke

All fires should be extinguished early enough so that they are out before the personnel leave the site, or an appointed fire - watchman should remain on the site for at least one hour after all fires have been extinguished. Extra care should be taken to ensure that no incipient fires are left when burning equipment (e.g. oxy - propane torches) has been used.

The particular requirements of smoke control areas should be ascertained from the Local Authority.

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Gas cylinders and similar containers, whether empty, in use or spare, should be stored in a safe place, in accordance with good practice, since if they become involved in a fire any resulting explosion may cause injury to persons and damage to property.

10.4 Methods of Demolition

General

This clause describes the various method of demolition in use, together with the appropriate precautionary measures that should be taken. While describe separately in this clause, it is common for several method to be used in combination or at such cases the precaution or at different parts of the demolition site. In such cases the precaution relevant to all the methods in use should be taken.

16.3.1 Hand Demolition

Hand demolition involves the progressive demolition of a structure by operatives using hand - held tools; lifting appliances may be used for lifting and lowering members once they are released.

Where work cannot be done safety from a part of a building or structure, a suitable working platform made from standard scaffolding or special purpose scaffolding should be used. Other means of support such as specially designed working platforms or a suitable skip suspend from a crane or aerial platform, or, in some instances, ladders, may also be used.

Buildings and other structures should generally be demolished in the reverse order to that of their construction. The order of demolition for buildings should be progressive, story by story, having regard to the type of construction.

On all sites debris should be allowed to fall freely to the ground internally or externally or externally only where the horizontal distance from the point of fall to a public highway, or adjoining property, is not less than 6 m, or half the height from which the debris is dropped, whichever is the greater. In other cases, chutes or skips should be used.

Where debris from walls, etc. above first floor level is to be dropped to the ground or basement level within a building, sufficient openings, clear of joists or beams, should be formed in the floors to enable the debris to fall without deflection. If it is proposed to remove one or more joists to allow the free passage of debris, care should be taken that such action will not jeopardize the stability of the surrounding structure.

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Precautions should be taken against flying or falling debris by sealing off all openings in walls adjacent to the area of fall. To prevent excessive lateral pressure, care should always be taken to avoid a building - up of fallen debris against walls in the lowest stories. This is of particular importance in confined spaces such as lift and tall chimneys.

When material is being dropped, a look - out man should be posted to ensure safety generally. Steel structural members and reinforced concrete structural members should be lowered to the ground or be cut into lengths appropriate to the weight and size of member before being allowed to fall.

Where possible, a crane and lifting gear should be used to support beams and columns whilst they are being cut and lowered to the ground. In framed structures of precast concrete or steelworks, similar support should be given to members while joints are being severed.

When only a portion of a structure is to be demolished, the stability of the part to remain should be checked.

10.3.2 Mechanical Demolition by Pusher Arm

Mechanical demolition by pusher arm involves the progressive demolition of a wall using a machine fitted with a pusher arm exerting horizontal thrust.

The pusher arm should be used only when the equipment is on firm level ground. It should not be overloaded and should generally be used from outside and not from inside the building. No person should be within that distance of the building where debris is liable to fly.

The pusher arm should be made of steel. Pusher arms of other materials should not be used.

The cab of the appliance should be robust enough to withstand impact from flying debris and the cab windows should be of shatter - proof glass.

The height of the building should, in the first instance, be reduced by hand demolition to a height to suit the machine being used; then the height should be reduced progressively by pushing small sections to the ground.

Where this method is adopted for demolition of attached building, the structure to be demolished should first be detached by hand demolition.

The clear space in which the equipment is to operate should be a minimum of 6 m.

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The plant should be used only in accordance with the manufacturer's recommendations; On no account should the point where the pusher arm is applied to a wall being demolished be more than 600 mm below the top of the wall. The plant should not be worked from a roadway without the permission of the Local Authority.

10.3.3 Mechanical Demolition by Deliberate Collapse

Mechanical demolition by deliberate collapse involves the removal of key structural members causing complete collapse of the whole or part of the building or structure being demolished.

Expert Employer's Representative advice should be sought before this method is used; it should be employed only on detached, isolated, reasonably level sites and where the whole structure is to be demolished. There should be sufficient space to enable equipment and personnel to be removed to a safe distance.

Sections of a structure should not be pulled down by deliberate collapse in separate operation if instability of the remaining structure may result, causing a possible hazard to personal on the site.

10.3.4 Mechanical Demolition by Demolition Ball

Mechanical demolition by demolition ball involves the progressive demolition of the building by the swinging of a weight suspended from a lifting appliance.

Three techniques may be used:

- (a) . vertical drop;
- (b) . swinging in line with the jib;
- (c) . slewing jib.

The operator should be experienced and skilled in the use of equipment and techniques of demolition and there should be high standard of inspection and maintenance.

Reference should be made to CP 3010. Cranes with telescopic jibs should not normally be used for demolition ball duties.

When high balling is to be carried out, it should be undertaken only by operators and experienced supervisors thoroughly conversant with this technique.

This method should not be used on buildings or parts of building where the angle of the jib would exceed 60° to the horizontal. The use of the demolition ball where attached to a normal duty mobile crane should be restricted to free fall vertical drop only. The use of a swinging motion to effect demolition by a ball weight, whether by swinging in line with the jib or

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by slewing, should be restricted to machines designed for arduous or heavy duty such as convertible dragline excavators.

An anti - spin device should always be used on the hoist rope in conjunction with the ball attachment equipment. In all cases, reference should be made to the machine manufacturers for guidance as to the limitation in service, e.g. the lengths of jib and the weight of the drop ball and attachment that may be used. It should be noted that certain manufacturers do not recommend the use of their machines for demolition ball duties or may approve this use only conditionally, with restriction on the techniques to be used or on the maximum jib lengths, etc. The hoist rope, anti - spin device, and the attachment of the demolition ball to the hoist rope should be inspected at least twice daily by a competent person.

It is advisable to reduce progressively the length of the jib as the demolition proceeds. But at no time should the jib head be less than 3 m above the portion of the building being demolished.

Swinging of the ball should be carried out by method that do not overstress the jib or hazard the stability of the machine. The supporting ropes should be of such length or be so restrained that it is not possible for the ball to swing against any structure other than that being demolished.

Jib derricking for the purpose of swinging the ball should not be permitted.

Slewing jib techniques can impose excessive stresses on the machine and also on the jib, which should be suitably rated for the purpose. Factors that could impose high operational stresses in the jib are as follows:

- (a) . Angle of slew (which should not exceed a total of 30°);
- (b) . Acceleration of slew;
- (c) . Rate of checking of slew;
- (d) . Weight of ball;
- (e) . Height at point of impact.

Only operators experienced in the use of slewing jib techniques should be employed for this work.

Care should be taken to avoid the ball becoming trapped when drop - balling masonry arches, suspended floor slabs or similar element of structure, as a sudden collapse could result in the

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machine being overloaded . If the ball is trapped, attempts should not be made to free it by a dragging or lifting action as this may overload the crane.

The cab of the machine should be robust enough to withstand impact from flying debris and the cab windows should be of shatter - proof glass.

In all cases the machine should be used only when standing on firm level ground. The machine should generally be positioned to operate from outside and not from inside the building.

Where this method of demolition is adopted on attached buildings, the structure to be demolished should first be detached by hand demolition and a clear space of at least 1 meter wide provided between the two buildings to ensure that transmission of vibration is kept to a minimum. At all times the stability and safety of the remaining property should be ensured.

The clear space in which the equipment is to operate should be a minimum of 6 m.

Where it is possible to demolish a building without endangering any adjacent building the whole building may be demolished with a ball, provided that personnel do not have to enter the building once demolition has commenced. If the building has a pitched roof, the roof structure should be removed down to wall plate level by hand demolition before using the ball.

Before walls are demolished, section of the floors should be removed by hand demolition to facilitate the free fall of debris. Generally between 50 % and 75 % of the areas of the floors can be removed but sufficient structure should remain to ensure the stability of the building. The demolition should be carried out progressively story by story, having due regard to the type of construction.

Debris should not be allowed to accumulate above an average height of 2 m from ground level before removal, nor should it be allowed to subject the containing structure to undue lateral pressure.

10.3.5 Mechanical Demolition by Wire Rope Pulling

Wire rope pulling should not be used on masonry structures exceeding 21 m in height. The rope should be of such length that horizontal distance from the demolition work to the winch or pulling vehicle is not less than twice the height of the heights part to be pulled.

Only steel wire ropes should be used for this operation. The size and strength of the rope should be adequate for the purpose for which it is to be used and in no case should the circumference of the rope less than 38 mm.

The rope should be inspected by a competent person before use and at least twice daily to

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ensure that its strength has not been impaired by wear or damaged. Damaged ropes should not be used.

The rope should be firmly fixed at both ends and the tension in the pulling rope should be gradually applied; snatch loading should not be permitted.

Any sharp edges round which the rope may be wound should be protected to avoid wear on the rope.

When pulling, no person should be forward of the winch or tracked vehicle and no person on either side of the wire rope within a distance of three quarters of the distance between the winch or tracked vehicle and the structure to be demolished.

If an attempt or several attempts are made to pull a building or structure and the equipment is found to be inadequate to cause collapse it is most probable that weakening of the building or structure will have taken place. Under these circumstances it is dangerous for a person to approach the structure and an alternative method of demolition should be used if at all possible, e.g. pusher arm, demolition ball or any other safe method.

Where it is required to demolish a building or structure by sections and it is not possible or practical to isolate such sections, the wire ropes should be attached to their respective sections prior to the first pull being made and the free ends should be left at a safe distance from the building.

Where sections of the building or structure are progressively completely isolated, such section may be progressively pulled down and the wire ropes re - fixed accordingly, having constant regard to the stability of the building or structure.

A well - anchored winch or a tracked or heavy vehicle should be used for pulling. Care should be taken to ensure that the vehicle does not lift from its tracks or tyres so as to endanger its stability during pulling. The direction of the tracks or tyres should be maintained in line with the line of pull.

Protection from rope breakage and flying debris should be afforded to the drive.

10.3.6 Demolition by Explosive

Reference should be made to the recommendations given in BS 5607 when explosives are to be used for demolition. A specialist experienced in the controlled application of explosives for the purpose of carrying out the demolition of civilian structures should be consulted before deciding

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whether explosives are to be used for demolition. Account should be taken of the type of structure and its situation. An explosives specialist firm or company should be employed, experienced in this type of work and holding the necessary license from the police to purchase explosives. Before blasting operations commence, the police should be informed and their assistance sought to keep people and livestock away from the area.

Utilities require special consideration, and the proximity of underground and over ground services should be carefully considered before blasting operations are carried out. Consultations should be carried out with the necessary authorities who are responsible for concealed underground works (e.g. pipes , cables , etc.).

The explosives specialist should decide the charges to be used and their placing. Adequate storage accommodation should be provided. Precautions should be taken to protect other property from shock and vibration, and flying debris should be controlled by means of blast mats or other baffles. In the event of a misfire the area should remain cleared until the explosives specialist has dealt with the situation. If, after blasting operation, a misfired charge is found during the subsequent removal of debris the area should be cleared and entrance restricted until the explosives specialist has rendered the misfire safe.

Under certain circumstances electrical and radio - transmitting installations can cause detonation of electrical detonators without physical contact; electrical storms may have the same effect. Guidance on protection against these hazards is given in BS 4992. Demolition by explosives should be supervised by personnel experienced in the controlled application of explosives.

10.3.7 Other Methods of Demolition

General

There are a number of other forms of mechanical, thermal or percussive demolition available. These are generally more limited in application, and in a number of cases are useful for smaller demolition works. As with the previously described methods, they may be used in combination with other techniques. In all cases they should be carried out by persons experienced in the use of the particular equipment involved, and the equipment should be used in accordance with the manufacturer's instruction.

10.3.7.1 Machine - Mounted Impact Hammer

A machine - mounted impact hammer is larger and heavier duty form of the hand - held pneumatic drill , and may be pneumatically or hydraulically operated . As in the case of the lighter equipment, it is useful for breaking up massive construction such as concrete base slabs or the like, and for breaking larger pieces of debris into manageable sizes. It should not normally be used to demolish tall vertical such as walls or columns from the side, because of the risk of debris falling on to the machine or the operatives.

10.3.7.2 Power Grapples and Shears

Power grapples and shears are frequently hydraulically operated . Power shears may be used as an alternative to oxyacetylene cutting or the like to crop and cut through metal such as reinforcing steel or beams, particularly where there might otherwise be a risk of fire or where the more precise cutting possible with a torch is not required. Care should be taken to ensure that any member to be severed is either effectively supported or, if to be allowed to fall, in so doing will endanger neither personnel nor the remaining structures. Power grapples may be used to handle waste material , either to move it about a site or to load other vehicles when disposing of the waste. As some debris resulting from demolition has high density, care should be taken to avoid overloading the equipment both to avoid damage to the equipment itself and to avoid the risk of the machine overturning as a result of instability induced by a heavy load.

10.3.7.3 Purpose -Built Grabs

Purpose - built grabs should generally be used only for moving debris from one location to another. As in the case of power grapples, care should be taken not to overload the equipment, in order to avoid collapse or instability.

10.3.7.4 Drilling and Sawing

Drilling and sawing are used either to remove totally part of a structure or to produce a potential fracture zone (e.g. by stich - drilling , which is drilling a line of overlapping holes) , and are frequently used in conjunction with other methods of demolition, particularly bursting. Diamond or tungsten tipped drills or saws are normally used . These method can be employed in confined spaces, or for work that requires a high degree of accuracy, or where the noise, dust and vibration resulting from some other methods would be unacceptable . They may be used to cut up floors and suspend slabs into manageable sizes, or to cut holes and slots in parts of a structure. Whist this is being done the piece to be removed should be adequately supported. Use of these methods avoids damage to the surrounding area.

In order to flush out the resulting dust, and to cool the equipment during use, it is usual to employ running water in volume as a coolant. This needs to be borne in mind if it is proposed to adopt this method of demolition, and measures should be taken to provide a suitable supply of water, and to collect and safely dispose of the waste water those results. Care should be taken that any sparks produced during sawing do not constitute a health or fire hazard.

10.3.7.5 Bursting

General

The technique of bursting is analogous to the use of explosives in that it makes use of expansion of a mass of gas or a mechanical device in a prepared crack in a mass in order to break it into fragments. It may be possible to use this method where the use of explosives would

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not be possible as a result of site conditions.

Gas expansion burstings. A Gas expansion burster operates with explosive force and should only be used and operated by persons skilled in its use. The effect of the burster is obtained by inserting it into prepared cavity in the mass to be demolished. Upon being energized by means of an electrically operated device, the resultant increase in pressure of the gas ruptures a diaphragm, releasing the gas into the crevices in the surrounding structure which is thus fractured. Extreme care should be taken to ensure that the burster is effectively restrained within the prepared cavity in order to prevent it from becoming an uncontrolled projectile.

10.3.7.6 Hydraulic Burstern

An hydraulic bursters also uses an expanding device to force apart a mass, but the process is not as rapid as in a gas expansion burster. Pistons or wedges are placed in a prepared cavity and are gradually jacked out under pressure, the resulting increase in size of the device fracturing the surrounding material. During use care should be taken that when the structure or mass collapses it does so without endangering the operatives or equipment.

10.3.7.7 Hydraulic Cannon

An hydraulic cannon projects a single, high - pressure, shot of water into a pre - drilled hole in a structure in order to break it up. It is generally used to break large pieces of rock or rubble into more manageable sizes for easier handling. As in the case of drilling and sawing, measures should be taken to ensure the safe and effective disposal of the water utilized by this equipment.

10.3.7.8 Thermal Reaction and Thermic Lance

General

The thermal reaction and thermic lance methods of demolition are two distinct techniques, but they each use heat as a means of weakening or severing a structure in order to facilitate its removal. As in all methods in which heat is used as the primary agent, care should be taken to prevent the risk of fire or explosion when these methods are used in the proximity of timber and other flammable materials and vapours. In particular consideration should be given to preventing localized oxygen enrichment because of the attendant risk of explosion.

Thermal Reaction

The thermal reaction technique is typically used in conjunction with wire rope pulling to break up structural steel member to be severed is surrounded by a mixture of a metal oxide and a reducing agent that when ignited reacts to liberate a large quantity of heat. After ignition, which may be remotely initiated electrically, the steel becomes plastic and a small unbalancing force

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applied by means of a pulling rope should normally be sufficient to effect the collapse of the member. Suitable precautions commensurate with the other techniques being used in conjunction with the thermal reaction should be taken .

Thermic Lancing

Thermic lancing is the technique of using a thermic lance to cut through materials, including concrete, that may not be amenable to the use of other forms of cutting equipment. The tip of the lance is preheated to start an oxygen / iron reaction that produces an intense heat source that is then applied to the material to be cut. Once started the reaction is self - supporting. During thermic lancing the products of combustion typically produce a thick smoke; suitable precautions should therefore be taken, particularly in a confined space.

Fire

The deliberate burning of buildings should not be used as a means of demolition. In addition, fire should not be used for removing temporary timber shoring or the like.

CHAPTER 11
MISCELLANEOUS BUILDINGS WORKS

11.1 Damp Proof Courses

General

Damp proof courses shall be laid for all walls. The damp proof course shall extend for the full thickness and shall be located at a minimum height of 150 mm above finished ground level or as shown in drawings or as directed by the Employer's Representative.

Note: Consideration shall be given to flooding and site drainage in deciding on the height.

11.1.1 Cement Concrete Layer

This shall consist of cement concrete of specified proportions and thickness, where so specified, water proofing material of approved manufacture shall be added to the concrete mix in accordance with the manufacturer's specifications. The surface of brick work or stone work masonry shall be leveled and prepared before laying the cement concrete. Edges of the damp proof course shall be straight, even and vertical. Side shuttering shall consist of wooden forms and shall be strong and properly fixed so that it does not get disturbed during compaction and the mortar does not leak through. The concrete mix shall be of workable consistency and shall be tamped thoroughly to make a dense mass. When the side formwork is removed, the surface revealed shall be smooth without any honey-combing.

Curing

The concrete shall be adequately cured after which it shall be allowed to dry.

Application of Hot Tar

The surface shall be properly cleaned with brushes and finally with a piece of cloth soaked in kerosene oil. Two coats of hot tar shall be applied at the rate of 0.25 litres per m² per coat.

11.1.2 Cement Mortar Layer

This shall consist of a 20 mm thick layer of cement mortar 1:2 finished with an application of two coats of hot tar applied at the rate of 0.25 litres per m² for each coat.

11.1.3 Vitrified Brick Damp Proof Courses

These shall consist of at least two courses of vitrified bricks set and jointed in cement mortar 1:3 and pointed to match surrounding work. The bricks shall conform to BS 3921 and shall not absorb more water than 3% of their weight when tested in accordance with BS 743.

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11.1.4 Damp Proof Courses in Sheets of Bitumen, Polythene, Lead or Chopper

These shall conform to BS 743 as regards materials and workmanship.

11.2 Damp Proofing of Walls/Tanking

This shall conform to BSCP 102.

11.3 Floor Screeds/Roof Screeds

General

Note: Screeds shall be provided over structural bases

- (a) to provide a degree of level and smoothness to suit a particular floor finish where this is not provided by the structural base.
- (b) to raise levels
- (c) to provide slopes for drainage or
- (d) to accommodate services

Unless otherwise specified, the thickness and bay sizes of screeds shall be as per Table 11.1 below:

Table 11.1

Type	Base	Thickness	Bay size
Monolithic	Concrete less than 3 hours old. (No preparation for base)	12 - 25 mm	15m ² maximum and length not exceeding 1 1/2 times the width.
Bonded	Sound, clean concrete more than 3 hours old but not including water-repellent admixture. Base preparation conforming to Sub Sections 11.2.3	40 mm (minimum)	
Unbonded	Damp-proof membrane or concrete which is weak, contaminated or includes water repellent admixtures	50 mm (minimum)	

11.3.1 Materials for Screeds

- Portland cement conforming to CS 107
 - Aggregates conforming to BS 882 and Max. nominal size 10
 - Building sands conforming to BS 1199
- Workability additives shall be of approved manufacture.

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11.3.2 Mixes

Unless otherwise specified, mix proportions (by weight) shall be as per table 11.2 below or as specified.

Table 11.2

Thickness of screed (mm)	Cement	Fine aggregate (dry sand or crushed stone graded 5 mm down)	Coarse aggregates (graded 10 mm down)
Upto 40	1	3 - 4 1/2	
40 to 75			
over 75	1	1 1/2	3

Note: The cement-aggregate ratio by weight shall not exceed 3. Batching by volume shall conform to Sub Section 4.3.2.1

A mechanical mixer shall be used. Hand mixing shall be adopted with the permission of the Employer's Representative. The driest mix which can be thoroughly compacted with the means available shall be used. A sample squeezed in the hand shall ball together without water being forced out. Workability aids to attain low water cement ratios shall be used to the manufacturer's instructions, if approved by the Employer's Representative.

11.3.3 Laying

Screed concrete shall be laid on bays and thoroughly compacted preferably by means of screed vibrator. Excess of laitance shall not be drawn to the surface while vibrating. The surface shall be leveled with wooden screed boards and wood floated to suit the flooring/roof finish as directed by the Employer's Representative.

11.3.4 Tolerance for Level

This shall conform to the tolerance for granolithic or other finishes. Please see Sub Section 11.2.10

11.3.5 Curing, Protection etc.

This shall be the same as for granolithic floor finishers.

11.4 Wall Tiling and Mosaic Work

General

Internal wall tiling and mosaic work shall generally conform to BS 5385: part 1, and external wall tiling and mosaic work to BS 5385 part 2.

Where directed, sample areas shall be furnished and approval of the Employer's representative obtained as regards materials and workmanship. The work on completion shall conform to the sample areas.

11.4.1 Materials

11.4.1.1 Glazed ceramic tiles and specials

These shall be of approved manufacture and for internal work, shall generally conform to BS 1281. For external work and for heavy duty work those recommended by the manufacturers shall be used. The tiles for external use shall be highly vitrified and thicker than internal tiles, and shall be glazed or unglazed as specified. Wall tile sizes shall generally conform to BS 1281.

The following tile sizes are manufactured by the Wall Tiles Corporation:-

4 1/4" x	4 1/4"	
6"	x	6"
6"	x	3"
8"	x	4"

The tiles shall be flat or round edged, glazed or matt white or other approved color as specified. The tiles shall be sound, hard, well and evenly glazed, free from twist and crazing and true to shape. Tile fittings shall not be less in thickness than the tiles with which they are used. The tiles shall not be damaged or soiled during storage and handling.

11.4.1.2 Mosaics

Mosaic Tessere shall be glazed or unglazed ceramics of sizes supplied to specified local standards.

Note:- These are assembled in the form of sheets to approved pattern and color with Nylon nets glued to the back of mosaics or with paper glued to the face of the mosaic.

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11.4.1.3 Cement sand mortar

Adhesives where specified, as bedding material for ceramic tiles and mosaics shall conform to BS 5980.

11.4.1.4 Adhesives

Adhesives where specified as bedding material for ceramic tiles and mosaics shall conform to BS 5980.

11.4.2 Fixing

11.4.2.1 Fixing tiles

A rendering or cement mortar 1:3 or 1:4 specified shall be applied over the prepared surface of the wall. The rendering shall be finished with wood floats to give an even texture. The surface shall neither be trowelled nor overworked. No water shall be applied while working and excessive laitance shall not be drawn to the surface. The surface shall be left scratched with wire nail or other pointed tool to provide adequate key for the bedding mortar. The rendering shall be cured for a week and allowed to dry.

The rendering shall be at least two weeks old (or as specified by the manufacturer of the tiles) before tiles are fixed. External tiling shall be started at the top and worked downwards. Before fixing tiles, the rendering shall be wetted and allowed to dry. Tiles shall be soaked in water for at least half an hour, then drained and stacked. One of the two methods of fixing tiles shall be adopted as approved by the Employer's Representative.

(a) The buttering method: The back of each tile shall be buttered with cement mortar 1:3 fill all frogs and other indentations filled and bedded solidly over the rendering. The thickness of bedding shall generally be 6 mm and shall in no case exceed 12 mm. The joint widths shall be uniform and normally about 2 mm.

(b) Floating method: The bedding mortar shall be applied to the rendered surface to a thickness of between 6 and 10 mm, and allowed to stiffen for a short period. A plastic and rich cement mortar 1:2 using fine sand shall be applied to the bedding mortar and evened up. The tiles shall then be pressed on to this surface. Alternatively the tiles could be buttered with the rich fatty mortar and pressed into the stiffened bedding mortar.

A straight edge shall be used to ensure that the surface of the tiling is flat and true. Any adjustment of the tiles shall be made within 10 minutes of fixing.

As the work proceeds, the joints shall be finished off with white (or colored Portland cement to match the color of tiles) and very fine sand mixed in the proportion of 1:1 to paste like

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consistency; the entire surface shall be cleaned down using a damp cloth before any cement smears and surplus mortar begins to harden on the surface or in the joint spaces, care being taken to avoid any disturbance to the tiles.

If adhesives are used for bedding, specifications of the manufacturer shall be followed.

11.4.2.2 Fixing mosaics

The back ground (of rendering) shall be prepared in a similar manner to tiles as per Sub Section 11.4.2

Before bedding face-papered sheets, the joint cavities on the fixing side of white (or colored) Portland cement and very fine sand in the proportion of 1:1 mixed to a paste like consistency. The backs of mosaics shall be cleaned free of grouting material.

The bedding mix of cement mortar 1:3 shall be floated on to the back ground by trowelling to a thickness not exceeding 10 mm and finishing with a wooden float. A coat of neat cement paste shall be applied and the surface evened up. The bedding shall be allowed to stiffen slightly before the mosaic is applied. The mosaic sheets shall then be hung in position and firmly pressed back at their top edges and the pressure continued downwards until the sheets are firmly bedded.

After a few sheets have been so positioned, this area shall be beaten with a suitable flat implement to ensure good adhesion and a true flat surface. The paper shall be soaked with water, removed, and adjustment of the mosaic done within 10 minutes of fixing. When the work is firm, a grout shall be rubbed over the surfaces to fill any voids remaining in the joints and the work cleaned off with moist cloth. After the grout has hardened sufficiently the surface shall be washed down with water and left clean.

In the case of sheets with nylon backing pre-grouting of joints between mosaics is not necessary. Post grouting of joints shall be done with a grout of cement and fine sand mixed in the proportion of 1:1 to paste like consistency as described before and the work finished off true and flat.

11.5 Asbestos Cement Sheet Ceiling

(Deleted)

11.6 Fibre Board Ceiling

These shall be fixed as described above. Painting shall be as specified in Chapter 18.

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11.7 Proprietary Ceiling System

These shall be of approved manufacture and shall be fixed to the manufacturer's specifications.

11.8 Brick Pavements

11.8.1 Bricks

Bricks shall, be good, hard and sound conforming to BS.

11.8.2 Mortar

Mortar used for bedding and jointing shall be lime mortar 1:2 and that used for pointing shall be cement mortar 1:3 all complying with Sections 3:1 and 3.2.

11.8.3 Sub Grade

The brick paving shall be done over a prepared base of consolidated stones, gravel, sand or earth as may be specified. The sub grade shall be provided with the slope required for the flooring itself. Floor - in verandahs, Kitchens, baths, water closets and courtyards shall invariably be provided with suitable sloped to drain off wash and rain water.

11.8.4 Laying

The bricks shall be wetted and shall be laid on edge of flat over a 12 mm thick mortar bed. Each brick shall be properly bedded and set home by gently tapping with the handle of the trowel or wooden mallet. Inside faces shall be buttered with mortar before the next brick is laid and pressed against it.

On completion of a portion of the flooring, the vertical joints shall be grouted with the mortar. The bricks shall be laid to the required slope by constant checking with a 2 m straight edge. The face joints shall be raked with a raking tool to a minimum depth of 12 mm when the mortar is still green and pointed with cement mortar 1:3

Note :If rendering is specified, the mortar for rendering shall generally be cement mortar 1:2. Minimum thickness of rendering shall be 12 mm. The rendering shall be tamped and wood floated to the required surface texture.

The beating shall continue until the concrete is well consolidated and the beater makes no impression and readily rebounds from the surface when struck on it. During the process of beating, the surface shall be kept continuously wet by sprinkling lime water of the sand with bitumen is complete and the mastic well stirred until homogeneous.

Curing and Protection

Shall be as for brick work.

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11.9 Plastering for Slab Bearings

Particularly in exposed locations or where specified cement plaster 6 mm thick finished with a floating coat of neat cement and a thick coat of lime wash shall be applied on the top of walls.

11.10 Water Proofing of Reinforced Concrete Roofs

General

Water proofing of flat roofs shall be of the best workmanship executed with utmost care and attention to detail so as to avoid failure. The slopes specified shall be accurately provided.

11.10.1 Reinforced Concrete Slabs Laid Flat

Note: The roof shall be cured for at least 7 days by ponding water to a depth of about 50 mm. (Sub Section 5.4.6.1) After the curing period is over, the roof shall be allowed to dry for another three weeks and attain sufficient strength before laying the water proofing.

11.10.1.1 The screed concrete

A screed of a suitable design shall be laid over the flat slabs and finished to specified slopes. The screed shall be one of the following.

Note: On completion of beating, there shall be no voids and the surface shall be smooth and even. The surface shall be kept moist for a period of 7 days.

11.10.1.2 Water proof cover

The surface shall be finished in one of the following ways:-

(a) **Tiling:**

Two courses of flat tiles of sound manufacture and 150 x 150 x 10 mm or such other size as specified shall be laid in cement mortar 1:3 with Nonvolatile crude oil at the rate of 10% by weight of cement or Water-proofing admixtures to the specifications of the manufacturers. The tiles shall be laid over a 10 mm thick bed of cement mortar with joints not exceeding 6 mm, and the joints of the 2 courses shall be staggered. Before the work dries up, the joints shall be raked up to about 6 mm and pointed with the same mortar and pressed and rubbed over with thin bar trowels (the excess mortar being scraped off) until the surface of the pointing attains a black polish. The edges of the tile layers shall be finished flush with the finishes for the edges of reinforced concrete slab with a 20 mm thick band of cement mortar 1:3.

(b) **Mastic Asphalt**

The mastic asphalt shall be of the following:
composition by weight:-

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Sand	70	-	74%
Bitumen 20/30 penetration	15	-	13%
Filler (Cement, etc.)	15	-	13%

The sand and bitumen shall be heated separately to about 200° C and bitumen added to the sand and stirred well. The filler shall be added when mixing

- (a) Cement concrete 1:3:6: (20 mm) with a minimum thickness of 25 mm conforming to Clause 4.
- (b) Lime concrete(25 mm) with a minimum thickness of 50 mm composed of one part by volume of slaked lime to 2.5 parts by volume of well burnt broken brick aggregate of maximum size 25 mm. No sand shall be incorporated. The brick aggregate shall be wetted thoroughly and mixed with lime adding just enough water to make it into a stiff paste.

This concrete is laid to a minimum of 50 mm in thickness and well beaten with wooden rammers 40 mm diameter and 1.2 meter long.

The surface of the roof shall be given a priming coat of bitumen, and while still cacky, the hot mastic should be poured on the surface, spread and tamped gently, smoothed out and worked with wooden float or trowels with sufficient pressure until it is free from voids and blow holes and a smooth homogeneous layer 12 mm thick is obtained.

The surface shall be sprinkled with a mixture of fine dry sharp sand containing about 10% of cement and rubbed with floats until a perfectly smooth surface is obtained.

The mastic shall be carried 75 mm up the walls or parapets previously painted with hot bitumen the angle between the wall and roof shall be rounded off and the part carried up the wall beveled.

(c) Bitumastic Emulsion

This treatment shall consist of a priming coat applied to the roof and 230 mm up the parapet walls of Flintkote, Type 1 or equivalent emulsion diluted with about 5% water at the rate of 0.75 litre/ m² a second coat shall be applied when the priming coat is dry, of the same but undiluted emulsion at the rate of 0.75 litre/ m². On this layer. When still wet, a woven fiber glass membrane or other approved fabric shall be embedded, overlapping all joints by 100 mm. When this is dry, a priming coat of the same emulsion at the rate of 0.5 litre/ m² shall be applied over the membrane. A final waterproofing coat of Flintkote, Type 7 or equivalent emulsion shall be applied by trowel at the rate of 2.5

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litre/ m². A thick coat of lime wash shall be applied over the Flintkote to avoid excessive heat absorption.

(d) Plastic Asphalt

The surface shall be cleaned thoroughly and a coat of Bituminous solution PF 4 applied as primer. Care shall be taken that the surface is perfectly dry Plastic Asphalt shall then be applied in two thin layers each 1.5 mm thick, the second coat to dry for four to six days.

(e) Bitumen felt roof covering

This shall conform to BS 747 for roofing felts and BSCP 144 for workmanship.

(f) Proprietary roof covering shall conform to the manufacturer's instructions in all respects.

Note: For b, c & d one coat of clay tiles set in cement mortar 1:3 shall be provided where specified or directed.

11.10.2 Reinforced Concrete Slabs Laid to Slopes

11.10.2.1 The screeds shall be uniform in thickness and one of the following:

- (a) A 12 mm thick layer of cement mortar 1:2 mixed with water proofing admixture to the instructions of the manufacturer.
- (b) A layer of cement mortars 1:3 treated with 2 coats of hot tar 3 mm thick and blinded with sand.
- (c) Cement concrete 1:3:6 (20 mm) 25 mm thick conforming to requirements of Section 4.1
- (d) Lime concrete - 50 mm thick conforming to the requirements of Sub Section 11.10.1

11.10.2.2 The water proofing covering

This shall conform to 11.10.1.2

CHAPTER 12

STRUCTURAL STEEL WORK

12.1 General

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Except where otherwise directed by this specification or authorized by the Employer's Representative in writing, the design, detailing, fabrication and erection of structural steelwork shall comply with the edition of BS 5950:Part 1:1990.

The Contractor shall not depart from this Specification except with the permission of the Employer's Representative in writing.

12.2 Supervision of Work

The work shall be supervised throughout by qualified Supervisors who are thoroughly experienced in the fabrication and erection of similar work.

12.3 Materials

12.3.1 New Materials

All materials used throughout the works shall be new unless otherwise specified or agreed by the Employer's Representative in writing.

12.3.2 Miscellaneous Materials

All materials not fully specified herein and which may be offered for use in the works shall comply with the appropriate standards. In the absence of such a standard they shall be to the approval of the Employer's Representative.

12.3.3 Grades of Steel

Unless otherwise specified steel for sections, plates, flats and bars shall comply with grades and standards to be specified.

(a) Rolled Sections and Hollow Sections

Hot rolled structural section and hollow sections shall comply with B.S.4 and BS 4848. Cold rolled sections shall comply with BS 2994.

(b) Black Bolts

Grade 8.8 bolts shall comply the BS 3692

Black bolts shall have the short thread length and are to be Hot Dip Galvanized to BS 729. Nuts to be similarly galvanized as blanks and then tapped up to 0.4mm oversize with the threads lightly oiled.

(c) Washers

Flat, circular and square taper washers shall comply with BS 4320 and be Hot Dip Galvanized to

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BS 729.

(d) Electrodes

Electrodes and fluxes for metal-arc welding shall be in accordance with BS 639 or BS4165 and shall be suitable for the highest grade of parent metal being joined.

12.4 Design and details

12.4.1 Amendments to Details of Design

Should the Contractor wish to propose alternative details to those specified for the design of the works application shall be made in sufficient time to permit the Employer's Representative to give full consideration to the proposals.

12.4.2 Shop Drawings

The Contractor shall prepare and provide detailed shop drawings and schedules for fabrication of the steelwork. These drawings shall be based on the Tender Drawings and on any further drawings or written instructions issued by the Employer's Representative during the Contract.

The Contractor shall provide at the outset two copies of a marking plan locating shop details to facilitate identification for approval.

The shop drawings shall clearly show all details and dimensions of the work, and the materials from which each part is to be made, and the calculated weight of the materials.

Fabrication of the steel work shall not commence until the Employer's Representative has approved the shop drawings, and for this purpose copies of checked shop drawings and copies of checked supporting calculations shall be submitted so that not less than fourteen clear days are available to the Employer's Representative for his consideration from the date of receipt of the drawings.

The Employer's Representative will verify the correct interpretation of his requirements but will not necessarily verify the dimensions, and the Contractor shall be entirely responsible for the accuracy of the drawings, the correctness of design and details of connections and joints. After the Employer's Representative has approved each drawing the Contractor shall provide the Employer's Representative with copies of all final drawings.

The Contractor shall supply to the Employer's Representative 6 copies of all drawings necessary for setting out the foundations to suit the permanent steelwork and to suit any temporary works required for erection of the steelwork and the Contractor shall be responsible for the

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accuracy of these drawings. Any requirements to suit temporary works shall be given in sufficient time to enable them to be incorporated in the foundations design and construction program.

At the completion of the Contract, the Contractor shall provide 3 copies of all shop drawings to constitute an "as built" set incorporating all amendments and modifications, which have been carried out.

12.4.3 Welded Connections

The length of fillet weld specified on the Drawings shall be the overall length including end craters.

The design shall provide adequate accessibility for welding and inspection during fabrication. The profile of the joints shall enable satisfactory non-destructive testing to be carried out.

No welds apart from the continuous longitudinal web to flange welds shall be made to tension flanges of members without the written permission of the Employer's Representative.

12.4.4 Bolted Connections

Nuts in connections subject to vibration shall be the self-locking type or provided with lock nuts.

Whenever bolted connections are used, the reduced sectional area of members shall be computed and the member strengthened if required.

12.4.5 Camber

Where members are to be cambered, the amount will be specified on the drawings and the means of achieving the correct amount of camber shall be agreed with the Employer's Representative and shown on the shop drawings.

12.4.6 Responsibility

The Employer's Representative's approval of the Contractor's design and drawings shall not in any way relieve the Contractor of responsibility for any error subsequently discovered in the detailing.

12.5 Fabrication

12.5.1 Cutting

Machine flame cutting or shearing of steel to BS 4360 grade 50B and 50C and of steel to BS 4360 grade 43D in tension flanges over 50mm thick is only acceptable if at least 3mm of

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material is removed from the flame cut or sheared edge by matching.

12.5.2 Straightening

All plates, bars and sections shall be flattened and straightened and made free from twist before any other work is done on them.

The method adopted for this work shall be such as not to injure or mark the material.

12.5.3 Notches

The ends of all beams or girders shall be square where required and flanges neatly cut away or notched where necessary. All notches shall be kept as small as possible and shall be radiused in the inner corner.

12.5.4 Drainage Holes

Drainage holes shall be provided in members where water could collect during and after erection.

12.5.5 Holes

Holes shall be in accordance with BS 5950 except that drilling shall always be used to form holes for friction grip bolts, even if these are in cleats. Holes shall be cleaned up and all burrs and deformed metal removed.

12.5.6 Machining of Joints

The butt ends of compression members which are to be spliced by bolting shall, except where the bolts carry the loads, have their abutting faces machined after fabrication so that they shall be square to the member axes and in tight bearing contact throughout when erected.

The ends of stanchions at intermediate splices and where they bear on bases or caps shall be machined after fabrication so that they shall be in tight bearing contact throughout.

12.5.7 Minimum Thickness

All gusset plates, rolled sections and built-up sections shall be not less than 8mm thick. This does not apply to the webs of rolled steel universal beams and channels.

12.5.8 Accuracy of Measurement

All dimensions shall be made with a steel tape related to a standard tape, which has been certified to be correct at 20⁰C. The tape and steel to be measured shall be at the same temperature and proper precautions shall be taken to tension the tape correctly to the

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satisfaction of the Employer's Representative.

12.5.9 Fabrication Tolerances

The maximum acceptable tolerances on fabricated items shall be as follows:

- (a) Length of compression member finished for tight bearing contact: ± 1 mm.
- (b) Length of any other member 9.0m long and/ under: ± 2 mm.
- (c) Length of any other member over 9.0 m long ± 0.4 mm
- (d) Width of plate girders: ± 3 m. Depth of plate girders (measured at centre line of web).
 - I. For depths up to 400mm: ± 3 mm
 - II. For depths over 400mm: ± 4 mm
- (e) Deviation from straightness: Length of finished member/1000
- (f) Deviation from straightness of sheeting rails: Length of finished member/500 but not more than 25mm.
- (g) Deviation of centre line of web from centre line of flanges in built-up members at contact surfaces: 3mm.
- (h) Deviation from flatness of plate webs of built up members in a length equal to the depth of the member: Depth/200 or 10mm whichever is greater.
- (i) Tilt of flange of welded plate girders.:
For flanges up to 450mm in width: 2mm
For flanges over 450 mm in width: 3mm

The offset shall be the amount the toe of the flange is out of square with the point of intersection of the web measured at the underside of the flange.

Deviation from squareness of fixed base plates to axes of column: 3mm. This dimension shall be measured parallel to the longitudinal axis of the column at the points where the outer surfaces of the column sections make contact with the base plate.

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Deviation from squareness of machined ends of axes of columns: 0.50mm

Deviation from squareness of machines faces of end plates to axes of beam or girder: 0.50mm.

Where a tight bearing contact is specified on the drawings. The abutting parts shall be deemed to be in contact when the following requirements have been fulfilled.

Over at least 60 per cent of the bearing surfaces the gap between the surfaces shall not exceed 0.25mm.

Over the remainder the gap shall not exceed 0.50 mm.

The above acceptable tolerances shall be uniformly distributed over the whole of the abutting parts.

Notwithstanding the above permitted fabrication tolerances, the structure shall be erected to comply with the specified erection tolerances.

12.5.10 Slab Bases and caps

Slab bases and caps shall be accurately machined over the bearing surfaces and shall be in tight bearing contact over the whole area of the machined end of the stanchion or column.

Holes of not less than 40mm diameter shall be provided in all slab bases where indicated to facilitate grouting.

Contact surfaces of connections blast cleaned as part of general surface preparation for works painting shall be masked with adhesive bands before any paint is applied. The masking shall be removed from both contact surfaces of a connection immediately before a connection is made.

Masking bands shall not be treated with an adhesive, which adversely affects the slip factor coefficient between the contact surfaces.

Contact Surfaces of Connections on Steelwork Located Externally.

Contact surfaces of non-friction grip bolted connections on steelwork having a paint finish and which is located externally shall be painted with one coat of red lead primer prior to bringing together.

12.5.11 Painting Near Welded Work

No paint other than pre-fabrication primer shall be applied within 50mm of the edges of steelwork, which is to be welded.

12.5.12 Coating of Inaccessible Surfaces of Unpainted Steelwork

Surfaces of member which will be rendered inaccessible when fabrication is completed and are not in close contact with other surfaces shall be protected by filling the cavity between the surfaces with sealing compound or by application of a coating system as shown on the drawings.

The coating system for surfaces of steelwork which are accessible after fabrication but are concealed and not accessible after erection shall be as shown on the drawings or as specified.

12.5.13 Identification of Steel

At all stages of fabrication, structural steel shall be positively identified by grade, either by colour marking or by another marking system.

12.6 Welding

12.6.1 General

Welding of structural steelwork shall be by an electric arc process. The procedure to be followed, plant and equipment to be used and the testing and inspection to be applied shall conform with BS 5135 and this specification.

All non-mandatory clauses and parts of the BS will apply. In particular, the recommendations of Appendix E shall be followed and all weld procedures shall indicate compliance with these requirements.

12.6.2 Terms and Symbols

On all drawings, welding procedure sheets, etc., terms and symbols relating to the welding and cutting of metals shall be in accordance with BS 5950 where applicable, unless otherwise agreed by the Employer's Representative.

12.6.3 Electrodes

Low hydrogen basic coated electrodes to BS 639 shall be used in the following circumstances.

For the welding of steel to BS 4360 grades 50B and 50C.

For butt welds in steel to grades 43C and 43D.

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For the root run of but welds in steel to grades 43B in tension flanges 26 mm thick and over.

The impact properties of the parent plate and/or the requirements of the relevant design code shall be considered in the choice of consumables.

12.6.4 Shop and Site Welding

Shop welding shall be carried out in workshops under the specified conditions of temperature, materials, welding procedure, workmanship, welding operations, supervision and inspection.

Site welding shall not be permitted without the special approval of the Employer's Representative and then only if it is carried out in compliance with the conditions specified above.

12.6.5 Welding Procedure and Quality Control

Details of the proposed welding procedures shall be submitted to the Employer's Representative for written approval three months prior to commencement of welding, together with related quality control documentation such as electrode specification, storage, drying and handling requirements.

Testing of welding procedures with accordance BS 5135 and BS 4870: Part 1 or other satisfactory evidence of the Contractor's competence will be called for by the Employer's Representative. No welding shall be carried out unless a procedure has been submitted and approved. This requirement shall include all repair welds, welded attachments, supports and fabrication aids even where these may subsequently be removed.

Welding procedure shall be such that distortion is reduced to a minimum.

Approval of the welding schedules and procedures shall not relieve the Contractor for this responsibility for correct welding and for the minimizing of distortion in the finished structure.

The contractor shall ensure that the design of welds is such that a full volumetric examination of the weldings may be made when ultrasonic or radiographic inspection is required.

12.6.6 Fusion Faces

The forms of weld joint preparation shall be in accordance with BS 5135 as applicable or as may be otherwise approve by the Employer's Representative.

12.6.7 Butt Welded Joints

The ends of butt welds shall have full throat thickness. On rolled sections this shall be achieved

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by the use of extension pieces, cross runs, or other means approved by the Employer's Representative. On all main plates this shall be obtained by the use of run-on and run-off plates cut from extensions of the main plates and securely clamped to the parent plate.

Such run-on and run-off plates shall have the same joint preparation as the parent plate and arranged so that the direction of rolling is the same as that for the parent plate.

12.6.8 Intermittent Welds

Intermittent Welds shall only be permitted with the approval of the Employer's Representative.

12.6.9 Testing of Welding Operators

The Contractor shall allow in the fabrication and erection rates for the steelwork for the cost of testing his welders and all associated costs including the provision of all labour, material and equipment for the preparation and testing of test specimens and for providing the services of a qualified welding examiner.

Welding operator shall be qualified using the appropriate tests corresponding to the weld positions and parent materials to be employed.

Only welding operators who can produce evidence acceptable to the Employer's Representative of having satisfied the appropriate tests shall be employed on welding.

12.6.10 Acceptance of Welded Structures

The acceptance of the welded work shall depend upon correct dimensions and alignment and absence of undue distortion in the structure, upon satisfactory results from the inspection and testing of the joints and the test specimens, upon the soundness of the welds and upon general good workmanship.

12.6.11 Marking

Every piece of steelwork shall be distinctly marked before dispatch in accordance with the marking plan prepared by the Contractor. It shall also be given other marks and symbols as necessary to assist erection at site, by showing from which works it has come.

Unless otherwise approved by the Employer's Representative members which are to be finished painted at works, metal sprayed or galvanized, shall have all marks hard stamped in addition to being painted. The hard stamping, to such a depth that it will not be obliterated by the metal spraying or galvanizing, shall be done at one end of the member and shall be ringed with a paint mark. Where steel is given anti-corrosion treatment before arrival on site, the marks must be painted with a white paint that can easily be covered with the final site anti-corrosion treatment.

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12.6.12 Inspection

Materials and Workmanship

All materials and workmanship shall be subject to inspection by Employer's Representative and this will be at the place of manufacture or fabrication or on the Site or at all any such places. On receipt of copies of orders placed by the Contractor for plant and goods of other manufacturers or suppliers, as called for herein the Employer's Representative will notify the Contractor as follows:

That inspection and/or testing will be carried out at the manufacturer's or the Contractor's workshop, or

That inspection will be carried out at Site by the Employer's Representative, or

That inspection will be waived subject to the Contractor furnishing the Employer's Representative with a Certificate of compliance with the Specification, or that no inspection or certificate is required.

The Contractor shall notify the Employer's Representative of the dates on which manufacture of items is to commence at his own factory or the dates on which standard items will be available for inspection. In the case of items, the manufacture of which takes place in stages over a period for which intermediate stages are to be inspected as the work proceeds, the Contractor shall from time to time notify to the Employer's Representative of the dates on which such inspection can be made.

The Contractor shall allow reasonable time (not less than 10 days) for the Employer's Representative to make arrangements for inspection or give permission for dispatch to site. Late notification will not be accepted as a reason for delay in completion of the works.

No items are to be erected until the Employer's Representative has inspected and approved them.

12.7 Site Erection

12.7.1 Plant and Equipment

The Contractor shall provide sufficient plant and equipment to facilitate the efficient erection of the steelwork to meet the program and other requirements. The Contractor shall maintain the plant and equipment in good working order.

The Contractor shall submit to the Employer's Representative for his approval, carnage

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proposals for erection of steelwork.

The proposals shall be such as to ensure that no damage occurs to the foundations, ground floor slabs or other works.

The carnage proposals which will include track positions and loadings, etc., shall be submitted to the Employer's Representative in sufficient time for a check to be undertaken on the design of concrete works prior to commencement of steelwork erection.

12.7.2 Erection Procedure

Details of proposed erection procedures accompanied by diagrams where necessary shall be submitted to the Employer's Representative for his approval in good time prior to erection. The Employer's Representative may call for other erection procedures should he consider them necessary.

12.7.3 Handling

Damage to any part of the structure either before or during erection shall be immediately brought to the notice of the Employer's Representative. No damaged part shall be assembled in the structure without the approval of the Employer's Representative.

12.7.4 Contractor's Area

The Contractor shall make adequate arrangements within his allocated area for storing and handling all his materials.

12.7.5 Setting out

The Contractor will be supplied with particulars of datums for line and level, which shall be used for setting out the structure.

The contractor shall be responsible for the correct positioning and the correct levels of the structure in relation to the datums given.

The contractor shall give the Employer's Representative not less than 24 hours notice of his intention to set out or give levels for any part of the works.

Errors subsequently found in the alignment or levels of the steelwork shall be corrected by the Contractor at his own cost.

12.7.6 Plumbing of Sections

The maximum permissible deviation from the vertical centre line about both axes shall not exceed 0.1% of the height.

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12.7.7 Lining and leveling

The permanent bolting up of connections shall not be carried out until a sufficient portion of the structure has been erected and temporarily connected up to ensure that there shall be no straining of members during erection, lining up and leveling of the remainder of the structure.

The maximum permissible deviation for horizontal line and level of the steelwork shall be +6mm on any part of the Structure.

Shims shall not be used without the approval of the Employer's Representative.

12.7.8 Temperature Effect

All steelwork shall be level and plumb within the permitted tolerances at mean ambient temperature at the time of issue of the completion certificate.

12.7.9 Foundation Bolts and Anchorage Materials

The Contractor shall supply such drawings and steel templates as may be required for the proper positioning of holding down bolts and bases. The foundation bolts shall be of an approved manufacture and shall be fitted with washer plates or anchor frames and nuts etc. as

12.7.10 Temporary Bracings

Temporary bracings shall be provided by the Contractor to ensure the stability of his work during erection. Details of the Contractor's proposals in this respect shall be submitted for the approval of the Employer's Representative before work is commenced.

12.7.11 Temporary stagings

Stagings of adequate strength and working area together with reasonable access thereto shall be provided by the Contractor to facilitate the work of erection and inspection.

12.8 Painting

In connection with the detailed system, the Contractor and the Paint Supplier may suggest changes in relation to the offer, but such changes shall be approved by the Client before use is allowed.

All systems offers shall comply with the required guarantees whether they are alternative or not.

12.8.1 Quality Surveillance

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The paint supplier shall be able to approve, without any reservations whatsoever, the detailed system.

As a minimum, the system shall be specified by the following information being available and agreed upon.

Data sheets for all used products from paint supplier.

Work hygienic data sheets for same products.

Complete system description in the form of:

Cleaning degree and method

Number of layers and thicknesses of each type of paint

Repair procedure for damages occurred during mounting

Total minimum dry film thickness.

Colour sample of finishing coat to be compared with colour requirements.

Extent of documentation for process control carried out.

Extent of documentation for end test carried out

12.8.2 Execution of Paint System

(a) Quality Specification

Before start-up of surface treatment, the paint contractor shall verify that the steel parts are in a satisfactory condition.

All sharp edges shall be ground, radius app. 2mm or 2 x 30 chamfering so that angles between surfaces become 3 angles of each 150 measured externally on the steel.

Degree of rust on the steel may in no place be more than C according to ISO 8501-1

No top rolls ("ash spots") or similar defects may occur in the steel surface.

Surface of welding joints shall be so even that the sandblasting results in a clean rust degree C. If the result obtained corresponds to Sa 2 ½ of rust degree D, the surface is too uneven and has to be ground.

Grinding splatters ("pearls") shall be removed.

Deviations from the above mentioned shall be submitted to the Client and repair shall be made before finishing the cleaning. Possible repairs shall be made by the steel contractor and do not give rise to extra payments.

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(b) Pre-Treatment

All steel surfaces shall be effectively free from oil and grease.

Cleaning of rust, iron scales, etc. shall take place by sandblasting (dry) unless otherwise agreed.

Cleaning degree at least Sa 2 ½ according to ISO 8501-1.

Means of blasting is optional but the roughness shall be according to BN9a-BN10 according to RUGOTEST No. 3 (may be adjusted in connection with choice of product).

Grinding is allowed to be locally used if this serves the purpose. The final result shall be according to BN9-BN10 according to RUGOTEST No. 2.

All mechanical cleaning shall, before painting, be finished with efficient removal of sand, dust and other loose material.

In case of doubts, the "tape test" gives the requirements.

(c) Painting

Generally, the paint supplier's requirements shall be complied with.

Painting may only take place by rolling if so recommended by the paint supplier.

Picking out with a brush shall be used in areas which experiences tell make problems with a full film thickness. This is the case for example with welding joints, edges and re-entrant corners.

Number of layers to be decided upon depending on final choice of type.

There shall be change in colours between each coat.

The final coat shall not be matt.

Runners and possible traces of brush may be accepted to the extent that they do not influence the quality of the corrosion protection of the treatment.

The final coat shall totally cover below colour.

Requirements to film thickness Are stated in the system specification.

All surface treatment, including the above-mentioned pre-treatment and cleaning, is assumed to take place in paint hall/shop.

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Repair of Defects, etc.

All repairs of defects, damages, repairs after mounting, etc. shall take place according to the supplier's indications.

(d) Documentation.

Below requirements to documentation are minimum requirements, which shall always be complied to.

Documentation shall be supplied for number of measurements of total dry film thicknesses both for work carried out in shop and carried out in open air (or outdoor climate)

Documentation shall furthermore be supplied on climatic conditions for works not carried out in workshops including for repairs of mounting damages not carried out in heated building.

The Client reserves the right to make unnoticed inspection and control during the execution of the work to the extent wished, including control of instruments for registration of climatic data.

Thickness of Layer and Measurement of Thickness

The construction to be divided into control areas in which measurements of coat thicknesses are carried out.

Within each control area is placed (possibly marked) a measuring area. This is naturally placed where the smallest thicknesses are found.

10 evenly distributed single measurements are carried out in each measuring area and the results written down.

(e) Acceptance Criterion.

In case the minimum value of the 10 single measurements is greater than specified minimum thickness of coat, the control area is approved and thus the construction part in question.

In case the minimum value of the 10 single measurements is greater than specified minimum (=100%) but greater than 90% of the specified value, another 10 evenly distributed single measurements are carried out (to be displaced compared to the first ones)

In case a maximum of 5 of the total 20 single measurements are below the specified minimum, but above 90% therefore the area is approved.

If this is not the case, the area, and thus the construction part, is rejected.

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In case more than 2 of the first 10 single measurements are below 90% of specified minimum, the control area, and thus the construction part, is rejected.

(g) Adherence

IN case of doubt concerning the adherence, the Client may demand that it be examined. Indications as to the quality of the adherence may be obtained by web cutting, but in case of doubts or uncertainty, the adherence shall be determined by the pulling method according to ISO 4628.

The values measured shall not be below 65% of the mean value of 10 samples carried out on test plates.

(h) Test Plates

The Contractor shall, before start-up of work, supply the Client with two test plates of steel (minimum 200x300mm). The plates shall be treated with the specified surface treatment system as the first app. 3cm shall be untreated, but Sa 2 ½, and each coat shall be scaled down app. 3cm compared to the previous coats. Of the 300 mm plate thus only app. 18cm are painted but sandblast.

(j) Documentation for Film Thickness

A report shall be supplied for results of measurements carried out of total (finished) dry film thicknesses.

(k) Documentation for paint Goods.

Before start-up of work in workshop, the Contractor shall send documentation for all paint goods to be used to the Supervisor.

Guarantee Requirements to Paint System

12.9 Quality Specification

The Contractor will prove that he will carry out the total execution process in a professional and correct manner in all details by guaranteeing the quality of the finished work.

Quality Assurance

12.9.1 Quality Assurance General

The contractor shall be responsible for the Quality Management as stipulated in the ISO Standard. ISO 9001: Quality system- Model for quality assurance in design/development, production, installation and servicing.

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The contractor may be at liberty to use his own QA-model if deemed equal to the ISO 9001 by the Employer.

12.9.2 Definitions

In the ISO 9001 Standard the following words shall have the meaning hereby assigned to them.

“The Supplier” means “The Contractor”

“The Purchaser” means “The Employer”

“The Purchasers representative” means “The Employer’s Representative”

12.9.3 Organization

The Contractor shall submit to the Employer, for review, his Quality Management Organization. The organization plan shall define all key personnel who manage, perform and verify work affecting quality. The responsibility, authority and interrelation of the personnel shall be clearly defined for the Contractors own personnel as well as for that of his subcontractors.

12.9.4 Quality System

The Contractor shall establish a Quality System as a means of ensuring that all work under his Contract conforms to the specified requirement.

The Contractor shall submit to the Employer, for review, a program which defines the procedures adopted to comply with this requirement as stipulated in ISO 9001.

The program shall comprise all aspects of the Quality System including.

- Design control
- Document control
- Purchasing
- Process control
- Inspection control
- Control of non-conforming products
- Handling storage, packing and delivery
- Erection control

12.9.5 Quality Records

The Contractor shall establish and maintain such records as are stipulated in ISO 9001 and these records shall be copied and submitted to the Employer.

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12.9.6 Verification of Purchased Products

The Employer shall be afforded the right to verify at source or upon receipt that purchased products conforms to specified requirements.

12.9.7 Use or repair of non-conforming products.

Proposal to use or repair non-conforming products shall be subject to approval by the Employer.

CHAPTER 13
IRONMONGERY

13.1 Ironmongery

Definitions

Locks

1. A device for securing a door, gate, lid, drawer or the like when closed, consisting of a bolt or a system of bolts propelled or withdrawn by a mechanism operated by a key or other means.

2. A mechanism combining in one case, a spring bolt and a dead bolt operated respectively by handles and a removable key .

Bolt

The part or the lock which provides the fastening by protruding from the lock case to engage in the staple, sticking plaster, link, shackle or other member.

Catch

A device to hold the spring bolt of a lock or latch in the 'in' and/or 'out 'position respectively.

Staple

A box like fitting fixed on a door jamb into which the bolts of a rim lock or rim latch shoot.

Mortice Lock

Any lock for fixing in a mortice cut in the closing edge of a door.

Latch

A device openable from both sides and generally self-engaging for holding closed a door, gate or the like. It consists of a movable part falling by gravity or sliding or moving by means of a spring into a retaining member of some sort, the moving part of the device being operated by handle and not by a removable key.

Mortice Latch

Any latch of fixing in a mortice cut in the closing edge of the door.

Rim Latch

A latch for fixing to the face of the door, having a beveled spring bolt and usually incorporating a jumbo bolt.

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Handle

Any item or part of any item of door, drawer cupboard or gate furniture, intended to be held in the hand for opening, closing or moving to another position, the article to which it is fixed.

Hasp and Staple

A device for securing a door, gate or lid in a closed position by the use of a padlock. The hasp consists of two members hinged together. One member is always a plate for fixing; the other member may be a slotted flap or wire loop arranged to pass over and around the staple. The staple consists of either a flat fixing plate from which a wire hoop projects or a flat bent plate pierced by a hole to receive the shackle of the padlock.

Door Bell

A device to enable callers to draw attention to their presence by means of ringing a bell.

Kicking Plate

A plate fixed across the face of a door to protect the lower part of the door from disfigurement or wear.

Push Plate

1. A plate larger than a finger plate fixed to the face of a door to protect the door from disfigurement.
2. Any plate lettered 'PUSH' which is fixed to a door as an instruction for opening.

General

This section deals with common items of ironmongery. These shall be of iron, brass, aluminum or as specified and shall be well made, reasonably smooth and free from flaws and other defects. All hinges lock etc. shall generally be of blackened steel except near the coast or unless otherwise specified.

Finish

The finish shall be as below or as specified.

- (a) Iron Fittings - These shall be smooth finished and treated against rust formation.

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- (b) Brass Fittings - These shall be finished bright, chromium plated, oxidized or as specified.
- (c) Aluminum Fittings - These shall be anodized. The surface shall be prepared to a satin finish, polish finish or bright finish and the grade of anodizing shall be as specified.

Note: Grades of anodizing shall conform to BS 1615 and depend on the location and frequency of cleaning. For example Grade AA 20 corresponds to 20 microns average coating thickness.

Fixing

Screws used for fittings shall be of the same metal and finished in the same way as fittings, except that chromium plate brass screws shall be used for fixing aluminum fittings. Fixings shall be of the size indicated in the drawings or as directed. Screw holes shall be countersunk to suit the head of specified wood screws.

Fittings

Fittings shall be fixed in proper position as shown in the drawings or as directed by the Employer's Representative. These shall be truly vertical or horizontal as the case may be. Screws shall be driven home with a screw driver and not hammered in. Recesses for countersinking of hinges etc. shall be cut to the exact size and depth and shall be close fitting. Holes for through bolts shall be carefully augured. Particular care shall be taken while fixings are made to flush doors made of plywood.

Samples of all ironmongery shall be produced well in advance and approval obtained from the Employer's Representative. Subsequent supplies shall conform in all respects to the sample produced. Sizes shall be as specified.

13.2 Hinges

13.2.1 Knuckle Type Hinges

General

All hinges shall be free from flaws and defects that may adversely affect the appearance or service.

All edges shall be smooth and square without burrs or sharp projections. Movement of the hinges shall be free and easy and shall have no play or shake. The leaves shall be free to rotate

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one with the through a minimum of 200⁰. The holes for the hinge pins shall be central and square to the knuckles. All hinge pins shall be riveted firm with well formed countersunk or domed heads. All screw holes shall be countersunk with no sharp edges at the back.

13.2.1.1 Steel Hinges

Steel hinges shall be one of the following types conforming to CS 30. All steel hinges shall be smooth finished and treated against rust formation.

Broad steel butt hinges Steel

butt hinges (heavy gauge) Steel

butt hinges (light gauge)

Steel cabinet hinges

Steel parliament hinges

Steel tee hinges Steel

strap hinges

Steel hinges of the following types shall conform to BS 1227 Part IA.

Rising butt hinges

falling butt hinges

Lift butt hinges

Hinges shall be manufactured from mild steel sheets, plates or stripes and hinge pins from mild steel wires all conforming to the requirements of CS30.

Tee hinges shall be fixed with 6 mm diameter bolts with the nuts on the inside.

13.2.1.2 Solid Drawn (Extruded) Brass Knuckles Type Hinges

The hinges shall conform to BS 1227 Part IA. Section 4 and shall be one of the following types:-

Brass broad butt hinges

Brass strong butt hinges

Brass washered butt hinges

Brass projection butt hinges

Brass rising butt hinges

Brass falling butt hinges

Brass back flap butt hinges

Brass counter flap butt hinges

Brass lift off butt hinges

Brass hinges shall be made of extruded brass sections (brass conforming to BS 249).

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Details of brass knuckle type hinges, diameter of pins etc. Pins shall be of made of steel or brass wire as specified. Hinges with washers shall be fitted with washers made of steel, phosphor bronze or nylon as directed.

The helix and lining of knuckles of rising hinges or falling hinges shall be of steel. The finish shall be polished brass, polished chromium plate, satin chromium plate bronze metal antique, or as specified.

13.2.1.3 Extruded Aluminum Knuckle Type Hinges

These shall conform to section 6 of BS 1227: Part IA. The hinges shall be anodized to Grade AA. 15 of BS 1615. Hinge pins shall be of Aluminum or Stainless Steel. Hinges shall be fitted with washers at least 1.27 mm thick between knuckles. These washers shall be of nylon or stainless steel.

13.2.2 Spring Hinges

These shall be single action when the shutter is to open on one side only or double action when the shutter is to open on both sides. The hinges shall be made of mild steel or brass as specified. They shall work smoothly and shall hold the door such truly vertical in the closed position.

The size of the spring hinge shall be taken as the length of the plate.

13.2.2.1 Mild Steel

The cylindrical casing shall be made either from mild steel of 1.60 mm thickness, lap jointed and brazed , welded and riveted, or from solid drawn tube of wall thickness 1.60 mm pressed to from the two casings . It shall be stove enameled black or as specified.

13.2.2.2 Cast Brass

The cylindrical casing shall be made either from brass sheet of 1.60 mm thickness, lap jointed and brazed or from solid drawn brass tube of not less than 1.60 mm wall thickness. It shall be satin / bright nickel plated, copper oxidized, or as specified.

13.3 Door Closer

Hydraulic door closer (exposed type) shall be made of cast iron /aluminum alloy/ zinc alloy and of shape and pattern approved by the Employer's Representative.

The door closers may be polished or painted and finished with lacquer to the desired color.

13.3.1 Mild Steel Closers

All dents, burrs and sharp edges shall be removed from various components and they shall be

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pickled scrubbed and rinsed to remove grease, rust, scale or any other foreign elements. After pickling, all the mild steel parts shall be given prospecting treatment, in accordance with standard practices.

13.3.2 Aluminum Closers

Aluminum alloy door closers shall be anodized and the anodic coating shall not be less than grade AA 15 of BS 1615.

13.4 Door Bolts

13.4.1 Sliding Bolts

General

The fixing and staple bolts shall be cast with 6 mm studs.

Bolts shall be finished to shape and have threaded ends and provide with round worms and nuts of square or hexagon type. All screw holes shall be counter sunk to suit the counter sunk head of wood screws of wood screws of specified size. All edges and corners shall be finished smooth. In the case of a single leaf door, a hole of suitable size shall be drilled in the door frame and an iron or brass shield plate cut to shape shall be fixed at the face of the hole.

13.4.1.1 Mild Steel Sliding Door Bolts

These shall be made of mild steel sheets and rods and treated against rust.

13.4.1.2 Cast Brass Sliding Door Bolts

These shall be made from rolled brass. The hasp shall be of cast brass and secured to the bolt. Alternatively, the hasp and the bolt may be cast in one piece: All components shall be finished smooth and polished before assembly. Cast brass sliding bolts shall be finished bright, chromium plated, oxidized or as specified.

13.4.1.3 Aluminum Sliding Door Bolts

These shall be made of aluminum alloy. Aluminum sliding door bolts shall be anodized to Gr. AA 15 of BS 1615.

13.4.2 Barrel Bolts / Tower Bolts

Tower bolts vary in length from 75 mm to 380 mm. These shall be well made and free from defects. The bolts shall be finished to the correct shape and shall have a smooth action. All tower bolts shall be made of sheet thickness. 1.2 mm or more, and shall have counter sunk screw holes to suit the countersunk head of the wood screw. All sharp edges and corners shall be removed and finished smooth. The plate shall be screwed to the inside of the door

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so that the bolt engages or shoots in a metal socket or staple fixed on the door frame, or metal socket let into the floor.

13.4.2.1 Mild Steel Bolts

Mild steel tower bolts shall have barrel made in mild steel plate. The bolt shall be mild steel or cast iron rod of suitable diameter. The plates and straps after assembly shall be firmly riveted or spot welded.

The rivet head shall be properly formed and the rivet back shall be finished flush with the plate.

The bolts shall be bright finished or plated as specified and the barrel and socket, stove enameled black.

13.4.2.2 Brass Bolts

Brass tower bolts with cast brass barrel and rolled or cast brass bolt.

Or

Brass tower bolts with barrel of extruded sections of brass and rolled or drawn brass bolt.

The knobs of brass tower bolts shall be cast and the bolt fixed with a knob.

Brass Tower Bolts.

Bolts and barrel polished or plated as specified.

13.4.2.3 Aluminum Bolts

Aluminum barrel tower bolts with barrel and bolt or extruded sections of aluminum alloy.

The knob shall be properly screwed to the bolt and riveted at the back.

Aluminum alloy tower bolts shall have anodized. Bolt and barrel, unless otherwise specified.

The anodic film may be either transparent or dye as specified. The quality of the anodized finish shall not be less than grade AA 10 of BS 1615.

13.4.3 Flush Bolts

These shall be cast brass, cast Aluminum alloy or extruded Aluminum alloy as specified. Only one material shall be used in the manufacture of all the components of flush bolts except the spring which shall be of phosphor bronze or steel strip. When the rod is completely in its maximum bolting position it shall be retained in that position by the spring. The length of the bolt shall be such that, when the bolt is pulled down, the top of the bolt

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shall be flush with the top of the lip face. The top of the bolt shall be given a tape of 450 to enable easy pull or push.

13.4.3.1 Brass flush bolts shall be satin or bright polished alternatively, they may be nickel or chromium plated as specified in BS 1224, or copper oxidized.

13.4.3.2 Aluminum flush bolts shall be anodized and the quality of the anodized finish shall not be less than grade AA 15 of BS 1615.

13.4 Mortice Latch / Mortich Lock / Mortich Latch and Lock

Rim Latch / Rim Lock / Rim Latch & Lock

These shall conform to BS 5872 in regard to design and dimensions.

13.5 Door Handle

The door handles shall be well made and free from defects. These shall be finished correct to shape and dimensions. All edges and corners shall be removed and finished smooth so as to facilitate easy handling. Cast handles shall be free from casting defects. Where the grip portion of the handle is joined with the piece by mechanical means, the arrangement shall be such, that, the assembled handle shall have adequate strength comparable to that of integrally cast handles.

The size of the handle shall be determined by the inside gripe of the handle. Door handle shall be of 100 mm size, and window handles of 75 mm size, unless otherwise specified. These shall be fixed with 25 mm long No, 6 wood screws.

Door handles shall be of the following types according to the material used.

13.5.1 Mild Steel Handles

These shall be of mild steel sheet, pressed into oval section. Iron handles shall be treated against rust formation.

13.5.2 Cast Brass Handles

These shall be of cast brass of specified size and of the shape and pattern specified. Brass handles shall be finished bright, chromium plated, oxidized, or as specified.

13.5.3 Cast Aluminum Handles

These shall be of aluminum of specified size and of shape and pattern specified. Aluminum handles, shall be anodized and the anodic coating shall not be less than grade AA 15 of BS 1615 or as specified.

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13.6 Casement Fastener

Where specified casement fasteners for windows shall be of brass and of a sturdy and suitable design with a cross tongue and a mortise plate fixed to the mullion of the window. The fasteners shall be oxidized black.

13.7 Casement Stays

These shall be of brass, straight or curved and conform to BS. The hinge pin shall be mild steel or phosphor bronze. There shall be no blow holes in any part of the window stay and the movement of the window stay shall be free and easy. The screw holes shall be countersunk to suit countersunk 19 mm x No 6 wood screws conforming to CS 6. The window stays shall be bright finished oxidized or chromium plated.

13.8 Hooks and Eyes

Hasp and Staple

These shall be mild steel, hard drawn brass, or as specified. These shall be well made and free from defects. They shall be finished to the correct shape and dimensions so as to function properly when they are in use. Cast hooks eyes and plates shall be free casting and other defects. All sizes of hooks and eyes shall be determined by the length of the hooks measured 'out to out'. Unless otherwise specified the articles shall be finished bright. Mild steel hooks and eyes shall be treated against rust formation. Cast brass hooks and eyes shall be finished bright or chromium plated.

13.9 Hasp and Staple

Hasp and staple shall conform to BS and shall be of Mild Steel, Brass or Aluminum. The hinge pin which in all cases shall be of mild steel (or phosphor bronze in case of brass hasp and Staples) shall be firm and its riveted heads well formed. The movement of the hasp shall be free, easy and square and shall not have any play or shake. The hasp shall fit the staple correctly. The size shall be determined by the length of the bigger leaf of the hasp.

The staple except in the case of a cast one shall be riveted properly to its plate. The safety type hasp shall be secured to the door by two small bolts whereas the staple is generally screwed on the door / frame. A padlock is a necessary adjunct to the hasp and staple. The padlock may be galvanized steel, brass or bronze. All screw holes shall be clean and countersunk to suit counter sunk wood screws conforming to CS 6. All edges and corners shall be rounded.

13.9.1 Mild Steel Hasp and Staple

These shall be manufactured from Mild Steel sheets and shall be finished with / without protective coating, stove enameled or plated.

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13.9.2 Brass Hasp and Staple

These shall be manufactured by casting and finished polished, oxidized, or as specified.

13.9.3 Aluminum Hasp and Staple

These shall be made from dye sections and shall be anodized. The anodic coating shall not be less than grade AA 15 of BS 1615.

CHAPTER 14
FLOOR FINISHES

14.0 Floor Finishes

- 14.1 Floor Finishes With Cement Concrete Tiles/ Clay Tiles Including Ceramic Floor Tiles/
Precast Concrete Slabs/ Natural Stone Slabs/ Artificial Stone Slabs/ Wire-cut Bricks

14.1.1 Materials 14.1.1.1

Clay Flooring Tiles

Clay flooring tiles shall generally conform to BS 1286 and shall be Ceramic tiles or clay floor tiles (quarries) as described below:-

(a) Ceramic Tiles

These shall be produced by compacting blended ceramic powders and firing to temperatures above red heat. They shall be either vitreous with water absorption not exceeding 4% or fully vitrified with water absorption not exceeding 0.3%.

The sizes of these tiles may be one of the following or as specified.

- 100 mm x 100 mm x 9.5 mm
- 200 mm x 100 mm x 9.5 mm
- 150 mm x 150 mm x 12.5 mm
- 150 mm x 150 mm x 9.5 mm
- 150 mm x 75 mm x 12.5 mm
- 150 mm x 75 mm x 9.5 mm

The color of the tiles shall be as specified. Deviation on length and breadth shall not exceed ± 1.5 mm for 100 mm tiles and ± 3 mm on the 200 mm tiles. Deviation on thickness shall not be more than $\pm 5\%$.

Tiles specified like round edges, coves, angle beads, step treads etc. shall conform to BS 1286 or as specified.

(b) Clay Floor Quarry Tiles

These shall be produced by extrusion or other plastic forming of a suitable clay or combination of clays and other minerals; the process includes firing above red heat (Note : These tiles are thicker than ceramic tiles and the surface less even and fine).

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The sizes of these tiles shall be one of the following or as specified.

150 mm x 150 mm x 16 mm

150 mm x 150 mm x 18 mm

150 mm x 150 mm x 22 mm

230 mm x 230 mm x 32 mm

150 mm x 75 mm x 16 mm

150 mm x 75 mm x 19 mm

150 mm x 75 mm x 22 mm

Deviation on length and breadth shall not exceed ± 2 mm for 150 mm lengths and ± 4 mm for the 230 mm lengths. Deviation on thickness shall not be more than 10%.

Water absorption of the tiles shall not exceed 10% when tested in accordance with BS 1286.

The color of the tiles shall be as specified. Suitable tile fittings shall be supplied as specified or directed.

14.1.1.2 Cement Concrete Tiles

These shall be manufactured with ordinary Portland Cement conforming to BS and hard dense aggregates from natural sources conforming to BS 802.

These shall comply with the requirements of BS 1197. The tiles shall be of the following sizes or as specified.

150 mm x 150 mm x 15 mm

200 mm x 200 mm x 20 mm

225 mm x 225 mm x 20 mm

300 mm x 300 mm x 30 mm

400 mm x 400 mm x 35 mm

500 mm x 500 mm x 40 mm

Deviation on sides shall be ± 1 mm and on thickness ± 3 mm.

Length of skirting shall be from 150 to 900 mm.

Height of skirting shall be 100 mm or 150 mm.

Thickness of skirtings shall be 12 mm.

Coves where specified shall have a radius of 25 mm.

When colored tiles are specified or when any special aggregate is specified for the wearing surface, the thickness of the facing layer shall be as follows:

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for tiles under 400 mm in sizes - the minimum thickness shall be 6 mm.
for tiles equal to 400 mm - the minimum thickness shall be 8 mm.
for tiles over 500 mm - the minimum thickness shall be 10 mm.

The color of the tiles shall be as specified. Pigments used in the manufacture shall comply with the requirements of BS 1014. For homogeneity of color, the pigments shall be milled in with dry cement before being added to the mix, or alternatively, colored cement shall be used. The color of the tiles shall be uniform throughout the wearing surface. There shall be no trace of efflorescence the tiles so that the color of the tiles is neither obscured nor reduced in intensity. Suitable water efflorescence. The surface of the tiles shall be smooth and plane, free from projections, depressions and crazing. All arrises shall be sharp and true.

Skirting and fittings shall have smooth surface free from crazing.

14.1.1.3 Chequered Tiles

Where chequered tiles are specified, thickness of the tiles shall not be less than 22 mm. Chequers shall 25 to 50 mm in size with a groove depth of 3 mm. The minimum thickness of the wearing layer shall be 6 mm measured from the top of the chequers.

14.1.1.4 Chequered Tiles for Stair Treads

Tiles for stair treads shall be chequered as above and shall comply with the following.

The length of the tiles including the nosing shall be as specified.

The nosing edge of the tiles shall be rounded and have the same wearing layer as the top.

The minimum thickness of the tile shall be 30 mm.

The front portion of the tile for a minimum breadth of 75 mm from and including the nosing shall have grooves running parallel to the nosing and spaced at centers not exceeding 25 mm. The rest the tile shall have the normal chequer pattern.

14.1.1.5 Brick

Clay bricks for floor finishes shall be wire cut or type 1 bricks conforming to BS.

14.1.1.6 Natural Stone Slabs

Paving slabs of natural stone shall be of granite or marble.

Granite slabs shall be of thicknesses depending on the sizes specified, but not less than 50 mm nor more than 150 mm. Marble slabs shall be not less than 20 mm nor more than 40 mm thick and be as specified.

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The thickness of slates shall vary from 6 to 12 mm for interior use and 32 to 38 mm for exterior use.

14.1.1.7 Artificial Stone (Cast Stone or Reconstituted Stones)

These shall conform to BS 1227.

14.1.1.8 Bedding Mortar

Unless otherwise specified, mortars for bedding shall be cement mortar 1:3 conforming to requirements of Chapter 3. The mortar shall contain the least amount of water necessary for workability.

Dry beddings specified for brick paving shall be a bed of clean sand 50 mm thick well rolled and laid to falls.

14.1.1.9 Separation Layer

Where a separation layer between the base concrete and finish is specified, this shall be one of the following:

- (a) Sand conforming to BS 1199.
- (b) Bituminous felt selected from those classified in BS 747.
- (c) Waterproofing building papers selected from those described in BS 1521.
- (d) Polythene film of specified thickness.

14.1.2 Laying

14.1.2.1 Laying the Separating Laying

(a) Sand: Where sand is used as a separating layer, this shall be soft building sand, slightly damp, laid on the base in a uniform layer not exceeding 20 mm in thickness and consolidated by tamping. If a fall is required, the thickness of the separating layer shall be varied from 12 mm to 25 mm. Additional falls needed shall be obtained by laying a screed beneath the sand layer to the required falls.

(b) Felt or building paper or polythene film: Where felt, building paper or polythene film is used, it shall be laid on an accurately formed base having a true and smooth surface to enable the bedding material to be constant in thickness throughout its area. The separating material shall be laid flat and lap jointed.

14.1.2.2 Bedding in Cement Mortar Direct to the Base or on a Separating Layer

The flooring units shall be soaked in clean water and allowed to surface dry before use.

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If a separating layer is not used and the base has become thoroughly dry, it shall be well wetted before laying the bedding mortar. Bedding mortar shall be freshly mixed and spread upon the base to the specified thickness, the thickness may vary from 10 to 12 mm for units upto 12 mm thick and 20 to 25 mm thick for thicker units. The bedding mortar shall be tamped down true to levels.

Over this bedding, neat cement slurry of honey like consistency shall be spread out at the rate of 4.4 kg. of cement per square meter of the floor over such an area as will accommodate about twenty tiles or slabs, at any one time.

The tiles or slabs shall be then placed in position and tamped down to the required finished levels.

Special care shall be taken in finishing to falls and cross falls in the case of baths and toilets.

Any cement brought to the surface shall be wiped off with a damp cloth.

Joints for tiles or slabs shall vary from 2 to 5 mm depending upon the size and type of tiles. As the laying proceeds, wide joints shall be pointed in cement mortar 1:3 with pigments added to match the color of the flooring. The joints shall be finished flush with the surface.

Bricks shall be laid to specified patterns with 10 mm joints and pointed in cement mortar 1:3.

14.1.2.3 Expansion Joints

The position of expansion joints in the sub floor base, bedding and finish shall coincide.

14.1.2.4 Curing

The floor finishing shall be cured for a period of at least seven days by wetting it with water.

14.2 Granolithic Floor Finishes

14.2.1 Materials

- (a) Cement - Portland cement conforming to BS
- (b) Sand - Sand conforming to BS 1198, 1199, 1200
- (c) Coarse Aggregate - Coarse aggregate for granolithic shall conform to BS 882. The aggregate shall be free from dust. The size of aggregate shall be from 5 mm to 10 mm.

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14.2.2 Thickness of Finish and Joints

Construction joints between bays of the floor finish need only be plain untreated vertical butt joints. Granolithic mix shall be laid in bays of sizes given in the table below. The length of bays shall not exceed 1 1/2 times the width. Vertical butt joints shall be located over construction joints in the base and movement joints must be provided to correspond with any in the base.

Construction	Thickness of Finish	Maximum pay size
Monolithic	10 - 25 mm	30 m ² on concrete base 150 mm 15 m ² on concrete base 100 mm thick.
Bonded Floors	40 mm min.	15 m ² and length not exceeding 1 1/2 x width.
Bonded stairs	15 - 20 mm min.	
Unbonded	Up to 75 mm	2 m ²

14.2.3 Preparation of the Base Monolithic Construction

Where the floor finish is laid monolithically, no special preparation of the base concrete is usually necessary. The finish shall be applied within 3 hours of laying the base concrete. The thickness shall be between 10 and 25 mm.

If the topping is to be laid whilst the base concrete is still green it would be sufficient if the laitance on the base concrete is removed by a light or mist spraying with water and by brushing.

Bonded Construction

Where the floor finish is laid on matured concrete, the surface of the base shall be thoroughly and carefully prepared to ensure adequate bond between the base concrete and floor finish.

This preparation shall include following:-

- (a) The laitance on the base concrete shall be entirely removed by complete hacking with a metal tool to expose as large a proportion of clean coarse aggregate as possible. All loose concrete and dirt shall be removed by thorough washing or hosing. These

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operations shall be delayed until shortly before the floor finish is to be laid to reduce the risk of further accumulation of dirt.

- (b) Several hours before the floor finishes to be laid, the base concrete shall be wetted and any excess water brushed off before grouting. The purpose of this operation is to produce as nearly as practicable a saturated but surface dry condition in the base concrete.
- (c) Note more than 1/2 hour before the floor finish is to be laid, a neat cement grout shall be brushed into the base. The grout shall consist of water and the same cement as is used in the floor finish, mixed to the consistency of a thick fluid. About 2 kg. of cement per sq. m of the surface will generally be found suitable for the purpose.

A proprietary bonding agent may be used as an alternative to the grout; but it should be noted that paragraphs (a) and (b) of this clause still apply.

- (d) Excess of grout shall be removed by thorough sweeping just prior to placing the topping material.

Unbonded Construction

These screeds generally 50 mm - 75 mm thick, are laid on a damp proof membrane or concrete which is weak, contaminated or include water - repellant admixture. The surface of the base shall be cleaned before laying the unbonded screed.

14.2.4 Mix for Granolithic Concrete

Mix proportions - The mix proportions shall be 1 part cement, 1 part fine aggregates, 2 parts coarse aggregate, by weight. The aggregates and cement shall be accurately batched by weight. In circumstances where batching by weight is impracticable, cement shall be batched by the whole bag, and accurate gauge boxes shall be used for bulking of damp fine aggregate. Method of Mixing : The materials shall be thoroughly mixed by mechanical means whenever possible. The amount of water added shall be the minimum necessary to give sufficient workability for laying and compacting.

14.2.5 Placing and Compaction

The concrete shall be placed between forms of steel sections or battens which are fixed rigidly to a firm foundation and supported throughout their length. The forms shall be true to line and level.

The concrete shall be fully compacted by means of a tamping beam or other suitable

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compacting equipment taking care that an excess of laitance is not brought to the surface.

14.2.6 Finishing the Surface

After the granolithic concrete has been fully compacted, the surface shall be trowelled at least three times at intervals during the next 6 to 10 hours, so as to produce a uniform and hard surface with a high resistance to abrasion. (The resistance to abrasion of the floor finish depends very largely upon the care with which the trowelling is carried out).

About two hours after the first trowelling, the surface shall be re-trowelled to close any pores in the surface. During this operation any laitance shall be removed and not trowelled back into the topping. A third, and possible fourth trowelling will be necessary, and the final trowelling shall be at such a stage when considerable pressure is required to make any impression on the surface.

Under no circumstances shall cement be sprinkled on to the surface to absorb surplus water. Colored granolithic finish shall be laid with colored cement or with an approved pigment to the satisfaction of the Employer's Representative.

14.2.7 Laying Stair Finishing

The finish to the risers and treads may be applied in either of the following ways:

1. Monolithic Construction

The formwork shall be erected to the finished profile. As concreting of the stairs proceeds, the finishing mix shall be placed against each riser board to the thickness specified and up to the level of the underside of the tread or landing. The structural concrete shall be placed to the same level and both mixes thoroughly compacted. The finish to the stair treads and the landings shall be applied as for the floor finish within 3 hours of completing the base concrete.

2. Bonded Construction

The structural concrete shall be laid to the profile of the stairs less the thickness of finish. Before commencing application of the finish, any laitance on the surface of the concrete shall be removed, the risers and treads hacked to provide a key for the finish; and the surface cleaned with air hose. Formwork shall then be set to the finished profile and the finishing mix shall be well tamped into the cavity between the riser board and the existing concrete face. Finally, the finish shall be laid over the tread as for the floor to the specified thickness.

The forms shall be removed after 24 hours of laying or as directed by the Employer's Representative. On removal of the formwork any small cavities or pinholes in the

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surface shall be filled with cement mortar by means of a wood float and the surface rubbed later with a stone to remove laitance or the finish to the risers may be applied by rendering. Where so directed, treads, landings etc. shall be given a non-stop finish with corborundum sprinkled in the proportion of 1.35 kg/sq.m of paving and well trowelled in before the granolithic has set.

14.2.8 Curing

As soon as the surface has hardened sufficiently to prevent damage, the concrete shall be cured continuously for at least 7 days in one of the following ways:

- (a) Wet canvas or straw mats, or a 50 mm layer of damp sand spread on the surface and kept continuously damp and in position for the full curing period.
- (b) Water proof sheeting kept in close contact with the surface of the concrete for the full curing period. The sheeting shall overlap the sides and ends of the slab and be securely held in position. Adjacent sheets shall overlap by at least 75 mm. For colored concrete, method (b) above shall be used.

14.2.9 Surface Treatment

Where specified for purposes of reducing dusting, surface hardening solutions like sodium silicate, silicon fluoride, drying oil and surface sealants shall be applied in accordance with clause 220 - BS 204 or as instructed by the Employer's Representative.

14.2.10 Tolerances on Level

This will depend on the area of floor but a maximum tolerance of ± 15 mm, shall be acceptable unless otherwise indicated in drawings.

Local variations in level shall be ± 3 mm under a 3 m straight edge. There should be no appreciable difference in level across joints especially where heavy moving loads are in service.

14.2.11 Adhesion to the Base

When the floor is tapped with a rod or mallet, it shall not sound hollow. Edges and corners of bays shall be particularly tested for adhesion. In addition if there are visible and measurable lifting of edges or cracks in the topping, the affected bays shall be wholly cut out and freshly laid.

14.3 Granolithic Sprinkled Finishes

Note: The general qualities and characteristics of the sprinkled finish are similar to those for granolithic concrete topping except that the wearing layer is thinner.

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The concrete floor slabs are brought to the finished floor level and while still plastic i.e. within three hours of laying, they are sprinkled with a mixture of 1 part cement and 2 parts granite or other hard aggregate graded 5 mm down., mixed dry and applied at the rate of 7.5 kg/sq.m. This mixture shall be tamped in with a wood float and trowelled as necessary to a smooth fine finish. The surface shall be coated with a single application of 10% solution of silicate of soda except where the floor is to be covered with linoleum in which case silicate of soda is not to be applied.

14.4 Cement Mortar/Cement Concrete (Floor Finishes)

14.4.1 Base Concrete

Where concrete is specified for the ground floor it shall be cement concrete 1: 3: 5 (25 mm) or as specified and not be less than 75 mm thick. For heavier loads this thickness shall be designed.

14.4.2 Topping

- (a) The floor finish of cement mortar 1:2, 12 mm thick shall be laid within 30 minutes of laying the concrete and finished rough with wood floats, or trowelled to a smooth finish as directed by the Employer's Representative. If the finish cannot be applied monolithically, the surface of the base concrete shall be prepared as per clause 14.2.3 and the finishing mortar bonded with a proprietary bonding agent applied to the base concrete to the instructions of the manufacturer. Panel sizes shall be limited to 15 m². If a colored floor finish is specified, a setting coat 3 mm thick shall be laid over the surface layer; this coat shall consist of neat cement and sufficient quantity of coloring pigment of approved make mixed dry until homogeneous. The surface shall be finished smooth with steel floats to the satisfaction of the Employer's Representative. Borders shall be formed and finished as shown in the drawings or as directed. All colored cement finishes shall be polished with floor polish of approved color before handing over the building.
- (b) Where the topping is specified to be cement concrete the mix shall be 1:2:4(10 mm). This shall be of 25 mm thickness or as specified.

The topping shall be finished by trowelling or floating shortly after the compaction of the concrete has been completed. Care shall be taken to avoid bringing an excess of laitance to the surface. If required, the finish shall be as for granolithic concrete. See clause 14.2.6.

All other clauses of 14.2 shall apply to cement concrete floor finishes.

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14.5 Cast - In - Situ Terrazzo Floor Finishes

Definitions

Terrazzo - A cement based polished exposed aggregate floor or wall surface, whether pre-cast or laid in-situ over an under layer. Please see (b) below;

Under layer - The layer of concrete in the terrazzo finish which lies immediately below the terrazzo topping.

14.5.1 Materials

- (a) Cement - Ordinary cement conforming to BS.
- (b) White/ colored Portland cement conforming to B.S. 12.
- (c) Facing Aggregates - The aggregates shall consist of good quality marble or other natural stone of similar characteristics such as Calcites, Dolomites, Serpentine, Calcite and Dolomite marbles and granites etc. They shall be of adequate hardness, angular in shape but not elongated and flaky. The aggregates shall not contain clay, iron oxide, pyrites or other harmful foreign matter in such a form or in sufficient quantity to affect adversely the bond or strength, or cause surface failure. The facing aggregate may be of the required color or may be a mix of aggregate of different colors in the required proportions.

Aggregate should preferably be graded and it is important to avoid high fines or dust content. The approximate sizes of aggregates corresponding to commercial grades are given in Table 14.1.

Table 14.1

Size of Facing No	Aggregate Corresponding to Commercial Grades mm
0	Less than 3
1	3 to 5
2	5 to 7
3	7 to 10
4	10 to 13
5	13 to 19
6	19 to 25

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7	25 to 32
8	greater than 32

- (d) Aggregate (both fine and coarse) for the terrazzo under layer : These shall conform to BS 882. The maximum size of coarse aggregate shall not exceed 10 mm.
- (e) Pigments used shall normally comply with the requirements of BS 1014.
- (f) Dividing strips - The dividing strips may be of copper brass, aluminum, plastic or similar material. Metallic dividing strips may have protective coating of bitumen. The thickness of strip shall not be less than 1.5 mm and width not less than 25 mm. Portions of the bottom edges of the dividing strips may also be cut to a height not exceeding 12 mm and twisted alternatively, or keyed so as to provide anchorage into the terrazzo finish. The spacing of such cut portion shall not be closer than 300 mm.

14.5.2 General Requirements

14.5.2.1The terrazzo finish normally consists of the terrazzo topping and a cement concrete under layer with a combined thickness of at least 40 mm. The thickness of terrazzo topping shall be not less than the following depending upon the grades of chips used.

Table 14.2

Grade No	Size of Chips		Minimum Thickness (mm)
	Retained on sieve size (mm)	Passing sieve size	
0	-	3	5
1	3	5	5
2	5	7	5
3	7	10	8
4	10	13	8
5	13	19	8
6	19	25	10
7	25	32	10
8	32	-	10

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Note: It is not necessary that any one chip should be wholly within the top terrazzo layer.

- 14.5.2.2** The under layer shall be cement concrete mix 1:2:4, and the maximum size of aggregates used shall not exceed 10 mm.

The mix for the terrazzo topping shall consist of cement with or without pigments, facing aggregates and water. A mix richer than one part of cement to two parts of facing aggregate by volume shall be avoided.

The proportions of cement shall be exclusive of any pigments added to the cement.

14.5.2.3 Prevention of Cracks in In - Situ Terrazzo Floor

While laying the floor, the joints in flooring shall always coincide with the expansion joints if any, in the structural slab. The floor finish shall be divide into panels not exceeding one square meter in area and separated by dividing strips.

The length of panels shall not exceed twice the width.

The water - cement ratio shall be kept as low as possible in order to reduce the drying shrinkage. Aggregates smaller than 3 mm shall not be used.

14.5.3 Mixing of Materials

Mixing of materials shall be done carefully and thoroughly in order to ensure uniform finish. If done manually the mixing shall preferably be done in a trough or tub. The complete quantities of cement and pigment required for any particular area shall be mixed and stored properly in order to avoid variation in color or appearance.

Where different colored chips are used they shall first be well mixed in the required proportions of the various colors and sizes. Colored cement may be procured as ready mixed material or mixed at site; in the latter case the pigment and cement in the required proportions shall be mixed thoroughly and sieved before mixing with aggregate.

The pigment and cement proportions for various shades are given for guidance in Appendix 14.A

The colored cement and the chips shall be mixed together dry. While mixing the aggregates, care shall be taken not to get the materials into a heap, as this would result in the larger chips falling to the edge of the heap and the cement working to the centre at the bottom.

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After the materials have been thoroughly mixed in the dry state, water shall be added in small quantities in a fine spray while the materials are being mixed until proper consistency is obtained. The mixture shall be plastic but not so wet that it will flow; a rough indication for the addition of the proper quantity of water in the mix is that it shall be capable of being moulded by hand without any water flowing out.

Machine mixing may be used, but the common type of concrete mixer shall not be used since it is not suitable. The mixer specially made for terrazzo work prevents segregation by blades with a lifting as well as rotating movement.

The mix shall be used in the work within half an hour of the addition of water.

14.5.4 Spreading the Under layer

Dividing strips including the strips required for decorative design shall be fixed on the base to the exact surface level of the floor and panel sizes limited as recommended in clause 14.5.2.3. Anchorage arrangements for dividing strips shall be provided as specified. Where dividing strips are not used, screed strips properly leveled to the correct height to suit the thickness of the floor shall be fixed on the base.

Before spreading the under layer, the base shall be cleaned of all dirt, laitance, or loose material and then well wetted with water without forming any water pool on the surface. It shall then be smeared with cement slurry just before the spreading of the under layer.

After application of the cement slurry, the under layer shall be spread and leveled with a screeding board. The slightly rough surface left by the screeding board will form a satisfactory key for the terrazzo.

14.5.5 Laying the Terrazzo Topping

Terrazzo topping shall be laid while the under layer is still green, but has hardened sufficiently, this is normally achieved 18 to 24 hours after the under layer has been laid. A cement slurry preferably of the same color as the topping shall be brushed on the surface immediately before laying is commenced. If possible the entire work of laying the topping shall be completed at one stretch.

The terrazzo mix shall be placed on the screed bed and compacted thoroughly by tamping or rolling and trowelled smooth. The time interval allowed between each successive trowelling is important as only that much trowelling which is sufficient to give a level surface is needed immediately after laying. Further compacting shall be carried out at intervals, the amount depending upon the temperature and the rate of setting of the cement.

Excessive trowelling or rolling in early stages shall be avoided as this will tend to work the

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cement up to the surface and this will produce a finish liable to cracking and will also necessitate more grinding of the surface in order to expose the chips.

Borders and decorative designs shall be laid before the main body of the flooring. They shall be laid and finished in the same manner as the flooring preferably using dividing strips. Where however, stencils or formwork of wood or metal are used instead of dividing strips, they shall be removed before the topping mix commences to harden. The removal shall be effected with as little disturbance to the materials as possible, and any ragged edges left after removal of all stencils or formwork shall be rectified with a trowel, care being taken to consolidate the terrazzo to avoid damage to the edges of the design.

14.5.6 Curing

The surface shall be left dry for air - curing for a duration of 12 to 18 hours. It shall then be cured by pouring water over it for a period of not less than four days.

14.5.7 Surface Grinding, Curing and Finishing

Polishing shall be done by machine. About 4 days after laying the top layer, the surface shall be watered and ground evenly with a machine fitted with special rapid cutting grit blocks (carborundum stone) of coarse grade (No. 60) till the marble chips are evenly exposed and the floor is smooth. After the first grinding, the surface shall be thoroughly washed to remove all ground mud and covered with a grout of cement and / or coloring matter in the same mix and proportion as the topping in order to fill any pin holes that appear. The surface shall be allowed to cure for 5 to 7 days and then ground with a machine fitted with fine grit blocks (No.120). The surface shall then be cleaned and repaired as before and allowed to cure again for 3 to 5 days. Finally the third grinding shall be done with a machine fitted with fine grade grit blocks (No. 320) to get an even and smooth surface without pin holes. The finished surface shall show the marble chips evenly exposed. Where use of machine for polishing is not feasible or possible, rubbing and polishing shall be done by hand if approved by the Employer's Representative. This shall be done in the same manner as specified for machine polishing except that carborundum stone of coarse grade (No. 60) shall be used for the 1st rubbing, stone of medium grade (No. 80) for the second rubbing and stone of fine grade (No. 120) for the final rubbing and polishing.

After the final polish either by machine or by hand, oxalic acid shall be dusted over the surface at 33 gm. per square meter; the surface shall then be sprinkled with water and rubbed hard with a pad of woolen rags. On the following day, the floor shall be wiped with a moist rag and dried with soft cloth and finished clean.

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In case a wax - polished surface is desired for the floor, the wax polish shall be sparingly applied with soft linen on the clean and dry surface. The polishing machine fitted with pads shall then be run over it.

14.5.8 Precautions

Flooring in lavatories and bathrooms shall be laid after the fixing of the water closet, squatting pans and floor traps. Traps shall be plugged while laying the floors and opened after the floors are cured and cleaned.

After the final polishing, the floor shall be protected against misuse or damage by subsequent operations. Due precautions shall be taken in the disposal of the washed off ground material and the Oxalic Acid used for cleaning. It is important to ensure that the ground material does not enter sewer pipes and the Oxalic Acid is not washed out into the surrounding area of the building as it will have a harmful effect on vegetation.

14.6 Cast - In - Situ Terrazzo Skirting and Wall Linings

14.6.1 Under layer

For a terrazzo finish on vertical surface like skirting and wall linings, the under layer shall consist of stiff cement mortar 1:3, finished rough so as to provide an adequate key for the topping.

14.6.2 Thickness

The combined thickness of the under layer and terrazzo topping shall be not less than 20 mm. The minimum thickness of terrazzo topping shall not be less than 6 mm.

14.6.3 Laying, Curing and Grinding

These shall be similar to those described for in - situ terrazzo flooring except that the grinding may have to be done manually.

14.7 Terrazzo Tiles Flooring

14.7.1 Materials

14.7.1.1 Terrazzo Tiles

Terrazzo tiles shall generally conform to BS. The size of tiles are given below in Table 14.3.

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Table 14.3

Length of each Work size in mm	Minimum thickness in mm
150 [±] - 1	15
200 [±] - 1	20
300 [±] - 1	30

The tiles shall be manufactured under a hydraulic pressure or not less than 14 N/mm² (approx. 200 psi).

The proportion of cement to aggregate in the base layer of tiles shall neither be leaner than 1:3 1/2 nor richer than 1:3 by weight. The proportion of cement to marble chips in the facing layer shall not be richer than 1:1 1/2. The proportion of pigment to be used shall not exceed 10% of the weight of cement. The facing layer shall be such as to provide a minimum wearing thickness of 6 mm after grinding.

The tiles shall be supplied

- (a) ground and grouted,
or
- (b) Ground, grouted and reground to a fine grit finish for floors, skirting and walls,
or
- (c) ground, grouted and high polish finished for skirting and walls.

The tiles shall be free from defects or flaws. The chips shall be evenly distributed. The face shall be free from projections, depressions, flakes and crazes. The edges of tiles shall be perpendicular to the surface. The planes of the upper and lower surfaces of the tile shall be parallel and adjacent vertical edges of square tiles shall be at right angles to each other.

All arrises shall be sharp and true.

The tiles delivered shall be practically uniform in color except as otherwise ordered. The age of tiles at delivery shall be not less than 7 days after pressing. When tested as per BS water absorption of tiles shall be as below:

- (a) Water absorbed by tile face : No single result shall be more than 4 kg/m².
- (b) Total absorption : No single result shall be more than 8%.

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Transverse strength of tiles when tested in accordance to BS shall not be less than 3 M Pa.

The tiles shall be stored in much a way as not to cause damage or discoloration during storage.

14.7.1.2 Chequered Tiles

These shall be of the same size as plain tiles; the dimension of chequers and thickness shall conform to the requirements of clause 14.1.1.3.

14.7.1.3 Tiles for Skirting

Skirting tiles shall be 150 mm to 600 mm long, 12 mm thick and 100 or 150 mm high or as specified. Radium of coves shall be 25 mm and base width 40 mm or as specified. Top side of the skirting tile shall be finished in a manner similar to that of the top surface of tile on per 14.7.1.1 above.

14.7.1.4 Tiles for Risers of Steps

These shall be at least 12 mm thick and of sizes specified, or directed.

14.7.1.5 Tiles for Treads of Steps

These shall be of chequered pattern and shall conform to clause 14.1.1.3 chequered cement tiles.

14.7.2 Laying

14.7.2.1 Laying of Floor Tiles Plain or Chequered

The sub - grade concrete or the reinforced concrete slab on which the tiles are to be laid shall be cleaned, wetted and mopped. The bedding for the tile shall be in cement mortar 1:3 with only the minimum volume of water required to achieve workability. The average thickness of bedding mortar shall be not more than 20 mm.

Cement mortar bedding shall be spread, tamped and screeded to proper levels. Over this bedding neat cement slurry of honey like consistency shall be spread at the rate of 4.4 kg of cement per square meter, over such an area as would accommodate about twenty tiles. The tiles shall be washed clean thoroughly wetted and fixed over the bedding one after another, each tile being gently tapped with a wooden mallet till it is properly bedded, and in line with the adjoining tiles. The joints shall be kept as thin as possible not exceeding 1.5 mm and in straight lines or to suit the required pattern. The surface of the flooring during laying shall be frequently checked with a straight edge at least 2 meter long, so as to obtain a true surface

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with the required slope.

Where full size tiles cannot be fixed, these shall be cut (sawn) to the required size and the edges rubbed smooth to ensure a straight and true joint.

Tiles which are fixed in the floor adjoining the wall shall butt in at least 12 mm under the plaster, skirting, or wall tiling with the junction finished neatly and without waviness.

As the tiles are being laid, surplus cement grout that may come out of the joint shall be wiped off with a damp cloth.

14.7.2.2 Laying of Skirting and Risers of Steps and Walling

Preparation of Surface

This shall conform to 16.1.2 in the case of brickwork/ block work and stone masonry and 16.5.2 in the case of formed concrete surface.

Laying

A 12 mm thick plaster of cement mortar 1:3 or as specified shall be applied and allowed to harden. The plaster shall be roughened while green, with wire brushes, or by scratching diagonal lines 2 mm deep at approximately 75 mm concrete both ways. The back of tiles shall be buttered with a coat of grey cement slurry, the edges with grey or white cement slurry with, if so specified, pigment to match the shade of tiles, and set in the bedding mortar. These shall be tamped and corrected to proper planes and lines. The tiles shall be set in the required pattern and butt joined. The joints shall be as fine as possible. The top of the skirting shall be truly horizontal and joints truly vertical except where otherwise indicated.

The risers of steps or skirting shall rest on the top of the tread or flooring. Where full size tiles cannot be fixed, the tiles shall be cut (sawn) to the required size and their edges rubbed and finished smooth.

14.7.3 Curing, Polishing and Finishing

The day after the tiles are laid all joints shall be cleaned of cement mixed if specified with pigment to match the shade of the topping of the wearing layer of the tiles. The same cement slurry shall be applied to the entire surface of the tiles in a thin coat with a view to protect the surface from abrasive damage and fill the pin holes that may exist on the surface.

The floor shall then be kept wet for a minimum period of 7 days.

The surface shall thereafter be ground evenly with a machine fitted with coarse grade grit

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blocks (No. 60). Water shall be used profusely during grinding. After grinding, the surface shall be thoroughly washed to remove all ground mud and cleaned and mopped. In order to fill any pin holes that appear, it shall then be covered with a thin coat of grey or white cement, mixed if so specified with pigment to match the color of the topping of the wearing surface. The surface shall be again cured. The second grinding shall then be carried out with a machine fitted with fine grade grit blocks (No. 120).

The final grinding with a machine fitted with a finest grade grit blocks (No. 320) shall be carried out the day after the second grinding.

For small areas or where circumstances so require, hand polishing may be permitted in lieu of machine polishing after laying. For hand polishing the following carborundum stones, shall be used:-

1st grinding - coarse grade stone (No. 60)

2nd grinding - medium grade (No. 80)

Final grinding - fine grade (No. 120)

In all other respects, the process shall be similar to machine polishing. The preceding description is for ungrounded tiles. If ground in the factory, only final grinding shall be done at the site. Chequered tiles shall be polished by hand or as directed. Care shall be taken to polish the chequer grooves and noses of stair treads to match adjacent work.

After the final polish, oxalic acid shall be dusted over the surface at the rate of 33 gm per square meter. The surface shall be sprinkled with water and rubbed hard with a pad of woollen rags. The following day the floor shall be wiped with a moist rag and dried with a soft cloth and finished clean.

If any tile is disturbed or damaged, it shall be refitted or replaced, properly jointed and polished.

The finished floor shall not sound hollow when tamped with a wooden mallet.

14.8 Glazed Tiles Flooring and Skirting

14.8.1 Materials

14.8.1.1 White Glazed Tiles

The tiles shall be of approved make and shall generally conform to BS 1281. They shall be flat, and true to shape and free from cracks, crazing spots, chipped edges and corners. The

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glazing shall be of uniform shade.

The tiles shall be of nominal sizes such as 150 x 150 mm, 100 x 100 mm or as specified. The thickness of the tiles shall be 5 mm or 6 mm as specified. The tolerance on facial dimension shall be ± 1.0 mm and on thickness ± 0.5 mm.

The top surface of the tiles shall be glazed. The glaze shall be either glossy or matt as specified. The underside of the tiles shall be completely free from glaze.

The edges of the tiles shall be preferable free from glaze; however, any glaze if unavoidable, shall be permissible on any one edge of the tile.

14.8.1.2 Colored Glazed Tiles

Only the glaze shall be colored as specified. The sizes and specifications shall be the same as for the white glazed tiles.

14.8.1.3 Decorative Tiles

The type and size of the decorative tiles shall be as follows:

- (i) Decorated on white back ground:
152 x 152 x 6 mm or 108 x 108 x 6 mm.

- (ii) Decorated and having colored back ground:
152 x 152 x 6 mm or 108 x 108 x 6 mm.

- (iii) Fantasy glazed tiles: 108 x 108 x 6 mm.

14.8.1.4 Glazed Tile Specials

The specials consist of coves, internal and external angles, beads, cornices and their corner pieces.

Coves, beads and angles shall be of thickness not less than the tiles with which they are used. The size of coves, beads, angles and cornices shall be as specified. The stipulated size of coves, beads and angles refer to the greatest width of the special measured in a straight line. The stipulated size of cornices is their height. The lengths of specials shall be 150 mm 100 mm or other standard size conforming to the size of tiles used.

14.8.2 Preparation of Surface and Laying

The sub-grade concrete or the reinforced concrete slab on which the tiles are to be bedded shall be cleaned, wetted and mopped. The bedding for the tile shall be with cement mortar 1:3 or as specified. The average thickness of the bedding shall be 10 mm.

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Mortar shall be spread, tamped, corrected to proper levels; float finished with a wooden float and allowed to stiffen sufficiently to offer a fairly rigid cushion for the tiles to be set and to enable the tiles to place wooden plank across and squat on it.

Over this mortar bedding neat grey cement slurry of honey like consistency shall be spread at the rate of 3.3 kg of cement per square meter over such an area as would accommodate about twenty tiles. The tiles shall be soaked in water, washed clean and shall be fixed in this grout, each tile being gently tapped with a wooden mallet till it is properly bedded and level with the adjoining tiles. The joints shall be kept as thin as possible and in straight lines or to suit the required pattern.

The surface of the flooring during laying shall be frequently checked with a straight edge about 2 m long so as to obtain a true surface with the required slope.

Where full size tiles cannot be fixed these shall be cut (sawn) to the required size, and their edge rubbed smooth to ensure straight and true joints.

Tiles which are fixed on the floor adjoining the wall shall butt at least 10 mm under the wall finish

As tiles are being laid, surplus cement grout shall be wiped off with a damp cloth.

Skirting work shall conform to the relevant requirements of 14.7.2.2.

14.8.3 Pointing and Finishing

The joints shall be cleaned of the grey cement grout to a depth of 2 to 3 mm using a brush or trowel, and all dust and loose mortar removed. Joints shall then be flush pointed with white cement added with pigment if required to match the color of the tiles. The floor shall then be kept wet for 7 days. After curing, the surface shall be washed and finished clean. The finished floor shall not sound hollow when tapped with a wooden mallet.

14.9 Parquet Flooring

Parquet flooring shall consist, unless otherwise specified, of specified timber blocks 150 x 75 x 25 mm thick. The top surface of the blocks shall be planned, smooth and the edges shall be square and plane for the top 12 mm and 'V' grooved along the bottom 12 mm.

In the case of ground floors, the parquet flooring shall be laid on 75 mm thick cement concrete 1:3:5 (25 mm) rendered with an additional 20 mm (max) thick cement and sand rendering 1:2

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mixed with suitable waterproof additive and finished with a medium rough surface. The concrete and rendering shall be cured with water for at least 14 days and shall be allowed to dry up and harden for at least another 7 days before the flooring is laid.

The prepared surface shall be treated with a mastic compound obtained by boiling together pitch and coal tar in the proportion of one cwt of pitch to 7 1/2 gallons of coal tar or suitable asphaltic bitumen.

The bottom surface and the 'V' grooves of the parquet blocks shall be treated with the same compound, and the blocks set on the concrete floor to an approved pattern with tight fitting joints. The surface shall be perfectly smooth and level and shall be protected with saw dust or other approved cover until completion when the whole surface shall be again cleaned, sand prepared and wax polished.

14.10 Skirting for Cement Rendered Floors

14.10.1 Skirting Work Shall be in Cement Sand Mortar 1:2

Cement mortar skirting shall be provided at the foot of the wall immediately above the floor finish. Unless otherwise specified the skirting shall be 100 x 15 mm thick with a sunk 'V' groove 12 x 12 mm provided at the junction of the skirting and the plaster above. The junction of floor finish and skirting shall be rounded with a radius of 25 mm or in the manner directed by the Employer's Representative. The finishing of the skirting shall match the floor finish. Skirting finished with colored cement shall be polished with floor polish of appropriate color before handing over the building.

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APPENDIX 14.A

CEMENT PIGMENT PROPORTIONS FOR VARIOUS COLORS
OF MATRIX IN TERRAZZO WORK

(All proportions shall be by weight)

Color	Pigment to be used	Proportion of Pigment	Proportion of ordinary Portland Cement	Proportion of White Cement
Red	Red oxide of iron	1	15 to 20	Nil
Black	Carbon black	1	25 to 40	Nil
Green				
Pink	Red oxide	1	Nil	100 to 300
Cream	Yellow oxide of iron	1	Nil	100 to 400
Yellow	Yellow oxide of iron	1	Nil	25 to 75
Light Green	Green chromium oxide	1	Nil	50 to 100
French Grey	-	Nil	1 to 2	1
Fawn	Yellow oxide of iron	1	6	4

CHAPTER 15
ROOF COVERING & ROOF DRAINAGE

15.1 General

The following specifications stipulate the fixing details of roof coverings in buildings subject to moderate winds. For buildings subject to high winds, fixing and bracing details shall be as specified in the drawings and the continuity and anchorage of the fixing through the structure to the ground shall be ensured. Guidance is available in the Manual on the "Design of Buildings for High Winds" issued by the Ministry of Local Government, Housing and Construction.

For water proofing of concrete flat/sloped roofs see relevant clause of chapter 15

15.2 Tiled Roofing

15.2.1 Materials

The tiles shall conform to the relevant Specifications given below. Prior approval of the Employer's Representative shall be obtained for samples of the tiles proposed to be used at the site. The approved samples shall be deposited with the Employer's representative and subsequent supplies shall conform with these.

15.2.1.1 Clay Flat Tiles (Calicut Pattern)

The tiles shall conform to BS. They shall be uniform in color, size and shape

The tiles shall be free from fire cracks, twists or bends and shall be true to shape. The tiles shall be free from fire cracks, twists or bends and shall be true to shape. The tiles shall be free from intrusions like particles of stone, lime or other foreign matter visible to the naked eye either on the surface or on a fractured surface of the tile. When struck, the tile shall give a ringing sound and when broken, the texture shall be clean and sharp at edges.

Length : 410 \pm 10 mm

Width : 245 \pm 5 mm.

Mass (average of 12 tiles selected at random)

not less than 2.7 kg.

Transverse strength:

Average breaking load of six tiles - 1000 N

Min. breaking load of individual tiles - 950 N

Water absorption

Average of six tiles : Not more than 18%

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Water permissibility : The specimen when tested by the method described in the BS shall show no traces of droplets of water on the underside.

Ridge tiles shall conform to the requirements of BS.

If so required, the Contractor shall furnish a certificate from an approved laboratory that the tiles conform to BS.

If, in the opinion of the employer's representative any of the consignment of tiles brought to site is not equal in every respect to the samples approved, the Employer's representative will be at liberty to select samples and forward them to an approved laboratory for testing. The cost of their packing and transport shall be met by the Contractor.

Tiles that are reported to be not up to the standards will be rejected and shall be removed from the site within 24 hours of notice to do so.

15.2.1.2 Clay Half Round Tiles - Country Tiles

Clay half-round tiles shall be sound and well burnt. They shall be true to size and shape, even and free from twist, bends or flaws; they shall give a clear ringing sound when struck. The texture of broken surface shall be uniform and compact.

Ridges and hips shall be of the same material as the tiles and shall conform to the requirements of roofing tiles in so far as these are applicable.

15.1.2 Laying

Calicut pattern (flat) tiling shall be laid on 50 x 25 mm horizontal reepers spaced to suit the gauge of the tiles.

Half round clay tiles shall be laid with laps not less than 75 mm On 50 x 12 mm horizontal reepers spaced at half the distance between the centers of lapping.

The maximum distance of the common rafters, centre to centre, shall not exceed 600 mm. Reepers shall be nailed to the rafters with 50 mm. Long gauge 9 nails. The reepers shall be in lengths not shorter than that necessary to span across at least four rafters. Jointing of reepers shall only be provide over rafters and the joints of two adjacent rows of reepers shall not be over the same rafter. Notching of rafters at wall-plate shall not exceed 1/4 x depth of the rafter.

Double reepers shall be provided at the edges of eaves. Where lapped boarding is specified to be used on top of the rafters, the horizontal reepers shall be nailed to similar counter reepers

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nailed over each rafter to and on top of the lapped boarding.

The tiles shall be laid from the eaves towards the ridge, the projection of the first row of tiles along the eaves being about 75 mm beyond the end of rafters. The tiles ending at the hips shall be cut suitably so as to disclose no gaps when laid.

The roofing shall be perfect and water tight on completion.

Ridges and hip tiles shall be bedded in lime cement mortar 1:1:5 and pointed with cement mortar 1:3 colored to match the color of the tiles.

Mortar bands 100 to 200 mm wide and 50 mm thick shall be provided in lime cement mortar 1:1:5 down the slopes at intervals not exceeding 1.8 meters and finished to match the tiles.

For buildings in high wind areas the fixings shall be as specified - see clause 12 general. At the junction of a roof with a wall, tiles shall be taken into the wall to a depth of 50 mm and the joint grouted with cement mortar 1:3. A band of mortar 100 mm x 100 mm shall be formed (along the junction) above the roof surface and finished as directed by the Employer's Representative. Flashings where specified shall conform to clause 15.5.1.

Gable ends of clay tiled roofs shall be provided with a band of mortar 230 mm wide, not less than 50 mm in height in lime, cement mortar 1:1:5 to bond the end tiles along the gable and finished with cement mortar 1:3 colored to match the color of the tiles.

Valleys for tiles roofing shall consist of 16 gauge galvanized steel sheeting 1200 mm wide. End laps for valley sheets shall be 230 mm along the slope. No nails or solder shall be used at end laps. The sheets shall be laid over timber boarding not less than 20 mm thick. The sides of the gutter shall be built up in cement mortar 1:3 colored to match the tiles.

15.3 Galvanized Corrugated Steel Sheet Roofing

15.3.1 Materials

15.3.1.1 Galvanized Corrugated Steel Sheets

Galvanized corrugated steel sheet shall comply with the requirements of BS or Australian standards. The corrugations shall normally have a pitch of 75 mm and a depth of 18 mm. The zinc coating shall be bright, clean and even and shall have been provided at the rate of 305 g/m². The coating adherence shall be such that no flaking of the zinc coating shall have taken place after corrugating the

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15.3.1.2 Ribbed Metal Sheet Roofing

- (a) Thickness of sheet and the thickness of galvanization shall conform to the requirements in Section 15.3.1.1
- (b) Fix sheets in single lengths for each roof plane less than 18mm in length, with high ends of sheet turned upwards.
- (c) Where eave gutters are used as barges, extend the decking approximately 125mm and attach the gutter with pop rivets or self-tapping screws or alternatively attach the gutter with clips or gutter straps before erection of end roofing panels.
- (d) Fix the sheeting in accordance with manufacturers' instructions, using special tools recommended by them.
- (e) Use solder of 60 tin/40 lead with non-corrosive flux. Clean and lap joints 18 mm minimum, double rivet unless otherwise specified, fully sweat and remove residual flux from completed joints.
- (f) Formed lipped holes for penetrations. Fix spigots with 4mm sealed type pop rivets and fully sweat to sheeting. Use the manufacturer- specified mastic over full interface areas , where applicable.
- (g) Fix all necessary stop ends, capping, flashing and other accessories.
- (h) Fix roof penetrations, such as vents, to correspond with rib sizes and positions wherever possible. Provide necessary extra support at ends of cut sheets.
- (i)
- (j) Lay sheets true to line and falls. Form lips at low ends.
- (k)
- (l) Permit thermal movement to occur.

15.3.1.3 Fixing Accessories

Fixing accessories like hook bolts, drive screws, bolts, nuts, rivets and washers shall comply with the requirements of BS 1494: Part I - See Clause 15.2.1.2.

15.3.1.4 Accessories

Ridges and hips shall be of plain galvanized steel sheets 600 mm wide, 0.6 mm (84 gauge) or 0.8 mm (22 gauge) thick as specified.

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15.3.1.5 **Storage, Transport and Handling**

The sheets shall be stored at site over timber battens in a dry clean shed.

Sheets and fittings shall be carefully handled so that they are not damaged during handling or transport. Where slings or grabs are used they shall be suitably arranged to avoid damage to sheet edges.

15.3.2 **Workmanship**

15.3.2.1 **Slope of Roof, Laps and Purlin Spacing**

Roof shall not be pitched at a slope flatter than 10^0 (i.e. 1 vertical to 5.67 horizontal).

End laps - The laps shall be a minimum of 150 mm for slopes of 10^0 or more, with a minimum of 100 mm for vertical falls.

Side laps - Side laps shall be formed on the side of the sheet away from the prevailing wind.

Side laps shall be one and a half or two corrugations, depending upon the conditions exposure.

15.3.2.2 **Laying**

Before laying it shall be checked that the roof framing is true to lines and levels. The final protective coats of paint to the roof framing shall be completed before fixing of sheet is commenced.

The sheet shall be laid on the purlins to a true plane with the lines of corrugations parallel or normal to the sides of the area to be covered, unless otherwise required in a specially shaped roof.

The laps in the sheet shall be painted with a coat of approved steel primer and two coats of approved steel paint before laying.

15.3.2.3 **Cutting and Drilling**

The holes for the fixing bolts shall be through the crown of the corrugation and shall be either punched or drilled. They shall be 1.5 mm larger in diameter than the bolts or fixing screws used.

Holes for fixing the sheets shall be in the exact positions required to suit the purlins.

No hole for a fixing bolt shall be nearer than 38 mm to the end of a sheet.

Where necessary, the sheets shall be cut to clean, true lines without any distortion.

Openings in sheets for outlets, vent pipes, flues, etc. shall be cut to the minimum size

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necessary and edges of openings reinforced as specified or as directed. All burrs, lubricant, dust, drilling swarf and any other foreign matter shall be removed before finally fixing the sheets in position.

15.3.2.4 Fixing

The sheets shall be fixed commencing from the leeward end so that the side laps will have the better protection from rain driven by the prevailing wind. The eaves course shall be laid first with the top edges extending at least 39 mm beyond the back of steel angle purlins or 75 mm beyond the centre line of timber purlins.

At side laps, (where the edge corrugations of the sheets are to opposite hand), the under lapping sides shall finish with an upturned edge and the over lapping sides with a downward edge.

Where sheets abut a wall the sheets shall finish with an upturned edge.

Sheets shall be fixed with hook bolts and drive screws of 8 mm nominal diameter spaced at intervals of not more than 375 mm. Sheets shall be secured to every purlin by at least two bolts.

Fixing to tubular purlins shall be "U" bolts at lap joints and eaves, and "J" bolts at intermediate purlins.

Each hook bolt or screw shall have a metal washer shaped to the profile of the sheet. A sealing washer of bituminous felt shall be provided between the metal washer and the sheet so that the bolt hole is sealed when the nut is tightened.

The sheets shall be adequately supported when holes are punched in position. Sheets with wrongly drilling holes shall be rejected.

15.3.2.5 Fixing of Ridges and Hips

The ridges and hips of plain galvanized steel sheets shall lap at least 200 mm on each side over the corrugated galvanized steel sheets. The end laps of the ridges and hips, as well as between ridges and hips shall also be not less than 200 mm.

Ridges and hips shall be fixed to the roof members below, such as the purlins, hip and valley rafters, with the same 8 mm diameter hook bolts or drive screws as fix the sheets to those roof members. At least one of the fixing bolts shall pass through the end laps of ridges and hips, on each side. If this is not possible, extra fixings shall be provided.

The end laps of ridges and hips shall be joined together by galvanized steel seam bolts 25 mm

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x 6 mm size, each provided with one bitumen and galvanized steel washer. There shall be at least two such bolts in each end lap. The ridges and hips shall be straight from end to end and plane and parallel to the general plane of the roof.

15.3.2.6 Finish

On completion, the fastenings shall be checked and adjusted as necessary to ensure that they are watertight and the sheeting is secure but not buckled or distorted. The roof, when completed shall be true to lines and slopes and shall be leak proof.

15.4 Rigid PVC Profiled Sheets and Glass Fiber Reinforced

Plastic (Grp) Profiled Sheets

15.4.1 Materials

Rigid PVC profiled sheets whether reinforced or otherwise shall be of approved manufacture conforming to BS 4203. The profile and color shall be as specified.

GRP profiled sheets shall be of approved manufacture conforming to BS 4154. The profile, finish and light diffusion class shall be as specified.

Fastenings and Accessories shall be of approved manufacture.

15.4.2 Workmanship

Workmanship shall conform to specifications of the manufacturer. Selection and spacing of fixings shall be as given in Appendix B of BS 5427.

15.5 Composite Roof (To Be Done)

15.6 Plastic Skylight Units

(a) Factory - assembled unit consisting of plastic glazing, extruded aluminum glazing retainer, gasketing, inner frame that may be incorporated into the curb, and integral curb with self-contained roof flashing flanges.

(b) Curb : Manufacturer's standard formed or extruded aluminum, including cants or flashing flange to receive roof flashing and counter flashing.

Or

(c) Curb : Self-flashing, self supporting double -wall, formed or extruded (or combination) aluminum curb, minimum 0.040 - inch wall thickness , enclosing minimum 1 -inch glass -

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fiber board (or equivalent) insulation and with minimum 3-inch roof flanges, with welded or sealed mechanical joints at corners.

1. Height: Minimum 200mm above roofing
 2. Taper: Where roof deck slopes more than 6mm per 300mm, provide tapered curb heights to match slope and result in level dome installation.
- (d) Operable skylight vent: Equip unit with hinges, operating hardware, and weather sealing gaskets.
1. Provide manually operated opening device with extension crank.
- (e) Glazing: Thermoformed polycarbonate.
- (f) Security: Equip each unit with security grille.
- (g) Comply with manufacturer's instructions and recommendations. Co-ordinate with installation of roof deck and other substrates to receive skylight units. Co-ordinate with installation of vapor barriers, roof insulation, roofing, and flashing as required to assure that each element of the work performs properly and that combined elements are waterproof and weather -tight. Anchor units securely to supporting structural substrates, adequate to withstand lateral and thermal stresses as well as inward and outward loading pressures.
- (h) Where metal surfaces of units are to be installed in contact with incompatible metal or corrosive substrates, including wood, apply bituminous coating on concealed metal surfaces, or provide another permanent separation.
- (i) Flange Seals : Except as otherwise indicated, set flanges of accessory units in a thick bed of roofing cement to form a seal.
- (j) Cap Flashing : Where cap flashing is required as component of the skylight, install to provide an adequate waterproof overlap with roofing or roof flashing (as counter flashing). Seal with thick bead of mastic sealant, except where overlap is indicated to be left open for ventilation.
- (k) Operational Units : Test operate units with operable components. Clean and lubricate joints and hardware. Adjust for proper operation.

15.7 Valley Cutters of Plain Galvanized Steel Sheets

Valley cutters of plain galvanized steel sheets 900 mm overall width and 1.6 mm (16 gauge)

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thick or other thickness as specified and bent to shape.

They shall lap with the corrugated galvanized steel sheets for not less than 250 mm width on each side the end laps of valleys shall be not less than 230 mm.

Valley sheets shall be laid over 20 mm thick wooden boarding laid to shape. The valley sheet shall be fixed to the roof members below, such as purlins and valley rafters, with the same 8 mm diameter hook bolts or drive screws as fix the sheets to those roof members. At least one of the fixing bolts shall pass through the end laps of the valley pieces, on each side. If this is not possible extra fixing shall be provided.

The edges of valleys shall be straight from end to end. The surface shall be true and without bulges and depressions. The valley sheets shall be turned up at the top end and down to the

gutter head at the lower end to suitable profile as directed by the Employer's Representative. The edges shall be dressed over a reeper.

15.8 Flashing

(a) Galvanized Steel Sheet

The junctions of all sloping roofs and walls are to be flashed with 12 mm (18 gauge) thick galvanized

Steel sheet flashing unless otherwise specified.

One edge shall be dressed over the roof to a width of not less than 300 mm the other edge turned up to a height of not less than 150 mm, tucked into a chase cut in the wall and pointed in cement mortar 1:2.

(b) Lead Sheet

Lead flashing, where specified, shall be of milled lead sheets at least 14 Gauge (2 mm) thick weighing 24.4 kg. per Sq.m. One edge shall be dressed over the roof to a width of not less than 300 mm and the other edge turned up to a height of not less than 150 mm and nailed to wooden plugs with copper nails. The upper edge shall be covered by an apron of the same material overlapping the flashing by 100 mm. The top edge of the apron shall be tucked into a chase cut in the wall for a depth of at least 50 mm, fixed with lead wedges, and the joint finally filled with cement mortar 1:2.

15.9 Gutters

Gutters shall be of the specified material and design. Details of fixing shall conform to the relevant clauses below or as otherwise specified. The gutter shall be true to lines and slopes and shall be leak proof.

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15.9.1 Gutters of Plain Galvanized Steel Sheets

15.9.1.1 Eaves Gutters

Eaves gutters shall be formed of 0.8 mm thick (22 gauge) sheets to the shape and section specified. Longitudinal edges shall be turned back to the extent of 12 mm and beaten to form a rounded edge.

At joints sheets shall be hooked into each other and beaten flush to avoid leakage; alternatively the joints shall be soldered.

The inside surfaces of eaves gutters shall be treated with two coats of hot tar and the outside with galvanized iron primer and two additional coats of anticorrosive paint.

The gutters shall be supported on and fixed to mild steel brackets 20 mm x 3 mm spaced at centers not exceeding 1.2m.

The minimum slope of the gutter shall be 1 in 120. For connection to down pipes, a proper drop end or funnel shaped connecting piece shall be made out of galvanized steel sheet of the same thickness as the gutter and riveted to the gutter. Unless otherwise specified, this shall be either 12" x 12" at top when square or 12" diameter when circular and the lower end shall be tapered to suit the size and shape of the down pipe, and provided with an outlet and spigot for joining to the down pipe.

The outlet shall have a strong grating of galvanized wire mesh fixed thereto.

15.9.1.2 Box Gutters

Unless otherwise specified, box gutters shall be of 1.2 mm (18 gauge) thick galvanized steel. The sections shall be well riveted together and bedded in red lead with a pad of Hessian Canvas soaked in red lead between the metal surface to ensure water tight joints and laid to a fall of at least 1 in 120.

Gutters having free sides (i.e. not adjacent to brickwork or timber framing) shall have 40 mm * 7 mm flat bar stiffeners at 1.5 m intervals across the top of the gutter and bolted to sides. The inside and outside surfaces shall have a thick coating of bitumen and sand.

The sides of box gutters next to shall have 0.8 mm (22 gauge) thick galvanized steel flashing; one edge shall be dressed over the edge of the gutter and secured with clips, and the other edge tucked and wedged into the brick joint and pointed in cement sand 1:2. Stopped ends, nozzles, short length shall be provided as required. For gutter heads see Clause 15.7.1.1.

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15.9.2 Asbestos Cement Gutters

These shall be half round or ornamental as specified. Lapping shall be in the direction of flow of water. Joints shall be fixed tight with either a mastic jointing compound or special synthetic rubber joint pads supplied by the makers of the gutter and finally caulked with 6 mm asbestos cord.

The gutter shall be fixed by means of galvanized mild steel brackets screwed to fascia boards or to the end of rafters. The centers of supports shall not exceed 900 mm and there shall be a bracket not more than 150 mm away from the socket end of each length. All specials be provided as required.

15.9.3 UPVC Gutters

Half round eaves gutters shall conform to BS 4576. Rectangular gutters, of approved local manufacture shall be used where specified.

The internal and external surfaces of the gutters, pipes and fittings shall be clean, smooth and reasonably free from grooving and other defects that would impair their performance. The ends of the gutters, pipes and fittings shall be cleanly cut and square with the axis of the component. The gutters and pipes shall be straight.

The fixing used shall have the following minimum requirements :-

- (a) The wall thickness of the fixing manufactured from PVC shall not be less than that of the gutter with which they are used.
- (b) When fixing, the gutter and bracket shall provide a secure component.
- (c) Every length of gutter shall be supported at intervals of not greater than 500 mm.

15.10 Rain Water Pipes

General

Rain water pipes shall be galvanized steel sheets, asbestos cement pipes or unplasticised P.V.C. pipes or cast iron as specified.

15.10.1 Galvanized Steel Rain Water Pipes

Unless otherwise specified rain water pipes shall be formed of galvanized steel sheets 0.8 mm thick (22 gauge) they shall be fixed 40 mm clear from the face of the wall with mild steel straps 20 x 1.5 mm, screwed to wooden blocks of durable timber embedded in the wall at a spacing of not more than 1.8 m. The outer surfaces of the pipe and the mild steel straps shall be painted as specified in Clause 15.7.1.1. Provision shall be made for all bends, offsets, swan necks, shoes, short length etc.

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15.10.2 Asbestos Cement Rainwater Down Pipes

(Deleted)

15.10.3 Cast Iron Rain Water Down Pipes

External cast iron rain water down pipes shall be of approved manufacture, neatly finished, free from sand marks and complying with BS 460. The pipes shall be 1.80 meter in length including socket ends.

Internal cast iron rain water pipes and fittings shall conform to BS 416. The pipes supplied shall be factory painted (with a tar base composition) both inside and outside.

Pipes shall be fixed 10 mm clear from the face of the wall by means of straps and screwed to tapered wooden blocks embedded in the wall to a depth of 100 mm.

Internal rain water pipes shall be jointed with yarn and molten lead or a caulking compound well caulked.

External rain water pipes shall be enjoined where specified they shall be jointed with red and white lead putty or approved mastic.

15.10.4 UPVC (Unplasticised Polyvinyl Chloride) Pipes

15.10.4.1 U.P.V.C. Circular pipes shall conform to BS 4576. For pipes of diameter larger than 65 mm BS 4514 may be referred to.

The dimensions of pipes shall be as follows :-

Nominal Diameter	Minimum wall thickness
63 mm	1.8 mm
82 mm	3.2 mm
110 mm	3.2 mm
160 mm	3.3 mm

Standard lengths of pipes shall be from 1.8 m to 3.6 m. Specials like bends, shoes, offset bend, branch, half rounds, stop ends etc. shall be supplied as required along with the pipes.

15.10.4.2 Handling and Storage

Pipes shall be stored under shade and on level ground. Pipes shall not be rested on their socket. They shall not be stacked in large piles.

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15.10.4.3 Jointing

Only pipes free from damage shall be used. Dust, oil, water grease etc. shall be wiped off the surface with a dry cloth. The grease shall be thoroughly removed with a suitable solvent such as Methylene Chloride. The mating surfaces shall be glass papered to the full depth of the socket and cleaned.

Solvent cement, not more than 12 months old, shall be applied on to the pipe and socket. The joint shall be made immediately, excess solvent wiped out and left undisturbed for one hour.

15.10.4.4 Fixing

The fixing used shall comply with the following minimum requirements:

- (i) The wall thickness of fixings manufactured from P.V.C. shall in no case be less than that of the pipe with which they are to be used.
- (ii) In the case of eared fixings the centre to centre dimension of the fixings holes shall be such as to avoid damage to the pipe when installing the system with the pipe in position.
- (iii) When assembled, the pipe and fixing shall form a sturdy unit.
- (iv) Every length of pipe shall be independently supported. Intermediate supports shall be provided for long lengths of pipe where necessary.
- (v) Any metal fixings shall be suitably protected against corrosion.
- (vi) Screws for use in brick work, concrete or masonry shall be not less than 50 mm and of minimum size No. 10.

CHAPTER 16
PLASTERING

16.1 Plastering

16.2 Lime Plaster - 15 Mm Thick

The plaster shall not exceed 15 mm total thickness. This shall consist of a single coat of lime mortar including where necessary the setting coat of pure white lime putty.

16.2.1 Materials

Lime mortar 1:2 or other specified proportion conforming to the requirement of Clause 3:1.

16.2.2 Surface Preparation

New brickwork or stone masonry shall have been finished with recessed joints to receive plastering see clauses 6.2.7 and 7.2.2.3 respectively. In the case of stone masonry, the bushing on the wall to be plastered, shall be removed to within 12 mm projection.

Where so specified for dense and smooth surfaces a suitable bonding treatment shall be applied to manufacturer's instructions before plastering.

All soft joints in old stone masonry or brick work shall be raked out to depth of not less than 12 mm.

The walls shall be brushed clean of all dust thoroughly wetted and surface dried before plaster is applied.

16.2.3 Application

Plastering of walls shall commence after completion of ceiling plastering if any. The plastering shall be started from the top and worked down towards the floor. All put log holes (i.e. holes left for scaffolding) shall be properly filled in advance of the plastering.

To ensure an even thickness and a true surface, gauges of plaster 15 mm x 15 mm, or broken clay tiles set in mortar shall be first established on the entire surface at about 2 meter intervals both vertically and horizontally.

The thickness of the plaster specified excludes the key i.e. the grooves or open joints in the brickwork.

The minimum thickness of the plaster over any portion of the surface shall not vary from the

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specified thickness by more than 3 mm.

Mortar shall be applied between the gauges to slightly more than the required thickness i.e. slightly proud of the gauges. The plaster shall be well pressed into the joints, leveled and brought to a true surface by working a wooden straight edge reaching across the gages, with small upward and sideway movement. Finally the surface shall be finished true with a wood float or trowel according to the type of finish required.

If a sandy granular texture is needed, the surface shall be wood floated. If a smooth finish is needed, trowelling shall be done to the extent required; during this process the setting coat of pure white lime putty shall be applied on the surface to facilitate finishing.

All molded work, apart from the coves shall be formed and run in lime cement mortar 1:1:15 with all ornaments, miters etc. neatly formed. These shall be finished with lime putty as described above.

All arises shall be plastered in lime cement mortar 1:1:15 and finished with lime putty for width of not less than 25 mm along each face of the arise.

All necessary dubbing behind, rounding of corners at the junctions of the walls plastering of cornices etc. shall be done.

In suspending work at the end of the day. the plaster shall be left cut clean to line both horizontally and vertically. When recommencing the plastering, the edge of the old work shall be scraped, cleaned and wetted with lime putty before plaster is applied to the adjacent areas, to enable the two to be properly jointed together. Plastering work shall be closed at the end of the day on the body of the wall and not nearer than 150 mm to any corners or arises. It shall not be closed on the body of features such as plaster bands and cornices, nor at corners or arises.

Horizontal joints in plaster work shall not be formed on parapet tops and copings, as these invariably lead to leakages.

No portion of the surface shall be left out initially to be patched up later on. Any cracks which appear on the surface, and all portions which sound hollow when tapped, or are found to be soft or otherwise defective shall be cut out in rectangular shape and redone as directed by the Employer's Representative.

16.2.4 Finish

The plaster shall be a true and plumb surface and to the degree of smoothness required. The work

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shall be tested frequently as the work proceeds with a true straight edge not less than 2.5 m long and with plumb bobs. The gap between the straight edge and any point on the plastered surface shall not exceed 3 mm. All horizontal lines and surface shall be tested with a level and all jambs and corners with a plumb bob as the work proceeds.

16.2.5 Curing

Curing shall be started 24 hours after finishing the plaster. The plaster shall be kept wet for a period of seven days. During this period it shall be suitably protected from damages, at the contractor's expense by such means as the Employer's representative may approve.

16.3 Lime - Cement Plaster - 15 mm Thick

The plaster shall not exceed 15 mm in total thickness. It shall consist of a single coat of lime cement mortar including where necessary the setting coat of pure white lime putty.

16.3.1 Material

Lime cement mortar 1:1:5 or other specified proportion conforming to the requirements of Clause 3:3.

16.3.2 Surface Preparation and Application

Preparation of surface of the masonry/brickwork, and the application and curing shall be as specified in clause 16.1.

16.3.3 Surface Finish

Unless otherwise specified all surface of lime- cement plaster for external rendering shall be wood floated; internal plastering shall be trowelled and finished with a setting coat of lime putty.

16.4 15 mm Thick Cement Plaster on Masonry/Brick Work

The plaster shall not exceed 15 mm total thickness comprising a single coat of cement mortar and the setting coat of neat cement slurry.

16.4.1 Materials

The cement mortar 1:3 or other specified proportion conforming to the requirements of clause 3:2.

16.4.2 Surface Preparation and Application

The surface preparation, application and curing shall be similar to the procedures specified in clause 16.1 taking account of the following details:

The setting coat of neat cement slurry shall be applied within an hour of the completion of plastering.

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It shall be trowelled smooth without showing signs of trowel marks or waviness or folds. Where a smooth finish is not specified, the surface shall be finished off with a rough wood float to the texture approved by the Employer's Representative.

16.5 18 mm Thick Coloured Cement Plaster - 2 Coat Work

This shall consist of 2 coats. The base coat shall be cement mortar 12 mm thick with a surface coat of coloured cement mortar 6 mm thick.

16.5.1 Materials

Cement mortar 1:3 or other specified proportion conforming to the requirements of clause 3:2.

An approved water proofing additive shall be used where specified.

16.5.2 Surface Preparation and Application

Surface preparation, application and curing shall be similar to the procedures in clause 16:1 taking account of the following details;

The base coat of cement mortar shall where specified include 3% by weight of an approved water proof additive. The base coat shall be left roughened with a wire brush to provide a key for the surface coat. The surface coat shall consist of a mortar of coloured cement and sand mix as specified applied to a thickness of 6 mm. It shall be applied not earlier than 24 hours of applying the base coat. It shall be finished with a rough texture to accord with the approved sample area or as directed by the Employer's Representative.

16.6 Cement Plaster on Concrete Surface

Cement plaster for concrete surface shall be of cement mortar of maximum thickness 6mm in the case of single coat work and of maximum thickness 10 mm in the case of 2 coat work.

The thickness of the plaster on the soffit of suspended floors shall be the minimum possible.

16.6.1 Materials

Cement mortar 1:3 or other specified proportion conforming to the requirements of Clause 3:2.

16.6.2 Surface Preparation

Projecting burrs of formed surfaces shall be removed and the surface scrubbed clean with wire brushes. The surface shall then be prepared as follows :-

- (i) A first coat of spatter dash shall be applied over smooth clean concrete surface if so

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directed by the Employer's Representative. The dashing shall consist of 1 part of cement and 2 parts of clean fairly coarse sand mixed to a thick slurry and kept well stirred. It shall be applied using a strong whipping motion normal to the face of wall. On setting and hardening, the subsequent coat to be applied.

- (ii) Where directed by the Employer's Representative, the surface shall be hacked with a pointed tool at spacing of not more than 50 mm the hacks being not less than 3 mm deep. The surface shall then be cleaned of all mould oil, grease etc. by scrubbing with water containing detergent and washing off with plenty of clean water. The surface shall be allowed to dry before application of plaster.
- (iii) Acid etching may be allowed with prior approval.

16.6.3 Application

(a) Soffit Plaster

Floor rendering and finishes of a suspended floor shall have been completed before commencing plaster of soffit. In the case of flat roofs, the weather proofing and other work shall have been completed so that the soffit plaster is not disturbed by subsequent operation on the floor or the roof. The concrete surface shall be wetted in advance and allowed to dry before application of plaster.

To ensure an even thickness and a true surface, suitable gauges shall be established at about 1.5 meter intervals in both directions as described in Clause 16.1.3 and the plaster applied and finished smooth as described the rain with a floating coat of lime putty. The finished soffit shall not show trowel marks, waves or folds and shall be true and plain. The mortar shall be used within an hour of adding water to the dry mix.

- (b) In the case of concrete surface other than soffits of suspended floors, the plaster shall be finished to a true and plumb surface and to the proper degree of smoothness required. All horizontal surface shall be tested with a leveling instrument and all jambs and corners with a plumb bob as the work proceeds. All internal surfaces shall be finished smooth with a floating coat of lime putty and external surfaces wood floated rough to the texture. desired, all to the satisfaction of the Employer's Representative.

16.6.4 Curing

Shall be as in 16.1

16.7 20 mm Thick 2 Coat Work

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Two coat work 20 mm thick shall comprise a first coat of 12 mm thickness, and a second coat of 8 mm thickness including the final lime putty.

16.7.1 Materials

The cement mortar, of specified proportions conforming to the relevant clauses of chapter 3.

16.7.2 Surface Preparation

Surface preparation shall be as for 15 mm thick lime plaster clause 16.1.2 .

16.7.3 Application

The first coat (Scratch coat) 12 mm thick. This shall be as per clause 16.1.3 except that the thickness of plaster is 12 mm as measured from the face of the brick work or stonework to the plastered surface. It shall be carried to the full length of the wall or to natural breaking points like doors and windows. The scratch coat shall be cross scratched to provide a mechanical key for the subsequent coat. The surface shall be kept continuously damp for at least 2 days following its application. It shall then be allowed to dry before application of the second coat.

The second coat 8 mm thick.

Before starting to apply the second coat, the surface of the scratch coat shall be dampened evenly by using fog spray to get uniform suction. The second coat shall be 8 mm thick and pressed well into the first coat. It shall be brought to a true even surface, with a trowel and the surface finished smooth with a setting coat of pure white lime putty.

16.7.4 Finishing and Curing

Finishing and curing shall be as per Clause 16.1.4 and 16.1.5 .

All plaster work shall be kept damp continuously for a minimum period of 7 days after the application of the finishing coat.

Should the plaster crack through neglect of curing or because of any other fault, the work shall be removed and redone at the contractor's expense.

16.7 20 mm Thick Rough Cast Plaster

(Note : This is a good water proof covering generally for external work)

It shall consist of 2 coat : The first coat shall be 12 mm thick of either lime cement mortar 1:1:5 or cement mortar 1:3. The second coat which is the finishing coat shall be at least 8 mm thick and made up of a mixture of cement and stone chips in specified proportions dashed over the freshly

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plastered first coat.

Where directed, a sample panel of rough cast work shall be done first and approval of the Employer's Representative obtained.

16.7.1 Materials

Cement mortar 1:3 or Lime cement mortar 1:1:5 conforming to the relevant clauses of Chapter 3.

16.7.2 Preparation of the Surface

This shall conform to the requirements of clause 16.1.2.

16.7.3 Application

The first coat of plaster 12 mm thick shall be applied and left rough to receive the finishing coat. The coat of rough cast shall consist of a mixture of one part of cement and three parts of stone chips 6 to 10 mm size. It shall be mixed well to a paste of proper consistency and flung on the first coat with large sized trowels to form an even rough cast. The second coat shall be applied while the first coat is still soft and unset.

The plastering shall be cured for at least 7 days.

16.8 Lath and Plaster

16.8.1 Materials

Metal Lath

Metal lathing for plasterers work shall be expanded metal lathing of the gauge specified and conforming to BS 1369: or other approved reinforcement, nailed and fixed to studs, brackets etc.

Cement Mortar

Cement mortar 1:3 shall conform to requirements of clause 3:2.

16.8.2 Procedure

The expanded metal shall be fixed with the 'long way' of the mesh across the supports. Sheets shall be lapped not less than 25 mm at the sides and ends. Sides shall be wired together with galvanized wire of not less than 18 S.W.G. every 75 mm between supports.

Before any plastering operations are commenced the metal lathing shall be thickly coated with cement slurry.

The cement mortar shall be applied in not less than three coats and finished smooth with pure

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white lime putty. No lime plaster shall be in direct contact with any metal work.

16.9 20 mm Thick Textured Patterned Plaster

Material

Cement mortar 1:3 or lime cement mortar 1:1:5 confirming to the relevant clause of chapter 3.

Ensure supplies of materials are sufficient to give consistent and uniform texture on each surface.
Obtain materials from one source as far as possible.

Preparation of Surface

This shall confirm to the requirements of Clause 16.12.

Application

The first coat of plaster 12 mm thick shall be applied and left rough to receive the finishing coat. The finishing coat minimum 8 mm) should consist of coarse sand adequate to form the required texture or pattern. It should be mixed well to a paste of proper consistency and flung on the first coat with large sized trowel to form an even and consistent finish. The required texture approved by the Employer's Representative should be obtained with a rough wood float or wet sponge as soon as wet sheen has disappeared from the surface.

The second coat shall be applied while the first coat is still soft and unset.

The plaster shall be cured as per Clause 16.15 in order to avoid quick drying and formation of thermal cracks.

Where directed a sample panel of texture/pattern work shall be done first and approval of the Employer's Representative obtained.

The work should be carried out on each surface as one continuous operation. It is recommended that only one operative be used on each surface if necessary to avoid variation in technique which may result in differences of appearance, particularly under oblique lighting.

16.10 Skin Coat

16.11 Treatment for Thermal Cracks in Plaster

Thermal cracks in plaster shall be filled with an approved quality crack filler/wall putty as directed by the Employer's Representative.

The filler should be applied with a trowel or knife pressing down firmly and allowed to dry as per

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manufacturer's recommendations.

The fill above the level of the surface should be removed with sandpaper when dry.

CHAPTER 17
GLAZING

17.1 Definitions

Glazing

Fixing of glass or a similar material in a framework or opening to admit light.

Clearance

Edge clearance - The clearance between the bottom edge of the glass and the rebate - Back

clearance - The clearance between the inside face of the glass and the rebate.

Sprig

A small headless nail casement or other building glass in wood surrounds while the putty hardens.

Surround

Any frame, sash, casement or other building component into which glass is glazed.

17.2 Materials

General

All glass used for glazing work shall be cut accurately to size with clean, undamaged edges and shall be free from flaws, specks or bubbles and surface disfigurement of any sort.

Tempered glass and laminated glass, where specified shall be manufactured to precise glazing size and with a permanent identification mark in a position which is visible but not prominent after fixing if so directed.

Samples of glass to be used shall be submitted to the Employer's representative and his approval obtained before purchase of the glass.

17.2.1 The following types of glass shall all conform to BS 952 –

Transparent sheet glass	Clean sheet glass
Flashed color sheet glass	Flat & polished plate glass
Pot color sheet glass	Rough cast glass
Transparent glass	Patterned glass
Transparent glass	Opal glass

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Laminated & Tempered glass

Wired glass

17.2.2 Linseed Oil Putty

This shall conform to BS 544

Note : As initial setting is controlled by absorption of some of the oils into the frame it may be used for soft woods. Linseed oil putty shall not be used on non- absorbent hardwoods like teak.

17.2.3 Metal Casement Putty

This shall be of an approved type suitable for bedding and fronting into metal surrounds, sealed timber or sealed concrete surfaces.

17.2.4 Self Adhesive Glazing Tapes/Velvet And Wash Leather shall be of Approved Make.

17.3 Workmanship

Glazing and fixing of glass for buildings shall generally comply with BS CP 152. In respect of all materials and products, the instructions of the manufacturer shall be followed.

External glazing shall be completely wind and water tight.

17.3.1 Preparation

All rebates and grooves shall be clean, dry and unobstructed. All heads and rebates in woodwork made of soft wood shall be given a coat of wood primer before glazing. In the case of hard wood which is non-absorbent, a metal casement putty shall be used.

Rebates shall be sealed with primer and at least one undercoat before applying metal casement putty.

In the case of metals surrounds a specified primer shall be applied to the surround and heads. The metal surrounds shall be free from dirt, dust, grease, burrs, weld spatter and other projections. They shall be smooth and undistorted and shall be painted before glazing is commenced.

Stone/ brick/ concrete surrounds, rebates or grooves shall be sealed with at least two coats of alkali-resistant sealer before application of compound.

17.3.2 Fixing

General

Glass panes shall be cut to fit the rebates of the sashes leaving an edge clearance of 3 mm all - round in which to bed the putty so that the glass does not touch the surround at any point. For panes exceeding 0.2 m² in area, the glass shall be set on small blocks of resilient materials spaced at not more than 75 mm from the corners, at locate the pane properly within the surround.

In timber or metal frames the thickness of back putty shall not be less than 2 mm. Rebates of 10 mm shall generally be available for fixing glass externally. Patterned/ wired glass shall be fixed with patterns or wires parallel to the surround or as directed. Adjacent panels shall be aligned as directed.

17.2.2.1 Glazing with Putty

The bedding putty shall be applied uniformly over the rebates and the glass pressed into position and secured with glaziers sprigs. These fixings shall be spaced at 450 mm around the frame. On pressing in the glass a certain amount of bedding putty is pressed out and the remaining putty which is called the back putty shall be at least 2 mm thick between the glass and rebates. The glass is then 'front puttied' and the putty shall be stopped about 2 mm from the sight line of the rebates so that when paint is applied it is carried over the glass up to the sight line and so seals the edge of the putty to the glass.

The front putty shall be sloped at an angle to prevent accumulation of water. The back putty shall also be stopped at an angle to prevent shrinkage causing a groove in which dirt can accumulate.

The putty shall be left for 14 days to harden before painting.

17.2.2.2 Glazing with Beads

The beads shall be of approved hard wood secured by rust proofed panel pins or preferably by brass counter sunk screws and cups. Pins shall not be more than 75 mm from the corners or more than 200 mm apart. For double glazed units, cups and screws shall be used.

Rebates and beads shall first be sealed with proprietary sealing compound applied by brush. The glass shall then be bedded in glazing compound and set in position using setting blocks and distance pieces to restrain movement. The bead shall then be bedded with the glaziers putty and screwed or pinned in position. For internal bead glazing, the bedding for the bead can be omitted.

Plate glasses shall be bedded on a strip of asbestos tape or felt to act as a cushion between the glass edge and the bead.

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Dry bead glazing where specified in internal situations shall be of self-adhesive glazing tapes or self-adhesive black velvet or wash leather, passed round the edge of the glass and trimmed off flush on both sides in accordance with the instructions of the manufacturers. The beads shall be sealed as specified and fixed to the surround by springs or screws.

17.2.3 Protection and Cleaning of Finished Work

White - wash indicators shall be restricted to small central areas of panes.

All smears and excess putty and sealant shall be cleaned off.

Putty shall be sealed and protected as soon as sufficiently hard by paint or varnish as specified or as directed. Broken panes shall be replaced and redecorated as directed by the Employer's Representative.

CHAPTER 18
PAINTING AND DECORATION

18.0 Painting and Decoration

Definition

Aluminum Primer

A Primer containing a proportion of aluminum pigment. It should be distinguished from an aluminum paint in which the aluminum is designed to float to the top of film giving metallic brilliance, a feature undesirable in a primer. Aluminum primers are especially valuable on resinous timber or timber which has been treated with oil soluble wood preservatives. This term must not be confused with a primer for aluminum.

Anti - Corrosive Paint or Composition

A Paint used for preventing the corrosion of metals and more particularly, a paint especially formulated to prevent the rusting of iron or steel.

Bituminous Paint

Originally a paint from the class of paints consisting essentially of natural bitumen dissolved in organic solvents; they may or may not contain softening agents, pigment and inorganic fillers. It is usually black or dark in color. By extension the term is applied also to dried films. Within recent years the term 'Bituminous' has, by common usage, come to include bitumen - like products such as petroleum asphalt is not recommend that the term should be used for paints based on coal tar or coal tar pitch. These are more generally known as black varnish (q.v) or 'Black Paint (Coal Tar Base)'.
'

Cement Paint

A Paint based essentially on Portland cement, supplied as a dry powder, for mixing with water immediately before use.

Copal

Natural resins formed from the exudation of various tropical trees. The hard fossil types were the basis of copal varnishes, the softer types frequently obtained by the tapping of live trees being mostly used for spirit varnishes. Congo copal is the main surviving member of the fossil class, Manila copal that of the spirit soluble class.

Distemper

Although there is a tendency to apply this term to all interior water paints used for house decoration, it should preferably be used solely to describe the earlier types of such products,

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namely those in which the binding medium consists essentially of either glue or case in or similar sizing material. (See also Water Paint').

Dryers

Substances which, when incorporated in relatively small proportions in drying oils, or in paints or varnishes based on drying oils, bring about an appreciable reduction of their drying times at ordinary temperatures. These substances are usually compound of lead, manganese or cobalt.

Drying

The process of change of a coat of paint or varnish from the liquid to the solid state, due to evaporation of solvent, physiochemical reactions of the binding medium or a combination of these causes.

Touch Dry

When a very slight pressure with the finger does not leave a mark or reveal stickiness.

Hand Dry

When the drying has reached such a stage that if deprived a further coat can be satisfactorily applied by brushing, necessary after flattening. The term is also used to describe certain degrees of film hardness when tested by specified methods.

Drying Oils

Oil, usually of vegetable origin of which linseed (q.v) and tung oil (q.v) are the commonest example, having the property of hardening by oxidation to a tough film when exposed in the form of a thin layer to air.

Efflorescence

The development of a crystalline deposit on the surface of brick, cement, etc., due to water containing soluble salts, coming to the surface and evaporating so that the salts are deposited. In some cases, the deposit may be formed on the top of any paint film present, but usually the paint film is pushed up and broken by the efflorescence under the coat.

Emulsion Paint

Generally, a paint in which the medium is an emulsion or emulsion like dispersion of an organic binder in water. Industrially, the name is mainly restricted to those paint in which the medium is an emulsion of a synthetic resin. The medium may also be called a latex by analogy with natural rubber latex; polyvinyl acetate emulsion paint is typical example.

Enamel

One of a class of finishes obtained by melting siliceous materials. The term is also used in the paint industry to describe pigmented varnishes which simulate in appearance the flow, smoothness and gloss of vitreous enamels; The same broad definition applies to 'enamel paint' and 'hard gloss paint' although all three may differ in degree in respect of one or more properties, such as flow, smoothness, gloss, capacity and in the retention of these properties on ageing.

Epoxy Paint

A paint based on an epoxy resin.; the designation is frequently qualified to indicate the nature of the cross-linking agent used, 'epoxy/amine', 'epoxy/polyamide' or 'epoxy/isocyanate' where the cross-linking agents are polyamines, polyamides and isocyanates respectively.

Filler

1. A composition used for filling fine cracks and indentations to obtain a smooth, even surface preparatory to painting. It may vary in consistency from paint to a paste, and may be applied in successive coats by brush or in one application by means of a broad knife.
2. Synonymous with 'extender'.

Flame Cleaning

The application of an intensely hot flame to structural steel resulting in the removal of mill scale and the dehydration of any remaining rust, leaving the surface in a condition suitable for wire brushing followed by the immediate application of paint.

Flat (Matt)

The description of a painted surface which scatters or absorbs the light falling on it, so as to be substantial free from gloss or sheen (see also 'gloss')

Flattening Down

Cutting or rubbing down the surface of a paint varnish with fine abrasives to produce a smooth dull surface.

French Polish

A lacquer made essentially from shellac and methylated spirit. Other spirit - soluble gums, such as sandarach and benzoin, are sometimes added to impart some special property. It is supplied with a cambric covered 'rubber' cotton wool, lubricated with oil. The oil is afterwards removed by 'spiriting off'.

Gloss

The degree to which a painted surface possesses the property of reflecting light in a mirror-like

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manner (specular reflection) The extent to which this property developed depends mainly on the composition of the paint, and the surface ranging from dead flat to full gloss being obtainable. The following stages in increasing order of gloss are normally recognized.

Flat (or matt)

Practically free from sheen even when viewed from oblique angles.

Eggshell flat

Eggshell gloss

Semi-gloss

Full-gloss - Smooth and almost mirror-like surface when viewed from all angles.

Gold - Size

1. An oleo-resinous varnish which dries rapidly to a tack condition, but which hardens off slowly. It is used chiefly as an adhesive for fixing gold size to a surface.
2. An oleo-resinous varnish containing a high proportion of driers, which rapidly dries hard after application. It is frequently used for the preparation of stopping and filling compositions.

Hard Stopping

A material in stiff paste form, which is usually applied by means of a knife to fill deep indentations in a surface and which dries hard throughout. It should not be confused with glazing putty which is of a different consistency and which hardens more slowly.

Inhibitive Pigment

A pigment which retards or prevents the corrosion of metals by chemical and/or electrochemical means, as opposed to a purely barrier action. Red Lead and Zinc Chromate are examples of inhibitive pigments as opposed to red iron oxide which has little or no inhibitive action.

Knotting

A quick-drying composition used in the preparation of joinery for painting to form a local impervious covering for knots and other resinous areas liable to stain or soften a superimposed coat of paint.

The most usual composition consists of a solution of shellac in industrial methylated spirit.

Lacquer

1. A coating composition which dries solely by evaporation of the solvents. e.g. cellulose and spirit lacquers.

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2. A gold stoving finish for tinplate which is not formulated on a spirit or cellulose basis and does not dry solely by solvent evaporation.

Laying Off

The final light strokes of the brush during a painting operation.

Lead Paint

A paint, the dry pigment content of which contains more than 5 percent of soluble lead compounds (expressed as Pbo) of the dried pigment.

Mastic

An adhesive composition. The term is loosely used to describe a plastic filler, stopper, putty or adhesive. Not to be confused with 'gum mastic' which is a natural resin used for picture varnish.

Resin, Natural

A glassy amorphous organic substance produced either in the metabolism of tree growth, e.g. copal or by insects, e.g. shellac. The former may be obtained from growing trees or dug up from the ground (fossil resin) where it has lain since the trees from which it was formed decayed in prehistoric times. These resins, as distinct from gums, are not soluble in water but may be dissolved in organic solvents or vegetable oils, if necessary after heat treatment to form varnishes.

Resin, Synthetic

Originally, a member of a group of synthetic substance which resemble and share some of the properties of natural resins, but now used for materials which bear little resemblance to natural resins. The term is generally understood to mean a member of the heterogeneous group of compounds produced from simpler compounds by condensation and/or polymerization. Chemically modified natural polymers, such as cellulose acetate and hardened casein, are not considered to be synthetic resins.

Resinous Timber

Wood from certain trees which contain resinous material in the cells. The resins have high solvent power for many paint media, even when these have partially dried. This resin frequently extrudes through paint films applied on such wood, especially in sunny locations.

Sealer

A clear or pigmented liquid used on absorbent surfaces prior to painting, which when dried reduces the absorptive capacity of the surface, often known as 'suction'. Also used where necessary to prevent any soluble or diffusible matter from 'bleeding' into and disfiguring new paint,

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or to protect the existing in a top coat. (see also 'sanding sealer').

Short Oil

A low ratio of oil to resin in a medium.(see also 'long oil')

Pink Primer

Traditionally, a wood primer based essentially on white and red lead pigments. Now sometimes loosely applied to wood primers, pink in color but based on pigments other than lead. The use of the term is therefore to be deprecated and where priming paint based on a mixture of white and red lead are required they should be referred to as such.

Primer

The first complete coat of paint of a painting system applied to an unpainted surface to provide adhesion, corrosion, inhibition and a firm base for subsequent coats. The type of primer varies with the surface, its condition and the painting system to be used. (see also 'plaster primer')

Plastic Emulsion Paint

These are paints which are bound with emulsion of vinyl, acrylic and polyurethane polymers. They harden within 2 - 3 hours and provide matt, sheen, luster or gloss surfaces. Emulsion paints are tougher, more elastic and through permeable are more resistant to weather than oil bound distempers.

Putty

A stiff plastic material of high mineral filler content which is applied by a knife and which normally hardens on exposure.

Glazing Putty

A type of putty used for fixing glass panes in frames, based on whiting and linseed oil.

Hard putty

See 'hard putting'

- a. Short oil alkyd. An alkyd resin containing not more than 40 percent of oil as a modifying agent.
- b. Short oil varnish. An oleo-resinous varnish other than an alkyd, containing not more than 1 1/2 parts by weight of oil to 1 part by weight of resin, in the finished varnish.

Solvent

A liquid usually volatile, which is used in the manufacture of paint to dissolve or disperse the film-forming constituents and which evaporates during drying and therefore does not become a part of

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the dried film. Solvents are used to control the consistency and character of the finish and to regulate application properties.

Spirit

In the paint industry, this term is used somewhat loosely but generally refers to commercial ethyl alcohol normally sold as industrial methylated spirit. The term mineral spirits is used particularly in America, for what is known on the U.K. as 'white spirit'. This consists mainly of a mixture of aliphatic hydrocarbons with a proportion of aromatic hydrocarbons.

Spirit Varnish

A lacquer based on a solution of resin or resins industrial methylated spirit.

The more correct term would be spirit lacquer. (see 'lacquer')

Stain

Solution or suspension of coloring matter in a vehicle designed to color a surface by penetration without hiding it. True stains are classified as water stains, oil stains spirit stains, according to the nature colored with transparent material. These have not the same powder penetration as the true stains and leave a colored coating on the surface.

Stainers

Colored pigments ground in a paint vehicle, which can be added in relatively small proportions to already prepared paints to modify their color. (see also 'tinters')

Stopper

A stiff paste used for filling holes and cracks and similar defects in surfaces, normally applied after priming. (see 'hard stopping')

Slight stickiness of the surface of a film of paint, varnish or lacquer apparent when the film is pressed with the finger.

Thinners

Volatile liquids added to paints and varnishes to facilitate application and to aid penetration by lowering the viscosity. They should be completely mixable with the paint or varnish at ordinary temperatures and should not cause precipitation of the non-volatile portion either in the container or in the film during drying. For some purposes, thinners containing a small proportion of non-volatile material may be used.

Tinting

The final adjustment of the color of a paint to the exact color required.

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Turpentine

A colorless volatile liquid distilled from the products of certain pine trees and consists of a complex mixture terpene hydrocarbons.

Turpentine was formerly extensively used in paints and varnishes but has now been largely replaced by 'white spirit'.

Undercoat

The coat or coats applied to a surface after priming, filling etc. or after the preparation of a previously painted surface, and before the application of a finishing coat. An undercoat should possess good hiding power, build up a film which can be rubbed down to a very smooth surface and a color leading up to that of the finishing coat, and should otherwise be suitable for use with the other paints in the system.

Varnish

A transparent coating composition based essentially on drying oils, resins and solvents. (see also 'spirit varnish' and 'lacquer') it provides a clear finish to timber enhancing its natural beauty.

Vinyl Resin

A synthetic resin of the thermoplastic type obtain by the polymerization of monomers containing the vinyl group. In strict chemical terminology the description covers not only the polymerized vinyl esters, e.g. polyvin acetate but also polystyrene and the polyacrylates. Vinyl resins may be applied as solution in organic solvent as plastisols, as organosols or in aqueous dispersion or latex form. (see 'emulsion paint')

White Sprit

The most commonly used thinner for paints and varnishes.

Zinc - Rich Primer

An anti-corrosive primer for iron and steel incorporating zinc dust in a concentration sufficient to give electrical conductivity in the dried film, thus enabling the zinc metal to corrode preferentially to the substrate, i.e. to give cathodic protection.

18.1 White Washing &Color Washing of new Walls

General

Unless otherwise specified, new wall surfaces shall receive three coats of white/color wash.

18.1.1 Preparation of the Surface

New surfaces shall be thoroughly cleaned of mortar or other splashes. Any damage to the plaster

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shall be made good to match the adjacent surfaces and the surface brushed clean of dust and dirt.

18.1.2 Preparation

Lime used for white or color washing shall be fresh burnt shell like. The lime shall be screened through a sieve of 850 microns and dissolved in a tub of sufficient water to give a thin creamy consistency.

When thoroughly mixed, it shall be strained through a clean course cloth. Gum Arabic or glue in the proportion of 4 g per liter of the cream shall be added.

ColorWash

Where color wash is specified coloring matter of the color specified shall be added. In the case of yellow wash, finely powdered yellow clay commonalty known as "samara" may be used.

The contractor shall paint sample areas for approval of the tint by the Employer's Representative.

Note: Only sufficient wash for the day's work shall be prepared each morning. The wash shall be stirred continuously during use.

18.1.3 Application

Each coat shall be laid on with a brush and allowed to dry before the next coat is applied. One coat comprises a stroke of the brush given from the top downwards, another from the bottom upwards over the first stroke and similarly one stroke from the right and another from the left over the first brush before it dries. The number of coats to be applied shall be as specified. At the end of the work, the whole surface shall present a uniform appearance and color shall be of even tint without exhibiting any patches, streaks or hair cracks.

The contractor shall take every precaution to prevent the white/color wash being splashed on the wall, floor, doors, windows, furniture and other surfaces and articles not to be white/color washed. The contractor shall clean up at his own cost, all such items to the satisfaction of the Employer's Representative. Ladders, poles, scaffoldings etc. shall be shod with gunny bags to prevent damage or scratching of the walls and floor.

18.2 White Washing and Color Washing of Old Walls

General

Unless otherwise specified, old walls shall receive one coat if there is no change of color. The white or color wash shall be prepared as specified in Clause 18.1.2.

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18.2.1 Preparation of Surface

All loose scales and flakes of the old white wash/color wash shall be removed thoroughly. Minor repairs to plaster such as filling nail holes, and removing damaged plaster and making good shall be carried out to the satisfaction of the Employer's Representative. Where so specified the entire surface of old whitewash/ color wash shall be thoroughly removed by scraping and the surface cleaned.

18.2.2 Application

For old work, after the surface has been prepared as in Clause 18.2.1 a coat of white or color wash shall be applied over the patches and repaired areas. One or more coats as specified shall be then applied over the entire surface.

18.3 Distemping new surfaces with Oil Bound Distempers

18.3.1 Materials

Oil bound distemper shall be of approved quality. Primer for new surfaces shall be an alkali resistant such as cement primer or distemper primer as specified and shall be of the same manufacture as the distemper.

18.3.2 Surface Preparation

The plastered surface shall be well cleaned down of efflorescence, dust etc. by scrubbing and washing. It shall then be allowed to dry for at least 48 hours and sand papered to give a smooth and even surface. Unevenness, pitting and small holes shall be filled with gypsum and allowed to set.

18.3.3 Application

18.3.3.1 Priming Coat

The priming coat shall be with distemper primer or cement primer as specified.

Note:

- 1. The cement primer is composed of a medium a pigment which are resistant to the alkalis present in the cement, lime or lime cement the wall finish; it provides a barrier for protection of subsequent coats of oil emulsion distemper paints.*
- 2. If the plaster has not dried completely, cement primer shall be applied before distemping the walls. but if the distemping is done after the wall surface is dried completely, distemper primer shall be applied.*
- 3. Oil bound distemper is not recommended to be applied within six months of the completion of wall plaster.*

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4. *For old work no primer coat is necessary.*

18.3.3.2 Distemper Coats

Note: 50 mm double bristled distemper brushes shall be used. Old brushes which are dirty and caked with distemper shall not be used on the work. After each day's work, brushes shall be thoroughly washed in hot water with soap solution and hung up to dry.

After the primer coat has dried for at least 48 hours, the surface shall be lightly sand papered to make it smooth for receiving the distemper taking care not to rub out the priming coat. All loose particles shall be dusted off after rubbing. One coat of distemper properly diluted with thinner (water or other liquid as stipulated by the manufacturer) shall be applied with brushes; a horizontal stroke followed immediately by a vertical one together constitute one coat.

The subsequent coats shall be applied in the same way. Two or more coats of distemper as are found necessary shall be applied over the primer coat to obtain an even shade.

A time interval of at least 24 hours shall be allowed between consecutive coats to permit the proper drying of the preceding coat.

18.4 Distemping old Surfaces with Oil Bound Distempers

18.4.1 Materials

This shall be as per Clause 18.3.1

18.4.2 Surface Preparation

All loose pieces and scales shall be thoroughly removed by sand papering. The surface shall be cleaned of all grease; dirt etc. pitting in plaster shall be made good with plaster of paris mixed with the color to be used. The surface shall be rubbed down again with a fine grained sand paper and made smooth. A coat of distemper shall be applied over the patches. The patched surface shall be allowed to dry thoroughly before the regular coat of distemper is applied.

18.4.3 Application

No primer coat is necessary. For old work the distemper shall be applied over the prepared surface in the same manner as for new work. One or more coats of distemper as are found necessary shall be applied to obtain an even uniform shade.

At the end of the work the surface shall be uniform in color without patches, overlap and brush marks.

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18.5 Cement Painting New Surfaces

18.5.1 Materials

Cement paint shall be of approved quality.

18.5.2 Preparation of Surfaces

The surface shall be thoroughly cleaned of all mortar dropping dirt, dust, grease and other foreign matter by brushing and washing.

All holes shall be filled with cement mortar or gypsum and allowed to harden.

18.5.3 Mixing and Application

The cement paint shall be thoroughly mixed with water to the proper consistency as specified by the Manufacturer, and applied uniformly with board hair brushes. The paint shall be used within an hour of being mixed.

After the first coat has set, it shall be cured with water spray at least for the next 24 hours. The surface shall then be watered again before the application of the next coat. A primer shall be used instead of the first coats shall be as specified. Unless otherwise specified, new wall surfaces shall be given one cement primer coat and two finishing coats of cement paint.

The lids of paint drums shall be kept tightly closed when not in use, to prevent air setting.

18.6 Cement Painting Old Surfaces

18.6.1 Materials

The cement paint shall be of approved quality.

18.6.2 Preparation of Surfaces

All loose particles shall be removed and dirt and foreign matter brushed off from the surface. Pitted surfaces shall be made good and patches wetted and primed with a coat of cement paint. The surface shall be sprayed water several times with a few minutes interval between each spraying to allow the moisture to soak into the surface.

18.6.3 Mixing and Application

This shall be as per Clause 18.5.3

18.7 Painting New Surfaces with Plastic Emulsion Paint

General

Manufacturer's instructions shall be followed, in the choice of paints for external work.

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18.7.1 Materials

Emulsion paints shall be of approved manufacture. The instructions of the manufacturer shall be followed in all respects, and in the choice of paints for external work.

18.7.2 Surface Preparation

Surface preparation shall be as per Clause 18.3.2. New surfaces shall not be painted until they are perfectly dry.

18.7.3 Application

A coat of alkali resistant primer shall be applied to the prepared wall surface. If the paint itself is of alkali resistant composition, one coat of the paint itself could be used as primer. Unless otherwise specified, emulsion painting of new walls shall consist of a coat of alkali resistant primer and two coats of emulsion paint to match approved samples.

Splashes of paint on shall be cleaned out without delay as they will be difficult to remove after hardening.

18.8 Painting of Old Surfaces with Plastic Emulsion Paint

18.8.1 Materials

These shall be as per Clause 18.7.1

18.8.2 Surface Preparation

This shall be as per Clause 18.4.2

18.8.3 Application

This shall be as per Clause 18.7.3

18.9 Painting

General

(a) Materials

Paints, oils, varnishes etc., of approved manufacture shall be used. Ready mixed paint as received from the manufacturer shall be used without any admixture. If for any reason, thinning of ready mixed paint is necessary the brand of thinner recommended by the manufacturer or instructed by the Employer's representative shall be used.

Approved paints, oils or varnishes shall be brought to the site in their original containers in the sealed condition.

Where directed, sample areas shall be provided of each type of coating including

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preparation of surfaces, and got approved by the Employer's representative before proceeding with the painting

(b) Preparation

Painting shall not be started until the preparations have been inspected by the Employer's Representative and approval given by him to commence the painting work. Painting shall not be carried out in adverse weather conditions as condensation may occur on surfaces being painted.

Painting, except the priming coat, shall generally be commenced after practically finishing all other building work. The rooms shall be thoroughly swept out and the entire building cleaned at least one day in advance of starting the paint work.

(c) Preparation of surface

Preparation of wood, steel and other surfaces, both new and painted shall conform to the relevant Sub Clauses of this specification - See Clause 18.9.1 to 18.9.6.

Priming coats shall be applied by brush unless otherwise approved.

(d) Application

Application of finishing coats shall be by brush spray or roller as specified and approved by the Employer's Representative. Paints used shall be brought to the requisite consistency by adding a suitable thinner recommended by the paint manufacturer. Each coat shall be allowed to dry thoroughly; this should be facilitated by through ventilation. Each coat except the last coat, shall be lightly rubbed down with sand paper or fine pumice stone and dust cleaned off before the next coat is laid. The paint shall be stirred thoroughly in its containers before pouring into smaller containers. Whilst applying also, the paint shall be continuously stirred in the smaller containers so that its consistency is kept uniform. No left over paint shall be put back into the stock tins. When not in use, the containers shall be kept properly closed.

(e) Brushing

The paint shall be laid on evenly and smoothly by means of crossing and laying off.

The crossing and laying off consists of covering the area over with paint, brushing the surface hard for the first time over and then brushing alternately in the opposite direction 2-3 times and then finally laying off in the direction of the grain in the case of wood work. In this process no brush marks shall be left after the laying-off is finished. The full process of crossing and laying off will constitute one coat.

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(f) **Spraying**

Where so stipulated, the painting shall be done by spraying. The spray machine used shall be a high pressure (small air aperture) type, or a low pressure (large air gap) type, depending on the nature and location of work to be carried out. Skilled and experienced workmen shall be employed for this class of work. Spray painting shall be done only when dry conditions prevail.

No hair marks from the brush or clogging of paint puddles in the corners of panels, angles of moldings etc. shall be left on the work.

In painting doors and windows, the putty round the glass panes must also be painted; but care must be taken to see that no paint stains etc., are left on the glass. Tops of shutters and surfaces in hidden locations shall not be left out in painting.

In painting steel work, special care shall be taken while painting over bolts, nuts, rivets, overlaps etc.

The additional specifications for primer and other coats of paints shall be as per the detailed specifications under the respective headings.

18.9.1 Painting New Woodwork

18.9.1.1 Preparation of surface

At the time of painting, the moisture content of timber shall not exceed that appropriate to its use.

Large, loose knots and other gross defects shall be cut out and the holes plugged with sound wood.

All heads of screws and nails shall have been set at least 3 mm below the surface and filled with hard stopping.

The surface shall be sand papered to a smooth and even finish and all projections, tool marks and other irregularities smoothed off. Resinous knots shall be treated with an approved quality shellac knotting conforming to BS 1366. Where resinous or oil exuding woods are to be painted, the entire area shall be treated with shellac knotting and allowed to set hard.

18.9.1.2 Priming coat for wood

The priming coat for new wood surfaces shall be as follows:-

Non resinous woods - Pink primer consisting of white lead in linseed oil with not more than 10% red lead, or Aluminum wood primer, or, Acrylic emulsion primers.

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Resinous or oily woods - Aluminum wood primer

Hardwoods like teak containing excess of natural oil - degreased by washing down with white spirit. The priming coats shall be applied by brush, worked into the surface, joints and angles, and particular care shall be taken to fill the end grain. The priming coat shall be of adequate thickness and suit the surface porosity.

Any primed surfaces which have deteriorated on site or in transit shall be touched up or reprimed as directed by the Employer's Representative. Immediately after joinery work is approved and before fixing, joinery surfaces like bottom edges of door shutters shall be primed and painted before fixing. Backs of members which will be in contact with external walls shall receive at least two coats, preferably of Aluminum wood primer.

Note: Aluminum wood primers have an alkyd or oleoresinous medium which adheres well even on dense and nonabsorbent wood. They seal against bleeding of resins in soft woods dispensing with the need for shellac knotting.

- 18.9.1.3** After priming is over, nails and screw holes and similar depressions shall be stopped with a proprietary hard stopping or putty(BS 544) pressed in well and finished off flush with the surface.
- 18.9.1.4** To obtain a fine smooth surface free from even minor irregularities filler shall be applied with a broad knife after priming or sealing and stopping. The filler shall be gypsum plaster or a water soluble cellulose based filler for interior work, and water proof proprietary paste filler for outdoor work.
- 18.9.1.5 Undercoats**
All exposed surfaces shall be painted with an even film of the undercoat specified avoiding uneven thickness at edges and angles. The undercoat shall be rubbed down to a smooth surface with abrasive paper and the dust removed before applying the finishing coat.
- 18.9.1.6 Finishing Coats**
The finishing coat shall be applied evenly over all exposed surfaces, avoiding brush marks, sags, runs and other defects. Where two hard gloss finishing coats are specified, the second coat shall be applied within 48 hours of the first coat.

The specified coats of paints shall be applied to rebates and beads before glazing and the putty shall be primed and painted in the same manner after glazing.

18.9.2 Repainting Old Woodwork

18.9.2.1 Preparation of Surface

If the old paint is sound and firm and its removal is considered unnecessary, the surface shall be rubbed down with pumice stone after it has been cleaned of all grease by washing with lime solution; it shall then be rinsed with water and dried. All dust and loose paint shall be completely removed and edges of surrounding paint work feathered off. The surface shall then be washed with soap and water, wiped and allowed to dry.

Prescribed treated decayed timber shall be cut out and replaced by compatible wood, except small areas where an approved hard stopper may be used. If decay of old wood work is considered likely, a paintable preservative shall be applied liberally and allowed at least 48 hours to dry before priming.

All cracks, splice and defects shall be spot primed, made good with an approved hard stopping, rubbed down to a smooth level surface and brought forward with an undercoat.

If the old painted surface is blistered or flaked badly, the old paint shall be completely removed as described in Clause 18.16.

18.9.2.2 Application

Painting including priming shall be as per new work. See Clauses 18.9 and 18.9.1

18.9.3 Painting New Iron/Steel Surfaces

Painting of iron/steel surfaces shall afford protection from corrosion.

18.9.3.1 Preparation of Surfaces

The surfaces of iron/steel shall be cleaned before application of the paint by chipping, scraping and wire brushing of the surfaces to remove rust, loose scale, welding slag and spatter. All dust and dirt shall be thoroughly wiped off the surface.

Where specified other methods of cleaning with oxy-Acetylene or butane gas, blast cleaning and chemical cleaning followed by brushing shall be carried out to the instructions of the Employer's Representative.

In the case of surface which have already been primed, defects in the primer, rust and loose scales shall be removed to expose the bare metal and the patches primed to match the existing primed surface. If the primed surface is satisfactory, dirt and grease shall be removed and the surface given a light rubbing.

18.9.3.2 Application

(a) Application of Primer

Surface preparation steel work refer clause. The prepared steel work shall be approved by the Employer's Representative, before commencing painting.

To the bright, clean, rust free surface a coat of rust inhibitive primer like approved zinc phosphate/pil based or red lead to B.S. 2523 or red oxide/zinc chromate shall be applied immediately after the preparation is completed. A second priming coat shall be applied to the arrises as paint tends to run away from the arrises. In corrosive conditions and external situation a second priming coat shall be given.

Primer shall be applied manually using brushes unless otherwise specified. In the case of flame cleaned surfaces, primers shall be applied while the metal is warm if the formulations permit such a procedure.

(b) Finishing Coats

Unless otherwise specified, two coats of ready mixed paint (the base of which shall consist of not less than 80% carbonate of lead and 40% oxide of zinc pigmented to approved tints) shall be used. The material shall be touch dry in not less than 4 hours and hard dry in not more than 12 hours. The finish coat shall be glossy; the first coat shall be of a lighter shade than the final coat.

18.9.4 Repainting Old Iron / Steel Work

18.9.4.1 Preparation of Surface

If the old paint is sound and firm and its removal is considered unnecessary, it shall be rubbed with wire brushes to remove any loose paint. All dust shall then be thoroughly wiped away. This surface shall be wiped finally with mineral turpentine to remove grease and then allowed to dry.

Corroded areas shall be cleaned to bare metal by wire brushing and/ or abrasion and wiped clean with white spirit, followed as quickly as feasible by spot - priming. The primer shall be an approved zinc phosphate/oil based or red lead to BS 2523 or red oxide / zinc chromate. The first protective coat shall be applied as soon as the primer is hard dry.

If the old painted surface is in a bad condition and blistered and flaked, the old paint shall be completely removed and the surface prepared as per Clause 18.16.

18.9.4.2 Application

Painting including priming shall be as for new work. See Clause 18.9 and 18.9.3.

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18.9.5 Painting of New Plastered Surfaces

Plastered surfaces shall not be painted until completely dry. Trial patches of primer shall be laid on and checked for drying before commencing painting.

18.5.1 Preparation of Surface

Plaster and mortar splashes shall be carefully scraped off. If it is necessary to rub down irregularities, care shall be taken to avoid causing variations in porosity leading to variation in the sheen of the paint.

Dust and efflorescence shall be cleaned off; efflorescence shall not be washed off. Defective areas shall be made good and stopped using the same plaster as used for the surface as a whole. Holes and undulations shall be filled up with plaster of paris and rubbed down.

18.9.5.2 Application

(a) Primer

For all plastered surfaces one or two coats of an alkali resisting primer like cement primer shall be used before applying paints containing oil.

(b) Finishing coats

Finishing coats as specified shall be applied to match with sample areas.

All other clauses of 18.9 - General shall be applicable in so far as they relate to this work.

18.9.6 Repainting of Old Plastered Surfaces

18.9.6.1 Preparation of Surfaces

If surfaces are damp, the cause of dampness shall be removed. Moulds or mildew causing discoloration shall be stripped and a mould inhibitor shall be applied. Unsound plaster shall be removed and made good.

Cracks and holes shall be filled with new plaster of the same type and finish as the old plaster and spot primed with suitable paint or alkali resisting primer as directed and shall be brought forward with suitable paint.

Old paint shall be washed off if water soluble and the surface allowed to dry. Other paints shall be rubbed scraped dry and the surface treated with a primer.

18.9.6.2 Application

Shall be as per 18.9 and 18.9.5.

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18.10 Varnishing of New Surfaces

18.10.1 Materials

The varnish shall be of an approved make with sufficient drying oils incorporated in the manufacture shall be touch dry in eight hours and hard dry in twelve hours.

18.10.2 Preparation of Surface

Surface preparation shall conform to clause 18.9.1.1, the surface shall be perfectly dry, smooth and free from dust. If knots are present in the wood, these shall be treated with shellac knotting as specified under painting. Where so directed, knots shall be cut to a slight depth and filled in with wood putty. Cracks and holes shall be cleaned of dust and shall be filled in with wood putty made as follows:

On a piece of wood say 200 * 150 mm face and on the side where cross grains appear, a small quantity of glue size shall be poured and the surface scraped with the edge of a fine carpenter's chisel. The very fine wood powder scraped off shall be mixed with the glue and the stiff paste thus formed shall be used for the filling.

The filling when dry shall be rubbed down with a carpenter's file : the entire surface shall then be rubbed down perfectly smooth with medium grained and fine sand papers and wiped with a dry clean cloth so that it presents a uniform appearance.

Sand papering across the grains shall be avoided.

(a) Undercoat of flattening varnish when varnishing without staining.

Where so specified, the surface shall be treated with an undercoat of flattening varnish thinned down with white spirit before applying the finishing coats of varnish. This undercoat shall be dry, hard and brittle, so that when cut and rubbed down it shall produce a smooth surface which shall enhance the gloss of the finishing varnish.

(b) Staining

Where staining is specified the stain shall be composed of suitable dyes in oil free from varnish. Two coats shall be brushed on with bristle brushes to approved depth of color, the second coat applied after an interval of not less than six hours, and these shall dry free from gloss.

18.10.3 Application

The number of coats to be applied shall be as specified. The top coat shall be given with an approved brand of finishing varnish.

The varnish shall be applied liberally with a full brush and spread evenly with short light strokes to

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avoid frothing. If the work is vertical the varnish shall be crossed and recrossed and then laid off, the latter being finished on the upstroke so that the varnish as it sets, flows down and obscures the brush marks. The above process will constitute one Coat. If the surface is horizontal, the varnish shall be worked in every direction with light quick strokes, and finished in one definite direction so that it will set without showing brush marks. In handling and applying varnish, care shall be taken to avoid forming froth or air bubbles. Rubbing down and flattening the surface with fine sand paper shall be done after each coat except the final coat.

While drying, the work shall not be exposed to draughts and damp air.

The finished, the work shall not be exposed to draughts and damp air.

The finished surface shall then present a uniform appearance with a fine glossy surface free from streaks blister etc.

Note : Any varnish left over in the small container shall not be poured back into the stock tin, it will render the latter unfit for use.

18.11 Varnishing Old Surfaces

18.11.1 Preparation of Surfaces

If the old varnished surface is firm and sound it shall be cleaned of grease and dirt with turpentine and then rubbed with water sand paper until the surface is clean and smooth. It shall dried and wiped clean with a soft cloth. Knots holes and cracks shall be stopped as specified in 18.10.2. The entire surface shall then be rubbed smooth with sand paper and wiped clean.

If the old varnished surface is peeled or cracked then it will be necessary to remove the entire varnish. See clause 18.16. Varnishing shall be then applied as for new work.

18.12 French Polishing of new surfaces

18.12.1 Materials

Pure shellac varying from pale orange to lemon yellow color, shall be dissolved in methylated spirit at the rate of 140 gm of shellac to 1 liter of spirit. Suitable pigment shall be added to get the required shade.

18.12.2 Preparation of Surface

The surface shall be cleaned. All unevenness shall be rubbed smooth with sand paper and the surface well dusted. Knots if visible shall be covered with preparation of red lead and glue size laid on while hot. Holes and indentations on the surface shall be stopped with glazier's putty. The

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surface shall then be given a coat of wood filler made by mixing whiting (ground chalk) in methylated spirit at the rate of 1.5 Kg of whiting per liter of spirit and colored to match color of the wood. The surface shall again be rubbed perfectly smooth with glass paper and wiped clean.

18.12.3 Application

Unless otherwise specified, three coats of polish shall be applied.

A pad of woolen cloth covered by a fine cloth shall be used to apply the polish. The pad shall be moistened with the polish and rubbed hard on the wood in a series of overlapping circles, applying the mixture sparingly but uniformly over the entire area to give an even level surface.

A trace of linseed oil on the face of the pad facilitates this operation. The surface shall be allowed to dry and the remaining coats applied in the same way. To finish off, the pad shall be covered with a fresh piece of clean fine cotton cloth slightly dampened with methylated spirit and rubbed lightly and quickly with circular motions. The finished surface shall have a high gloss and clear finish showing off the natural grains.

18.13 French Polishing Old Surfaces

18.13.1 Preparation of Surface

The old polished surface shall be cleaned of grease and dirt by rubbing with turpentine and then rubbed with fine sand paper.

If the old polished surface is much soiled then it will be necessary to remove the entire polish ; this shall be done as described in 18.16. French polish shall then be applied as for new work.

18.14 Wax Polishing of new surfaces

18.14.1 Materials

Proprietary wax polish or wax polish prepared as follows:

Pure bees wax free from paraffin or stearine adulterants shall be used. Its specific gravity shall be 0.965 to 0.969 and melting point shall be 63°C. The polish shall be prepared from a mixture of bees wax, linseed oil, turpentine and varnish in the ratio of 2 : 1 1/2 : 1 : 1/2 by weight.

The bees wax and boiled linseed oil shall be heated over a slow fire. When the wax is completely dissolved the mixture shall be cooled till it is just warm and turpentine and varnish added to it in the required proportions and the mixture shall be well stirred.

18.14.2 Preparation of Surfaces

Preparation of surface shall be as described in Clause 18.12.2 with the exception that knotting, holes

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and cracks shall be stopped with a mixture of fine saw dust formed of the wood being treated, beaten with sufficient bees wax to give it cohesion.

18.14.3 Application

The polish shall be applied evenly with a clean soft pad of cotton cloth in such a way that the surface is completely and fully covered. The wax shall be allowed to remain overnight so as to soak into the pores of the wood. The next day the superfluous wax shall be wiped off and the surface rubbed with soft flannel to a fine polish.

18.15 Waxing Old Surfaces

The wood work shall be cleaned of all grease by washing with lime water. The surfaces shall then be washed with soap and completely dried. Then it shall be prepared smooth as specified in Clause 18.14.2.

The polish shall be applied in the manner specified in Clause 18.14.3

18.16 Removing Old Paint

18.16.1 With Patent Paint Remover

Solvent paint and varnish remove. This shall be applied by brush, to soften the paint or varnish film, to facilitate its removal by scraper . Several applications of the remover may be made, allowing sufficient time for the paint or varnish to soften right through. The surface shall then be cleaned with white spirit.

18.16.2 Burning Off

This may be allowed for painted wood work where the heat of the flame will not affect the supporting surface, and where the paint coating is not itself highly inflammable. Fire extinguishing equipment shall be at hand when using this method. Suitable precautions shall be taken when burning off lead paints.

18.16.3 Flame Cleaning

Flame cleaning with oxyacetylene flame may be used on steel which is thick enough not to distort.

18.16.4 Scraping, abrasion or grit blasting may be adopted as directed.

18.17 Painting cast iron rain water and soil pipes

18.17.1 Materials

Short oil varnish , Red oxide paint, anti-corrosive paint (Aluminum or Bitumastic paint)

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18.17.2 Application

Areas treated with Dr. Angen Smiths solution shall be given a priming coat of short oil varnish. Over this priming coat shall be applied one coat of red oxide paint and two coats of anti - corrosive bitumastic or aluminum paint as specified.

18.18 Painting of Floors

Materials

Paint used for floor painting shall be of approved Manufacture. The instructions of the manufacturer shall be followed in all respects.

Surface Preparation

The floor should be well cleaned with an appropriate detergent and shall be free from dust. Grease and wax.

The floor should be flooded with a dilute solution of Hydrochloric Acid (1 part of Hydrochloric Acid to 5 parts of water) and allow to soak for 20 to 30 minutes. Wash the floor with plenty of water to remove excess acid.

Application

Painting including priming shall be as per manufacturer's recommendations. Any specific instructions by the manufacturer should be strictly followed.

18.19 Painting of Water Retaining Structures

Materials

Paint used for water retaining structure painting shall be of approved Manufacture. The instructions of the Manufacturer shall be followed in all respects.

Surface Preparation

The surfaces should be well cleaned with an appropriate detergent and shall be free from dust, grease and wax.

The surfaces should be flooded with a dilute solution of Hydrochloric Acid (1 part of Hydrochloric Acid to 5 parts of water) and allow to soak for 20 to 30 minutes. Wash the floor with plenty of water to remove excess acid.

Application

Painting including priming shall be as per manufacturer's recommendations. Any specific instructions by the manufacturer should be strictly followed.

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18.20 Painting of Exposed Surfaces

Materials

Paint used for exposed surface painting shall be of approved Manufacture. The instructions of the Manufacturer shall be followed in all respects.

Surface Preparation

The preparation of the surface shall be as 18.1.1 On powdery surfaces apply a coat of approved masonry sealer.

Application

Painting including priming shall be as per manufacturer's recommendations.

CHAPTER 19
SEALANTS

19.1 General

19.1.1 Work Included

- A. Clean and prepare surfaces to receive sealant materials.
- B. Install sealant and backing materials in exterior concrete and masonry joints around perimeter of exterior located windows and door frames, exterior and interior joints between dissimilar materials and expansion joints.

19.1.2 Related Work

- A. Shop Drawings, product Data and Samples to be prepared, submitted and approved prior to execute the work

19.1.3 Product Data

- A. Submit Product Data for approval and products shall conform to BS 5212:1990
- B. Submit manufacturer's descriptive literature; including surface preparation and installation instructions.

19.1.4 Warranty

- A. Provide written warranty in accordance with "Conditions of Contract".
- B. Warranty is to provide for repairing and replacing, at no cost to the Owner, sealants used for joints in Concrete which fails to perform as intended, because of either leaking, crumbling, hardening, shrinkage, bleeding, sagging, staining or loss of adhesion, within a minimum period of ten years from date of Substantial Performance of Work as certified by the Employer's Representative

19.2 PRODUCTS

19.2.1 Acceptable Manufacturers

- A. The Contractor shall submit to the Employer's Representative the names of three manufacturers and their products which will be acceptable under this Section. Approval of the manufacturer or product must be obtained before proceeding with associated work.

19.2.2 Sealants Materials

- A. Sealant: Polysulphide base, one component, chemical curing; conforming to Shore "A" hardness of minimum 15 and maximum 50 non-staining and non-bleeding; color selected by the Employer's Representative.

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- B. Sealant: Polysulfide base, two component, chemical curing; type 1 - self leveling, 2 - non-sagging, conforming to Shore "A" hardness of minimum 15 and maximum 50 non-staining and color selected by the Employer's Representative.
- C. Sealant: Polysulphide base, one component, air curing; conforming to Shore "A": hardness of minimum 15 and maximum 50; non-staining and non-bleeding; color selected by the Employer's Representative.
- D. Sealant: Terpolymer base, multi-component, chemical curing; Type 1 - self leveling, Type 2 - non-sagging, conforming to Shore "A" hardness of minimum 15 and maximum 50; non- staining and non-bleeding; colors selected by the Employer's Representative.
- E. Sealant: Silicone base, one component, solvent curing; conforming to requirements of class A; indicating an instantaneous Shore "A" hardness of maximum 50; non- staining; color selected by the Employer's Representative.
- F. Sealant: Silicone base, one component, chemical curing; conforming to requirements of class A; indicating an instantaneous Shore "A" hardness of maximum 50; non- staining; color selected by the Employer's Representative.
- G. Sealant: Silicone base, two component, chemical curing; conforming to requirements of class A; indicating an instantaneous Shore "A" hardness of minimum 12 and maximum 25; non-staining; color selected by the Employer's Representative.

19.2.3 Reparatory Materials

- A. Primers: Non-staining types recommended by sealant manufacturer to suit applications.
- B. Joint Cleaners: Non-corrosive types recommended by sealant manufacturer; compatible with joint forming materials.

19.3 EXECUTION

19.3.1 Preparation/Installation

- A. Maintain workmanship of the highest quality in accordance with best trade practice. Perform all work in accordance with General Specifications.
- B. Clean and prepare joints in accordance with manufacturer's recommendations. Remove any loose materials and other foreign matter which might impair adhesion of sealant.

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- C. Ensure that joint forming materials are compatible with sealant.
- D. Examine joint dimensions and size materials to achieve required width/depth ratios. Use joint filler to achieve required joint depths, to allow sealants to perform properly.
- E. Install sealant in accordance with manufacturer's recommendations. Use one part type sealant for up to 20mm joints. Use two part type sealant for over 20mm joints.
- F. Apply sealant within recommended temperature ranges. Consult manufacturer when sealant cannot be applied within recommended temperature ranges.
- G. Form joints concave, free of air pockets, embedded matter, ridges and sags.

CHAPTER 20
ELECTRICAL INSTALLATION SYSTEM

20.1. GENERAL REQUIREMENTS

All temporary power fixtures and equipment and cables, costs used during the construction stage shall be born by the contractor.

Materials for electrical conduit systems and for cable duct systems shall be stored in accordance with the manufacturers' recommendations in a dry and weatherproof store.

Holes and recesses shall be left in structures for electrical installations. If instructed by the Employer's Representative, holes and recesses shall be cut in structures for electrical installations.

Holes and recesses in internal floors, stairways and platforms shall be protected with temporary covers or by other methods agreed by the Employer's Representative until the electrical installation starts. Holes and recesses in roofs, external walls and external floors shall be sealed with watertight temporary covers until the electrical installation starts.

Holes in structures shall be filled and made good after electrical installations are complete.

Holes left in structural elements designated as fire barriers shall be sealed to at least the same degree of fire resistance as the structural element.

20.2. MATERIALS AND EQUIPMENT SPECIFICATION

20.2.1. ELECTRICAL CONDUITS AND FITTINGS

Electrical conduits and fittings shall comply with BS 4568:1970 Parts 1 and BS EN 50086-1:1994 and shall have Class 4 heavy protection inside and outside. Conduits shall be heavy gauge with screw-end construction in steel and shall have an external diameter of at least 20 mm. Conduits shall be longitudinally welded.

Metal boxes for enclosing electrical accessories shall comply with BS 4662:2006+A1:2009 and shall have heavy protection inside and outside. The boxes shall be of preferred sizes and shall be 35 mm or 47 mm deep as appropriate. Circular ceiling boxes of deep pattern shall comply with BS 4568:Part 2 and shall have Class 4 heavy protection inside and outside. The boxes shall be at least 60 mm deep internally.

Circular boxes, dome covers and hook covers shall be cast iron. Bushes and plugs shall be brass.

20.2.2. CABLE DUCTS AND FITTINGS

uPVC cable ducts for installation above ground or for casting into concrete shall be Class 0 uPVC pipes complying with BS 3506. Cable ducts for installation below ground shall be Class B uPVC pipes complying with BS 3506:1969.

Joints and fittings for use with uPVC cable ducts shall comply with BS 4346:Part 1 and BS 4346:Part 2. Solvent cement for uPVC pipes and fittings shall comply with BS 4346:Part 3.

Steel cable ducts shall be steel tubes complying with BS EN 10255:2004, medium series, screwed and

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socketted tubes and shall have screwed sockets suitable for screwing to BS EN 10226-1:2004, Table 2 pipe threads. The tubes, sockets, clamps and saddles for ducts shall be hot dip galvanized in accordance with BS EN ISO 1461:2009.

20.2.3. PAINT FOR CONDUIT AND DUCT SYSTEMS

Bituminous paint for steel conduits and steel cable ducts shall comply with BS 3416, type 1:1991.

Anti-rust paint for concealed electrical conduit systems shall be of a proprietary type approved by the Employer's Representative.

Zinc chromate primer for cable duct systems shall comply with BS 4652:1995.

Galvanizing paint for cable duct systems shall be of a proprietary type approved by the Employer's Representative.

20.2.4 FIRE BARRIERS

Internal fire barriers shall be a type offering adequate fire resistance for the application.

The material shall be approved by the Employer's Representative in compliance with Buildings Department's requirements and shall be resistant to fire, smoke, gas and water.

Internal fire barriers shall be constructed in service channels, service shafts and service ducts for electrical installations at the following locations:

- (i) At points of intersection with structural elements designated as fire barriers,
- (ii) At 5 m centres in vertical and inclined shafts, and at intersections with floor slabs, and
- (iii) At termination points and open ends.

20.2.5 CONCEALED ELECTRICAL CONDUIT SYSTEMS

01 CONSTRUCTION

Concealed electrical conduit system is an electrical conduit system, including all bends, couplers, bushes, saddles, boxes, covers, plugs, draw wires and other conduit fittings, which is cast into concrete or fixed in chases in brickwork with a minimum cover of 20 mm or which is laid directly in the ground.

Concealed electrical conduit systems shall be electrically continuous and shall be effectively earthed.

Principal conduit runs shall be either vertical or horizontal. Tee pieces and elbows, including those with provision for inspection, shall not be used unless approved by the Employer's Representative.

Joints shall be made using coupler units into which the ends of the conduits shall be inserted and tightened. Running couplings shall not be used unless permitted by the Employer's Representative. If permitted, the couplings shall be made by screwing each of the conduits half way into the coupler with a hexagonal lock nut against each end of the coupler.

Adaptable boxes shall be provided at:

- (i) Every second bend,
- (ii) After a bend and a straight run of 10 m or less, and
- (iii) Every 15 m in straight runs.

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Adaptable boxes for conduits installed in floor screeds shall have the lids set flush with the adjacent floor. The boxes shall be covered with the same material as the remainder of the floor and shall remain accessible at all times.

The clearance between conduits entering adaptable boxes and between adjacent or parallel conduits shall be at least the nominal maximum coarse aggregate size of the concrete plus 5mm.

02 INSTALLATION

Concealed electrical conduit systems shall be arranged and installed in accordance with best trade practice and in such a manner that all cables can be drawn with ease and without damage.

Bends in concealed electrical conduit systems shall be formed by using proprietary bending equipment of a type agreed by the Employer's Representative. Connections and other work shall be carried out using purpose made equipment.

Conduits shall not be bent by more than 90° and the internal radius at bends shall be at least 2.5 times the external diameter of the conduit. Conduits shall not be flattened at bends.

Burrs and sharp edges shall be removed from the ends of conduits before installation. Concealed electrical conduit systems that are to be cast into concrete shall be fastened to the reinforcement with tying wire of the same type used for the reinforcement. The conduit systems shall not be positioned between the reinforcement and the outside face of the concrete unless permitted by the Employer's Representative.

Conduit boxes shall be of a compatible size and shall have a single extension ring of the required depth if the plaster finish exceeds 13 mm thick. Multiple extension rings shall not be used.

03 TERMINATIONS

Screw fitting couplers shall be provided at each end of conduits which terminate in distribution boards, busbar chambers, motor starters, cable ducts, boxes or similar termination points. The item at which the conduit terminates shall be drilled with an unthreaded clearance hole to receive a brass male bush. The bush shall be screwed into the coupler from the inside of the item in such a manner that the surface of the item is gripped between the coupler and the bush. The threads shall be at least half the length of the coupler.

04 PROTECTION

Concealed electrical conduit systems shall have special arrangements designed by the Contractor to permit movement of conduits to take place on each side of movement joints in structures. A separate circuit protective conductor shall be installed to maintain effective electrical continuity across the joint. The protective conductor shall have a cross-sectional area rated to suit the largest live conductor to be drawn into the conduit.

Steel conduit systems laid in contact with or adjacent to other metal work shall have efficient and permanent metallic connection made between the conduit and the metal work. Underground steel conduits and conduits in contact with soil shall be painted with two coats of bituminous paint before installation.

Exposed threads and damage to protective coatings of conduit systems shall be painted with two coats of anti-rust paint. Conduits shall be laid in such a manner that accumulation of condensed moisture in the conduit system is prevented. Measures shall be taken to prevent water from entering the system.

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Water, moisture and deleterious material shall be prevented from entering permanent and temporary terminations in concealed electrical conduit systems, including conduit boxes, by using conduit-stopping plugs of a type approved by the Employer's Representative. Paper or rags shall not be used.

05 CLEANING

After installation, concealed electrical conduit systems shall be swabbed out with draw-in tapes and absorbent cloth of a type agreed by the Employer's Representative. All obstructions shall be removed and draw wires shall be installed. After cleaning, exposed conduit ends shall be sealed as stated.

06 CONDUIT SYSTEM

All conduit systems shall be installed fully in accordance with the requirements of the I.E.E. Wiring Regulations of the latest edition.

All conduits shall be swabbed through to clean out all dirt, burrs and moisture.

All sets and bends in conduit runs are to be formed on site with bending machines. Distortion of conduits due to bending is not acceptable. Runs between draw-in boxes are not to have more than two right angle bends or their equivalent and the length of such runs shall be limited to 12 m to permit easy drawing-in of cables.

Chase for conduit in walls shall be perpendicular and horizontal. All conduit runs shall be secured in dry wall or recessed in the floor screeding.

20.2.6 FLEXIBLE CONDUIT

Flexible conduit shall be used for final connections to equipment subject to vibration or liable to withdrawal for maintenance or servicing.

Flexible steel conduit and solid type adaptors shall comply with BS EN 50086-1:1994. The conduit shall be watertight with the provision of separate earth wire enclosed for earth continuity. All flexible steel conduits shall be PVC sheathed.

20.2.7 CABLE DUCT SYSTEMS

01 INSTALLATION

Changes in direction in cable duct systems shall be constructed in such a manner that the cables in the duct will have radii of curvature of at least 800 mm. Ducts entering draw-in pits shall be on the same horizontal plane as the draw-in pit.

uPVC cable ducts shall be jointed in accordance with the manufacturer's recommendations. Steel cable ducts shall be jointed using screwed hot dip galvanized sockets and spun yarn or by an equivalent method approved by the Employer's Representative such that the jointed pipes abut. The threads shall be painted with two coats of bituminous paint. Internal rags and burrs shall be removed to provide a smooth bore through joints in the cable duct system.

Surface mounted cable ducts shall be secured by hot dip galvanized steel clamps or saddles at spacings not exceeding 3 m.

02 PROTECTION

After jointing, exposed bare metal in cable duct systems shall be cleaned and painted with two coats of

STANDARD TECHNICAL SPECIFICATION

zinc chromate primer and two coats of galvanizing paint.

Surface-mounted hot dip galvanized steel cable ducts shall be cleaned and painted after fittings and jointing have been completed.

03 CLEANING

After jointing, cable duct systems shall be cleaned internally by scrubbing with a cylindrical brush of a type agreed by the Employer's Representative. The ends of ducts, including ends of ducts in draw-in pits and spare ducts, shall be fitted with tapered hardwood plugs to prevent water, moisture and deleterious material from entering the system and a 6 mm diameter nylon draw line shall be installed.

The plugs shall be centrally drilled for the draw line and the draw line shall be secured by a knot tied on the outer face of the plug to leave at least 1500 mm of surplus line at each plug.

20.2.8 CEILING / EXPOSED CABLE TRUNKINGS / WIRE MESH BASKET

Cable trunking shall be manufactured in minimum lengths of 2 m from 1 mm thick zinc spayed sheet steel finished with rust resisting primer and sprayed overall grey enamel. Covers are to be held in place by screws. Trunking shall be terminated with end flanges bolted directly to switch or distribution boards. Connection pieces shall be used and bolted with cadmium plated mushroom head steel screws, nuts and shake-proof washers. Each joint shall have a copper link to ensure electricity continuity.

Conduit entries to trunking shall be made with couplings and brass male bushes. Knockouts will not be required and trunking may be drilled on site. Trunking shall not contain more cable than allowed as the space factors described in the I.E.E. Wiring Regulations.

Wire mesh basket and cable ladders shall comply with all electrical wiring regulations. The contractor shall only use these items inside the IT equipment room.

20.2.9 P.V.C. INSULATED CABLES

PVC insulated cables shall consist of copper conductors, PVC insulated to C.M.A. Standards and to B.S. 6004:2000. Cables for three phase and single phase circuit shall be 600/1000 volt grade.

The current carrying capacity shall be in accordance with the Regulations and shall be limited to the specified voltage drop. Minimum size of copper cables shall be as follows:-

- (i) Lighting - 1.5 mm
- (ii) Power - 2.5 mm

All wiring shall be carried out on the loop-in system and the wires shall be drawn into the conduit after the whole of this installation has been completed. No joints or connectors will be allowed in any such cable, except that connectors may be used in accessible position within light fittings.

20.2.10 SOCKETS AND SPUR UNITS

Sockets shall be complying with B.S. 546:1950 or B.S. 1363 and shall be shuttered type except 2A 3 pin and 5A 3 pin fixed on ceiling or at high level.

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Sockets shall be fitted with switches, unless otherwise specified. The switch shall be single pole contained within the same enclosure as the socket.

All sockets shall be connected with earthing cable between the socket and the junction box. The earthing cable shall be – green / yellow colour. Fused Spur Unit shall be of double pole, switched type with neon indicator complying with B.S. 5733:1995. The rating shall be of 13A. Each unit shall incorporate a fuse link to B.S.

1362:1973 rate to suit the appliance to be fed. An earth terminal shall also be provided for the connection of the circuit protective conductor to the appliance.

All power socket outlets shall be installed on the wall as indicated in the drawings. Height of the socket outlet shall be 300mm off the floor level or approved by Contract Administrator.

Socket outlets shall be mounted onto junction boxes embedded in the wall. Final circuit labels shall be provided. Utility power outlets shall be taken from the power outlet MCB.

20.2.11 LIGHTING AND FLUORESCENT TUBE & FITTINGS

All fluorescent tubes shall be of energy saving type unless specified. Lighting colour for fluorescent tubes shall be approved by Employer's Representative. Fluorescent tube samples with operating temperature ranges between 3900K to 4500K shall be provided. A selection shall be made on site by the Employer's Representative.

EMSD approved Electronic Ballast with power factor correction capacitor shall be installed in all light panels where fluorescent light fittings are used. Catalogue and certificate (letter) of compliance from EMSD shall be submitted to the Employer's Representative for approval.

Emergency fluorescent tube shall be provided and replaced the existing lighting in the staircases landing and half-landings of the entire building. Emergency lighting for all premises shall comply with BS 5266:Part 1.

Emergency lighting shall be backed up by emergency power supply or provided with secondary battery. In the event of power failure, the emergency lighting shall be activated within 5 seconds. For emergency luminaires indicated, integral battery pack and control unit shall be installed within the selected light fittings, for a duration period of 2 hours.

Batteries used shall be of the sealed Nickel Cadmium type. Batteries shall be maintained in good condition on site with all necessary precautions being taken to prevent deterioration. They shall be handed over, at the completion of the Work, fully charged.

Simulation of mains failure shall be by means of a tamper-proof switch operated by a removable key.

The wiring installation shall comply with the relevant clauses of this Specification. The type and size of cables shall be of a suitable size and type.

Wiring shall not be drawn into the same conduit, trunking compartment or ducting compartment as cable of other Category 3 circuits. The cores of emergency lighting circuits shall not be contained within the same multicore cable, flexible cable or flexible cord as cores of any other circuits.

20.2.12 STEP DOWN TRANSFORMER FOR LOW VOLT LIGHTING DOOR BELL

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All transformers shall be double wended specific for the operation assigned and no auto transformer shall be accepted. Individual transformer shall be used for each lighting fitting or door bell.

20.2.13 FUSED SWITCHGEAR AND ISOLATORS

All fused switchgear and isolators whether mounted in a cubicle type switchboard or separately mounted shall be heavy duty type conforming to the requirements of BS 5419:1977, utilization category AC23. All contacts shall be fully shrouded and shall have a breaking capacity on manual operation as required by the British Standards.

Operation of fuse switches shall be independent of the operator's control, with a quick make / quick break action.

The fuse links for fuse-switches and switch-fuses shall be high rupturing capacity, cartridge type conforming to B.S. 88 and ASTA certified for class Q1 fusing factor. Fuse-switches and isolators mounted in cubicle type switchboards shall be enclosed in separate sheet metal compartments, and mechanical interlocks shall be provided between the cubicle doors and the switch operation mechanisms, so arranged that the cubicle door may not be opened with the switch in the 'ON' position. Similarly it shall not be possible to close the switch with the cubicle door open; except that provision shall be made within the cubicle for authorized persons to defeat the mechanical interlock for test purposes, and close the switch with the door in the open position.

The 'ON' and 'OFF' positions of all switches and isolators shall be clearly indicated by a mechanical flag indicator or similar device.

In T.P. & N. fuse-switch units, bolted neutral links shall be fitted. For single pole and neutral fuse-switches and isolation switches, the neutral conductor shall be taken through a bolted link.

Contactors shall be double air-break, double-pole, and triple-pole, conforming to B.S. 5424. The rating shall be as noted on the drawing but in any case, shall not be less than 10A or the rating of the circuit, whichever is the greater. All ratings shall be 'continuous', and all contacts shall be silver plated. Contactor coils shall operate from a single phase electricity supply.

20.2.14 DISTRIBUTION BOARD

All distribution board shall contain a main switch. All wiring, bus-bar etc. within the distribution board shall be adequately shrouded and an insulating front shield of 3 mm thickness shall be provided to completely screen the distribution unit interior. Only the MCB, RCCB and MCCB operation dolly and insulated surround shall project through the shield.

Neutral bars shall be of adequate cross section, mounted on insulator, and drilled to receive circuit wiring. The distribution board shall be completed with circuit record card, suitably roofed and finishes, giving the total number of points served by each MCB, total load per way and the area served.

The sheet metal for the MCB Board shall be not less than 1.0 mm and 1.5 mm for MCCB Board. Engraved labels shall be fixed to all MCB, RCCB and MCCB etc., showing the circuit numbers and

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purpose.

Engraved labels to identify the purpose of distribution boards shall also be fixed to the panel door/cover. IP rating for the Distribution Boards shall be submitted to the Employer's Representative prior to installation for approval.

20.2.15 MINIATURE CIRCUIT BREAKER AND RESIDUAL CURRENT DEVICE (RCD)

Single pole Miniature Circuit Breakers shall be used for sub-circuit control and protection on all lighting circuits and shall be manufactured and tested to the requirements of BS EN 60898- 1:2003+A1:2004. Interrupting capacity shall be 5,000 Amp. at 200/220 volt. Except for the terminals and toggle, the entire current carrying and operating mechanism of circuit-breakers shall be contained within a molded plastic case. The operating mechanism shall be arranged such that it is trip-free and impossible for the circuit breaker contacts to be held closed by means of the toggle under overload conditions.

The circuit breakers shall have an inverse current/time characteristic in which the time delay on tripping shall be inversely proportional to the magnitude of the load current, up to approximately seven times full load current rating. On heavy overloads or short circuits, breakers shall trip instantaneously.

The body and base of the MCB units shall be molded Bakelite or similar material and the units to be sealed after assembly.

The load handling contacts shall be silver / tungsten and the contacts and operating mechanism so designed as to give a wiping action, both make and break.

The RCD shall be in compliance with B.S. 4293:983 or IEC 27. A quick break switching mechanism irrespective of toggle switching speed with trip free mechanism shall be provided and the switching mechanism shall be totally enclosed within molded Bakelite case.

The RCD shall be 4-pole for three phase circuit and 2-pole for single phase circuit. Three phase circuit breaker shall be interlocked internally so that earth leakage on any one phase shall trip all three phase of breaker simultaneously.

Operating toggle shall have distinct OPEN and CLOSED position which shall be clearly labeled.

The RCD shall be equipped with durable silver tungsten contacts.

Test push button shall be provided to simulate earth fault condition to enable testing of tripping mechanism. A leakage indication lamp or target indicator with manual reset button for visual indication of earth leakage tripped condition shall also be provided.

Rated sensitivity current shall not be in more than 100mA and shall be 30mA if used for final circuit protection.

On final circuit combination clip in place MCB/RCD's shall be used. Each MCB fuse shall carry approximately 10 lighting fixtures.

20.2.16 EARTHING SYSTEM

Provide new electrical bonding for newly installed equipment to existing earthing system to satisfy the latest statutory obligations, regulations and specifications.

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All metal working associated with the electrical installation not forming part of a phase or neutral circuit shall be bonded together and shall be solidly and effectively earthed.

Pits and trenches for electrical earthing systems shall be excavated at positions and at the times instructed by the Employer's Representative.

After the electrical earthing systems have been installed fill material shall be deposited and compacted in the pits and trenches to a depth of 300 mm above the electrical earthing system.

Fill material shall be sand or fine fill material which has been selected from the excavated material, and which is free of stones retained on a 20 mm BS test sieve. Fill material shall be compacted by hand rammers in a manner approved by the Employer's Representative.

20.2.17 GROUTING FOR ELECTRICAL INSTALLATIONS

Grouting to machine bases, crane rails, electrical equipment and other electrical and mechanical installations shall comply with the requirements stated below.

Grouting shall be carried out at the times instructed by the Employer's Representative and shall be completed within 7 days of the instruction unless otherwise permitted by the Employer's Representative.

The permission of the Employer's Representative shall be obtained before items or equipment are grouted. The Contractor shall inform the Employer's Representative within 3 days, or a shorter period agreed by the Employer's Representative, before grouting starts and shall allow the Contract Administrator sufficient time to inspect the work that is to be grouted.

Concrete surfaces shall be scabbled to remove laitance and loose material and to expose the aggregate before the item or equipment is installed in position.

The voids to be grouted shall be cleaned and thoroughly wetted immediately before grouting.

Excess water shall be removed by using a compressed air jet or by other methods agreed by the Employer's Representative.

Grout shall be mixed and placed by methods agreed by the Employer's Representative.

If grouting is to be carried out in two operations, holding down bolts shall be grouted into preformed pockets and sufficient time shall be allowed for the grout to cure and for the bolts to be tensioned before the remaining voids are grouted.

Exposed grout surfaces shall have a uniform, dense and smooth surface free of trowel marks and which is produced by steel trowelling the surface under firm pressure. The exposed surfaces shall be cured by either:

- (i) Using a liquid curing compound applied to the surface by a low-pressure spray until a continuous visible covering is achieved, or
- (ii) Covering the surface with hessian or sacking. The hessian or sacking shall be lapped and securely held in position and shall be kept damp for at least 4 days.

20.2.18. COMPLETION AND PROTECTION OF WORK FOR ELECTRICAL INSTALLATIONS

Work shall be completed to the conditions stated in section C23.16 before structures are made

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available to others for electrical installations.

The structure shall be clean, dry and free of dust. Work that in the opinion of the Contract Administrator will produce large quantities of dust shall be complete.

Holes and recesses, concealed electrical conduit systems and cable duct systems required for the installation shall be complete. Concrete surfaces on which items and equipment are to be installed shall be scabbled.

Plinths, trenches, louvres, openings and similar work shall be complete and shall have hardened sufficiently to allow the installation to proceed.

Floors and slabs shall be complete to the specified finishes except that floor tiles shall not be laid until after the installation is complete.

Plant rooms shall be complete, including fixtures and fittings, to a secure and weatherproof condition.

Two sets of door keys for the plant room shall be provided for the Employer's Representative.

Paintwork and similar finishes in plant rooms shall be complete to undercoat level. Final coats shall not be applied until after the installation is complete.

Temporary power supplies and connections required for the installation shall be complete. The supply shall be metered and shall be a 346V, 3-phase supply of 20A maximum rating.

Temporary power supplies shall be provided for the periods stated in the Contract. Structures in which electrical installations are being carried out shall be maintained in a clean, dry condition, free of dust, during the installation.

The dust level in plant rooms shall be kept to a minimum by using industrial dust extractors of a type agreed by the Employer's Representative during and after the installation. Temporary screens shall be installed to separate dust-affected areas from the installations or temporary covers shall be installed around the installation.

20.3 INSPECTION, TESTING AND COMMISSIONING

01 INSPECTION OF WORK FOR ELECTRICAL INSTALLATIONS

The Contractor shall allow the Employer's Representative to inspect the following work for electrical installations:

- (i) Completed concealed electrical conduit systems, cable duct systems, electrical earthing systems and items and equipment which are to be grouted or covered up,
- (ii) Items and equipment which are to be tested, and
- (iii) Structures that are to be made available for electrical installations.

The Contractor shall inform the Employer's Representative three days, or such shorter period agreed by the Employer's Representative, before work is covered up, tested or made available.

02 TESTING

Concealed electrical conduit systems shall be tested to determine the earthing continuity. The system shall be tested:

- (i) Before the system is cast in concrete or covered up,

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(ii) After the system is cast in concrete or covered up, and

(iii) After electrical wiring that is installed by the Contractor is complete.

Unless otherwise approved by the Employer's Representative the method of testing shall be in accordance with Appendix 15 to the IEE Wiring Regulations, 15th Edition, 1981 issued by the Institution of Electrical Employer's Representatives.

The results of tests for earthing continuity shall comply with the IEE Wiring Regulations, 17th Edition, 2008 issued by the Institution of Electrical Employer's Representatives.

The Contractor shall carry out all the inspection and test listed below but not limited to the following:

(i) Visual inspection of low voltage installation.

(ii) Continuity of ring final circuit conductors test.

(iii) Continuity of protective conductors tests, including main and supplementary equipotential bonding test.

(iv) Insulation resistance test.

(v) Polarity test.

(vi) Earth fault loop impedance test.

(vii) Functions of all protective devices test.

(viii) Functions of all items of equipment test.

CHAPTER 21

BORE HOLE WELL WITH SUBMERSIBLE PUMP

21.1 INTRODUCTION

These technical standards refer to public, non-piped ground water supply, which includes the following components:

- In take Structure(bore hole)
- Pumping equipment, including the pump platform and discharge accessories.

The work includes drilling boreholes, installation of casings and screens; provision of gravel packing; development of the boreholes; test pumping; obtaining rock and water samples; water quality analysis; platform casting and pump installation; as specified hereinafter and as directed by the Supervisor.

21.2 DESIGN CRITERIA

Design criteria of this guideline cover the following stages of a new implementation and contractor is responsible to implement all the procedures in right manner.

- Drilling of borehole
- Borehole installation which include casing, screen, filter pack, grouting
- Borehole development
- Pump installation
- Platform construction

21.3 DESIGN CRITERIA TO MYANMAR

Design criteria are elaborated to comply as far as possible with the following parameters:

- The tube well should be designed to last period of at least 20 to 50 years.
- Hydrogeological and geophysical survey must be conducted by the contractor to identify the most suitable borehole location on site before the commencement of bore hole drilling
- The utilization of available local resources must be optimized.
- The water supply facility should meet water discharge rate of more than 600lt/hour (10lt/min). Refer to clause 21.4 of this technical specification.
- Water quality shall be tested (refer to Bills of quantities) and established to meet safe drinking water specifications to comply with the WHO Guidelines as tabulated below.

Standard Drinking Water Specification

Sr. No.	Substance or Characteristics	Requirement(Desirable Limit)
ESSENTIAL CHARACTERISTICS		
1.	Colour, Hazen units, Maximum.	5
2.	Odour	Unobjectionable.
3.	Taste	Agreeable
4.	Turbidity NTU, Maximum.	5
5.	pH Value	6.5 to 8.5
6.	Total hardness (as CaCO ₃) mg/1, Max.	300
7.	Iron (as Fe) mg/1, Max.	0.3
8.	Chlorides (as Cl) mg/1, Max.	250
9.	Residual, free Chlorine,mg/1,Min.	0.2
DESIRABLE CHARACTERISTICS		
1.	Dissolved solids mg/1, Max.	500
2.	Calcium (as Ca) mg/1, Max.	75
3.	Magnesium (as Mg), mg/1, Max.	30
4.	Copper (as Cu), mg/1, Max.	0.05
5.	Manganese (as Mn), mg/1,Max.	0.1

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6.	Sulphate(200 SO ₄),mg/1,Max.	200
7.	Nitrate(as NO ₂),mg/1,Max.	45
8.	Flouride(as F),mg/1,Max.	1
9.	Phenolic compounds.(as C ₆ H ₅ OH),mg/1,Max.	0.001
10.	Mercury(as Hg)mg/1,Max.	0.001
11.	Lead(as Pb),mg/1,Max.	0.05
12.	Mineral oil mg/1,Max.	0.01

21.4 GENERAL CONDITIONS

21.4.1 BOREHOLE TYPE

The final borehole will be of the following type, depending on the lithology and formations;

A) Open Holes

In stable rock or formation, unscreened with plain casing through the overburden only

B) Protected boreholes

In fractured or broken bedrock encountered in otherwise stable formations, as above with slotted casing for formation support and plain casing extended to the bottom.

C) Screened boreholes

In unconsolidated sediments, soft or very broken bedrock, support by casing and screen, installed with filter pack: C1=Formation filter, C2=artificial gravel pack (sieved)

21.4.2 ROCKS AND FORMATIONS IN Myanmar

Stable formations are:

- Fresh crystalline rocks such as: granite, gneiss, quartzite, meta-arkose, basalt, rhyolite, etc.
- Consolidated sedimentary rocks such as: compact sandstone, limestone, dolomite, etc.
- Cement laterite and ironstone

Unstable formations are:

- Weathered crystalline rocks such as: weathered or fracture/ broken gneiss or arkose, schist, weathered basalt, weathered rhyolite, etc.
- Brittle sedimentary rocks such as: lithified sandstone, poor cemented conglomerate, ironstone, etc.
- Unconsolidated formation such as: sand river, alluvium, sand, silt, loose laterite, etc.

21.4.3 LOCATING BOREHOLE PLACE

Boreholes site should be chosen principally on hydrogeological grounds, yet an important cornerstone of the new philosophy of community water supplies is the complete involvement of the community in all aspects of water supply, including the decision on siting of bore holes. Distance to the nearest possible source of pollution must not be less than at least 30m in the direction of the ground water flow. Source of pollution can be latrine pits, cattle sheds, drains, burials grounds, garbage disposal dumps etc. The Borehole should be sited as near as possible to the health center and the maximum walking distance to the well for fetching water should ideally be less than 200m from the furthest health center building. In addition to the above field reconnaissance, The contractor should be responsible to deploy the "experience eye" that refer to the hydrogeologist who draws upon his scientific training and experience to assess the natural clue for siting a borehole: the type of vegetation, rock outcrops, soil colour, topography, valleys and drainage areas, existing nearby wells or boreholes and springs. Negative indicators such as high ground, areas of mudstone or basalt overburden etc. are also considered.

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21.4.4 ENDORSEMENT OF SUCCESSFUL BOREHOLE

Unless in very specific geological context (highly confined aquifers) or preliminary agreed between the parties (Installation of electric/mechanic pumps for example), the maximum drilling depth shall be 600 feet below the ground level, this in order to be able to install a submersible pump.

A borehole is considered productive, positive or successful if a minimum yield of 600 liters per hour (10 Liters per Minute) is measured at the end of the development process. If a pump can't be used, then the "air lift" discharge shall be at least 800 liters per hour. Boreholes with capacity less than 0.6m³/hour (10 liters per minute) shall be abandoned.

A borehole is considered unsuccessful, if for any reason due to drilling problems, collapsing conditions, breakdown of the machine or any other reasons the bore hole can't be completed. No payments will be made for unsuccessful bore holes. A successful borehole must be completed with the items specified below.

21.4.5 DRILLING ADDITIVES

Chemical foam and bio-degradable mud should be preferred to Bentonite slurry and other non-degradable mud.

21.4.6 REPORTING

Drillers shall report the geological formation, the aquifer characteristics, the yield, the water quality, the borehole construction and pump installation details upon completion of drilling. After drilling has been completed in one site (dry or successful), the driller should systematically fill in a borehole completion form and submit to the UNOPS Employer's Representative.

21.5 BOREHOLE FINAL PRODUCT

21.5.1 FINAL DIAMETER

A minimum diameter of 6" (152mm) at the completion of the borehole- including casing installation as required, above and below the water conducting layer in order to install a submersible pump with a cylinder.

21.5.2 BOREHOLE CONSTRUCTION

Percussion, air rotary or mud rotary method should be used for drilling and minimum final drilling diameter is 6" (152mm) in overburden (Alluvial, laterite weathered or soft bedrock). Borehole should be drilled at least 6 meters below any water bearing fractures to allow sufficient space for a sedimentation sump. Fractured bedrock is considered as not collapsing and can be left without casing. In collapsing bed rock, the borehole needs to be protected with steel casing/screen. In case of unconsolidated soil profile, Filter pack and steel casing (blind and slotted) should be provided. (refer to items in BoQ under bore hole installation)

21.5.3 BOTOM OF THE BOREHOLE

Boreholes should be drilled at least 6 meters below any water bearing layers or fractures to allow sufficient space for pump. As far as possible, boreholes shall be drilled into the underlying bedrock or if the depth to the bedrock is too deep, drilling should stop in an impervious formation underlying the aquifer- a clay layer for example.

The bottom of the hole acts as a sedimentation sump and a support for the casing and screen. The sump shall be a bottom plain casing of at least 1.5 meter length-3 meters recommended- with the same diameter as the screen, and with its underside sealed with a bottom plug (wooden or PVC).

21.5.3 SCREENING DESIGN

Screen design shall be determined in order to avoid drawdown of the water level in to the screened section of the well or below the first water strike in the water- bearing layers.

The screen should normally be installed within the coarsest provided that the calculated pumping drawdown does not reach below the top of the screen or below the main water strike.

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Notwithstanding the above, normally only the lowest 2/3 of the saturated strata (or parts thereof) is screened. The length and position of the screened section affects the yield of the borehole. When the nature of the aquifer is well identified, the screened section shall be designed conformably to the nature and hydrostatic pressure in the aquifer.

A first minor water strike shall be sealed off with plain casing if it can be estimated that pumping will lead to dewatering of the water strike.

21.5.4 FILTER PACK

Artificial gravel pack (Filter pack) is required to prevent particles entering the well and to improve Hydraulic properties in and around the catchments section of the borehole.

Gravel pack shall consist of siliceous material with rounded, smooth and uniform particles. Unstable minerals such as feldspars, calcite (limestone), laterite, etc. will easily decompose and change the properties of gravel pack. Flaky particles such as schist and micas will clog the screens.

Gravel pack should be clean and well –sorted, i.e. there must be no particles of clay or silt adhering to the individual sand or gravel grains of the packs. Filter material should be treated with care to avoid any kind of contamination.

The artificial gravel pack is combined with a suitable screen. Installation of gravel pack in the annular space between screens and borehole walls, plus 3 meters above the top of the first screen. Gravel pack is topped with a one-meter clay seal.

21.5.6 GROUTING

Grouting is a standard practice for all public water supply boreholes. Typically, boreholes should be grouted from the surface down to a depth of at least 5 meters to prevent leakage and percolation of contaminants from the surface. Because of logistics constraints, grouting of the top 1.5 meter can be admitted.

The following practices are optional in the existing context of Southern Sudan:

- Boreholes drilled in rocks that are overlain by thin overburden shall be grouted from the surface to the rock
- Boreholes drilled in sandy aquifer overlain by an impervious overburden shall be grouted from the surface to the aquifer.
- In some formations where poor-quality aquifers are interspersed with high-quality water zones, the poor-quality aquifers shall be cemented off.
- The minimum thickness for satisfying grouting or clay seal is 0.5 m, but a thickness of 1m should be used whenever possible to minimize contamination risks.
- Clay and backfilling material must be thoroughly compacted in order to avoid cracks between the slab and the concrete cover afterwards.

21.5.7 HEAD OF THE BOREHOLE

The top casing shall come out between 55cm and 60 cm above of the ground level. It will be correctly cemented in the ground. If a hand pump is not installed immediately, then the top of the bore hole must be sealed adequately.

21.5.8 BOREHOLE VERTICALITY

Installed casing shall be round and straight. Straightness and plumbness should be tested at the end of the casing screen installation. The minimum standard of quality can be controlled by lowering down a standard hand pump cylinder to the final depth of the borehole without opposing any resistance.

21.5.9 BOREHOLE DEVELOPMENT

Development improves the borehole performance and the quality of water. All boreholes must be developed on completion of drilling and after casing, screen, grouting and filter pack are installed.

The minimum requirement is the “air lift” method until the ground water runs clean and turbidity free, but in any case for a minimum of 3 hours. If this condition is not achieved after 6 hours, air lift will be carried-out until the water becomes limpid, but up to a maximum of 12 hours with any extra hours on top of 6 hours to be invoiced accordingly.

Routine evaluation of the borehole yields should be limited to the air-lift capacity test after development of the

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well.

21.5.10 BOREHOLE PUMP TESTING

There are two main reasons usually cited for pump testing a borehole:

- a) To measure the well performance and efficiency with a varying discharge.
- b) To measure the aquifer characteristics of storability and permeability (for the aquifer as a whole it is called transmissibility)

Pump tests are fundamental in ground water hydrology. Boreholes are pumped for extended periods and the drawdown is measured over time, thus enabling assessment of well performance and aquifer characteristics. Pump tests normally vary from 6-72 hours and at times are even longer. However, here, contractor should carry out pump test over the 36 hours.

21.5.11 BOREHOLE DISINFECTION

All boreholes shall be disinfected after completion. This can be achieved by placing a chlorine solution in to the well so that a concentration of at least 50mg/l (0.005%) of available chlorine exists in all parts of the well at static conditions. All borehole parts above the water level should be completely flushed with the solution. The solution shall remain in the well a minimum of 12 hours before pumping the well to waste.

21.5.12 SOIL SAMPLING

During drilling, formation should be sampled at least every length of rod. Aquifer formation should be logged on the borehole completion form.

21.5.13 WATER SAMPLING

During the drilling, all water strikes should be sampled and basic routine parameters measured: temperature plus conductivity and/ or TDS measurement, bacteriological test can be done on site or off site. Perform chemical and microbiological analyses of the water to determine the characteristics of the water in the aquifer. This helps predict the susceptibility of the well to encrustation or erosion, provide information on the water quality, and serve as a base line record to detect any changes in water quality or contamination.

21.6 PUMPING EQUIPMENT & SUPERSTRUCTURE

21.6.1 PUMP IN-TAKE

In a non-screened borehole (Type A), the pump in take (bottom of the cylinder) shall not be installed deeper than 1m above the first water strike.

In a protected borehole equipped with slotted casing (type B) or a screened borehole (type C), the pump in take shall not be installed deeper than 1m above the top of the slotted casing or screen.

The water level above the main water strike or screen is too little to conform to the above specifications, and then a complete test pumping should be carried out to determine precisely the borehole capacity (in-take depth, discharge rate and pumping duration).

21.6.2 PUMP BODY

Contractor should use galvanized/noncorrosive hand pumps and accessories. These accessories will depend on the casing material and diameter, and on the type of hand pump.

The pump body shall be fitted over the casing and casted in to the slab. Welding the pump body on the top of the casing is not recommended, because the casing string cannot absorb all the shocks and vibrations in the longer term.

21.6.3 PUMP PLATFORM

21.6.3.1 PLATFORM

The Platform consists of a standing slab, a drain and a soak-away pit if the spill water cannot be evacuated

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elsewhere otherwise.

Height below the pump outlet must be sufficient to fit buckets and 20 liters jerry cans. The apron shall slope slightly towards the outlet of the platform (drain).

Whenever possible, sand used for the mortar should be clean, sharp, not rounded, free of mud, clay and silt. Sharp sand has a rough surface which improves adhesion. Stones for the hardcore should be free of mud, clay and silt, and 10 to 20 cm in size.

The platform must be strong and water tight and the surface must be highly resistant. Therefore the mortar for the hardcore must be dense. The following proportions are recommended.

Cement: Sand: aggregate=1:2:4 and cement: sand =1:3 floor screed

21.6.3.2 DRAINAGE AND SURROUNDINGS

Spill water shall flow towards a drainage area without creating muddy places. The drain must be 5 meter long minimum. A soak-away pit shall be dug if the spill water is not used for irrigating a garden, for watering livestock, or cannot be driven to a riverbed or a natural drainage, so that it does not create unhygienic surface pools. The soak-away pit shall be 80 cm diameter and one meter deep. It can be filled with stones, broken bricks and gravels, or coarse gravel to ensure that the water is controlled as it seeps away in to the subsoil.

Poor natural drainage can also be improved by planting moisture absorbing shrubs and trees. Planting trees may often be a better solution than a drainage pit, which can tend to clog quickly, especially in clay soils.

The Platform must be fenced to prevent animal to penetrate inside the pumping surface. Wooden poles, thatch grass, bamboo, etc, can be used to complete a fence around the pump platform.

21.7 ENVIRONMENTAL MANAGEMENT

21.7.1 PROTECTION OF ENVIRONMENT

The contractor shall take all reasonable steps to protect the environment on and off the Site and to avoid damage or nuisance to persons or to property of the public or others resulting from pollution, noise or other causes arising as a consequence of his methods of operation.

During continuance of the contract, the contractor shall abide at all times by all existing enactments on environmental protection and rules made there under, regulations, notifications and bye-laws of the Government, or local authorities and any other law, bye-law, regulations that may be passed or notification that may be issued in this respect in future by Government or the local authority.

21.7.2 PREVENTION AND CONTROL OF WATER POLLUTION

Contamination of Ground and Surface Water

The contractor shall take all necessary precautions for the prevention and control of pollution of the ground and surface water from oil and waste oil spills, sanitary facilities, construction wastes and any other chemicals used in the construction.

Drainage and Flood Control

Contractor shall take all necessary precautions to prevent the blockage of water flow from the construction materials like earth, stone, or appendage.

Stagnation of water within or outside the project area from the project activities should be avoided to prevent mosquito breeding and other vector borne diseases

Siltation of Water Bodies and Degradation of Water Quality

The Contractor will not excavate beds of any stream/canals/ any other water body for borrowing earth. The contractor shall ensure that construction materials containing fine particles are stored in an enclosure such that sediment-laden water does not drain into nearby water course.

PREVENTION AND CONTROL OF AIR POLLUTION

Transportation of Construction Materials

All vehicles delivering fine materials to the site shall be covered to avoid spillage of materials and

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dust generation. Photographic record of this activity should be maintained.

Vehicles, Equipment and Machinery

All vehicles, equipment and machinery to be used in the project should have pollution control equipment such as exhaust dispersion systems and silencers.

Dust Generation from Construction Site

Dust generation from the construction site should be minimized by sprinkling water on the stock piles of wastes before loading for disposal and by covering the materials containing fine particles during the high winds

21.7.3 PREVENTION AND CONTROL OF NOISE POLLUTION

The quieter equipments available in the market shall be used in the Project. Diesel Generator Sets having acoustic enclosures shall be used for the project.

21.7.4 PREVENTION AND CONTROL OF SOIL POLLUTION

Control of Oil Spills

Contractor shall not carry out any vehicle/machinery maintenance on site to avoid contamination of ground. If the emergency maintenance is to be carried on site, proper collection and disposal systems should be arranged before carrying out the maintenance. In such cases the contractor should arrange for collection, storage and disposal of oil wastes generated during the emergency maintenance to the nearest work shop for further handling.

Contractor shall not dispose diesel, lubes, paints and any other materials on site which may contaminate the soil.

21.8 CONSTRUCTION MATERIALS

21.8.1 Construction Water

The contractor can use ground water/surface water as a source of water for the construction and or can take water from existing sources with written consent from owner of the bore well.

To avoid disruption/disturbance to other water users, the contractor will extract water from fixed location and details of the bore well will be recorded and filed.

If the new bore hole is created for the project water requirement, it should be left for the public use

21.8.2 Coarse and Fine Aggregates

The contractor shall procure coarse and fine aggregates from the government authorized suppliers. The Contractor should obtain receipts of the purchase of materials and file copies of these receipts

21.8.3 Soil

Deep borrow areas shall not be created for the project. Depth of the borrow area shall be limited to 60 cm. Top soil removed and preserved from the borrow area shall be spread after completion of borrowing of soil. The waste materials generated from the excavation should be disposed in borrow areas created for the project, if they are not suitable for the filling.

21.9 HAZARDOUS WASTE

All the hazardous wastes shall be disposed of as specified by the supplier

21.10 CLEANING OPERATION

On the completion of the construction, the contractor shall remove all waste materials and excess materials

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from the site.

21.11 CONSTRUCTION CAMP / SECURITY ROOM

The contractor shall provide proper water supply, cooking facilities, sanitation and solid waste collection and disposal systems to the construction camp / security room. The contractor shall preferably use unskilled labor drawn from local communities to give the maximum benefit to the local community to avoid impacts on the local environment

The contractor shall set the guidelines prohibiting poaching and collection of plants/wood with meaningful consequences for violation such as termination of the employment.

21.12 REPORTING

The contractor shall submit proper environmental management plan including solid waste management system which is planned to adopt during the construction stage. This plan shall include all the environmental impact prevention, minimization and mitigation action including collection, storage and disposal of solid waste generated from the Project.

The contractor should submit a completion report on the environmental management practices adopted on the completion of all site activities. This completion report shall include details of the difficulties faced and methods followed for overcoming these difficulties. The completion report should include photographic records and copies of agreements and receipts for materials.

21.13 SAFETY MANAGEMENT

21.14 CONSTRUCTION SAFETY

The contractor shall take all necessary steps to provide safety for project workers, the persons residing near the project, to the property of the public or others from the project activities arising as a consequence of his methods of operation.

The Contractor shall comply with all Safety Legislations and its Subsidiary Legislations, Regulations which are in force in the Country and any amendments or re-enactments.

The Contractor shall not permit any person to do anything not in accordance with the generally accepted principles of safe and sound practices. The Contractor shall ensure safe environment on site at all times. The Contractor shall ensure that necessary and sufficient precautions are taken by his workmen when safety provisions are used.

21.15 BARRICADING

The Contractor shall provide and maintain guards, fences or barriers around excavations, pits or other similar potential places of danger to prevent accidents. The barricade should be at least 1.1m high and strong enough to withstand a lateral point load of 50 kg.

21.16 WARNING SIGNS

The Contractor shall display warning signs of sizes 900 mm x 600 mm at a minimum of 4 points around the periphery of the site where the construction activities are located in near the residential area, roads, at locations where there is a chance of children can come to work site and where trespassing is likely to occur. Such signs shall have the words "DANGER - KEEP OUT OF SITE"

21.17 STORAGE OF FUELS

Fuels shall be stored in a room/ enclosed space, the room/ enclosed space shall have impervious platform and berm along the periphery of the storage area to contain spills of the fuels.

21.18 SAFETY OF MACHINERY

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The Contractor shall employ only qualified operators for the machinery to be used on Site. All the machinery shall be locked when they are parked to avoid unauthorized operation of the machinery.

21.19 FIRST AID

At least two first aid kits shall be kept at site for attending the emergency treatment to the victims of accidents or chemical poisoning or excessive exposure to toxic substances. The first aid kit shall include a leaflet of standard First-Aid procedure in addition to the medicines and medical tools. At least one staff member who has undergone First Aid training should be posted at site.

21.20 FIRE SAFETY, EMERGENCY AND RESCUE

The Contractor shall establish Fire Safety, Emergency and Rescue arrangements to contain fire and take necessary action during emergency. The contractor should place fire extinguishers at the work site, materials storage area and at site accommodation. The contractor should keep minimum 6 fire extinguishers within the work place

21.21 ELECTRICAL SAFETY

All electrical equipment should be listed and labeled, free from hazards, and used in the proper manner. The electrician should be protected from electrical shocks and provided necessary safety equipment

All temporary electrical installations in the site should be verified regularly to ensure that all the leaks in the wires are rectified/ faulty wires are replaced. The contractor should also ensure that all electric joints are leak proof.

21.22 PERSONAL PROTECTIVE EQUIPMENT

The Contractor shall provide and maintain suitable personal protective equipment for all workmen employed on the site to provide protection against falling objects and harmful substances which can cause injury. The Personal protective equipment shall include boots, hand gloves, helmet and goggles. The Contractor shall record the issuance of all equipment to his workmen and kept in the site office.

21.23 HOUSEKEEPING

The Contractor shall provide safe working environment by keeping the site neat and tidy, and free from debris. All materials shall be stacked safely. All accesses shall be kept free from hazards and debris.

Housekeeping shall be carried out in such a manner and at such times so as not to cause any inconvenience to either the adjoining owners, occupiers or the public. Debris shall be wetted to minimize the risk of dust. Containers for debris, rubbish and other wastes shall be provided at the designated places.

21.24 OPERATION AND MAINTENANCE

The contractor shall demonstrate and train ministry staff on the operation and maintenance of the water supply system. This includes but not limited to testing and commissioning of pumps, taps, etc. The contractor shall provide operation and maintenance manual for the water supply system.

CHAPTER 22
MECHANICAL SERVICES

22 General

22.1 Aims

Airconditioning load calculations

Calculate the cooling and heating loads using one of the following:

- Manual methods: AIRAH DA9, ASHRAE or Carrier.
- Electronic methods: ACADS-BSG Camel, Carrier E20 or Trane Trace.

Design

General: Provide systems designed in conformance with the following unless specific items of equipment are identified in the schedules.

Outside design conditions: Use outdoor design conditions listed in AIRAH DA9, Table 1 or Table 1A for the location geographically closest to the site and Comfort Conditions.

Inside design conditions:

- Summer: 25°C dry bulb, 50% relative humidity
- Winter: 20°C dry bulb.

Zoning: Divide the systems into temperature controlled zones to suit the proposed uses of the facility and heat loss/gain conditions.

Fresh air: Supply fresh air to spaces with airconditioning systems via the air handling systems as applicable.

Windows, walls, floors and roofs: Refer to drawings for construction and insulation.

Lighting load: Refer to drawings for lighting layout and details.

Supply air: To each airconditioned space ≥ 4.5 L/s/m² at all times the plant is operational.

Ambient noise emitted: Lower than the level that can be heard within a habitable room in any neighbouring premises, regardless of whether any door or window to that room is open.

Fire separation: Refer to drawings.

Heating: Use reverse cycle plant to provide heating.

Duct design: Size ductwork as follows:

- Rigid sheet metal duct: ≤ 6 m/s and ≤ 1.2 Pa/m.
- Flexible duct: ≤ 4.0 m/s.

22.2 Submissions

General

Before starting work, submit the following for approval from the Employers representative:

- Outside design conditions, corresponding geographic location and source of data.
- Calculated total and sensible cooling capacities and heating capacity.
- Name of calculation method used.
- Makes and model numbers of proposed equipment.
- Any assumptions on which the calculations are based.
- Details of any departures from this specification.
- Details of fire provisions.
- A drawing of the proposed duct, pipe and equipment layout. Show proposed zoning and methods of heating.

22.3 Inspection

Notice

Give sufficient notice so that inspection may be made of the equipment in place before connection and commissioning.

22.4 *Note that persons licensed for certain types of work (e.g. electricians) may be licensed to service appliances but not to install airconditioning systems.*

22.5 *Products*

Refer to **Non-ducted** and **Ducted air conditioning system schedules** for details.

22.6 *Airconditioning equipment*

Standards

Ducted airconditioners: To appropriate international standards from country of origin.

Non-ducted airconditioners: To appropriate international standards from country of origin.

Equipment

Performance: Provide equipment as follows:

- Is made by a manufacturer with a demonstrated ability to provide spare parts and service promptly to the site.
- Will operate within the specified range of outdoor design conditions under the calculated loads without excessive head pressure or icing.

Reverse cycle units: Provide an effective outdoor coil defrost facility that prevents room temperature dropping more than 3°C during defrost.

Cabinet: Aluminium, powder coated steel or moulded ABS plastic with metallic-coated steel or stainless steel fasteners. Insulate and vapour seal cabinet and drain trays to prevent external condensation under all operating conditions.

Drain trays: Aluminium, stainless steel or plastic to collect all moisture inside indoor and outdoor units.

Filters: Washable panel type.

Coils: Copper tube with aluminium plate fins.

Controls

Provide the following functions:

- Temperature control for each zone located to accurately sense zone temperature.
- Fan speed selection for multi and variable speed fans.

22.7 *Electric duct heaters*

General

Standard: To appropriate international standards from country of origin.

Elements: Sheathed in steel or nickel alloy.

Frames: Assemble elements in a galvanized steel frame with terminal connections contained in an enclosed terminal box.

Heating section: Install to allow access to the terminal box and removal of the assembly without disturbing other components.

Refer to **Power accessories schedule**.

22.8 *Grilles and diffusers*

Refer to **Air grills schedule** for details.

General

Size and locate diffusers to provide even air distribution and temperatures without draughts.

Ceiling diffusers: Provide at least one per airconditioned room and at least one per 12 m².

Construction:

- Variable volume diffusers: Powder coated pressed steel.
- All others: Powder coated aluminium.

Dampers: Provide a damper to each diffuser and grille. If connected by flexible duct, locate the damper at the duct spigot unless a damper in this position is inaccessible.

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Supply diffusers and grilles

Louvre ceiling diffusers: Multi-bladed, removable core 4-way blow configuration, fitted with a matt black blanking plate for 1, 2, or 3-way blow, as appropriate. If the outlet neck is smaller than the outlet necessary to suit the louvre face size, provide a matt black reducer neck.

Side wall registers: Double deflection type with horizontal front louvre blades and vertical rear blades at 19 mm maximum centres, capable of field adjustment of air throw over the range \square 45°. Support blades > 600 mm long at mid point on a notched support bar.

Return or exhaust grilles – indoor

Ceiling and wall louvre type: Half chevron louvres at 25 mm maximum centres.

Egg crate type (ceiling use only): Elements at 90° to each other, and at 15 mm maximum centres.

Door grilles: Full chevron, 50% minimum free area. Frame to suit door thickness.

External intake and discharge louvres

General: Refer to *Windows* worksection.

22.9 Fans

Refer to **Power accessories schedule** for details.

General

Guards: Provide galvanized steel or bronze mesh guards.

Steel components: Corrosion protect by zinc plating or better.

Motors in air stream: Direct mount to impellers. Provide terminal boxes external to fan casings and wired to fan motors.

Motor minimum degree of protection: IP55.

Bearings: Provide sealed for life or grease packed bearings.

Balancing: Dynamically balance impellers.

Connections: Provide flexible duct connections at fan.

Centrifugal and mixed-flow in-line fans

Casings: Rectangular or circular manufactured from metallic-coated steel sheet, fibreglass or plastic with spigot or flanges for duct mounting.

Impellers: Backward or forward curved blades, constructed from metallic-coated steel, aluminium or polypropylene. Provide fans with non-overloading power characteristics.

Propeller fans

Mounting: Mount on contoured diaphragm plate.

Impellers: Aluminium or UV stabilised ABS or polypropylene.

Window or wall mounted fans

Propeller type: Complete with isolating mountings, discharge cowls or louvres, birdmesh guards and backdraft shutters.

Roof mounted fans

Type: Centrifugal, mixed flow or propeller. Comply with the respective clauses above.

Housing: House fans in compact bases fitted with weathering skirts and manufactured from zinc-coated steel or UV stabilised plastic or composite.

Finish:

- Metallic-coated steel: UV stabilised powder coat to match roof colour.
- Other materials: Manufacturer's standard colour.

Vertical discharge fans: Provide weatherproof galvanized steel, plastic or aluminium backdraft dampers where the weather may enter when units are stopped.

Birdmesh: Where backdraft dampers are not fitted, provide birdmesh guards.

22.10 Execution

22.11 Ductwork

Rigid duct

Material: Metallic-coated sheet steel.

Flexible duct

Material: Alumidised fabric clamped on formed metal helix with insulation blanket wrapped around duct and covered with an outer vapour barrier.

Installation: Install flexible duct as straight as possible with minimum number of bends. Maximise bend radius. Check for and rectify any crushed flexible duct.

Support: Limit sag to < 40 mm/m.

Duct insulation

Insulate ducts to reduce heat gain and prevent condensation. Provide continuous vapour barrier around ducts carrying conditioned air. Insulate flexible connections on ducts carrying air below ambient temperature.

Cleaning

Clean interior of ductwork progressively during installation.

22.12 Refrigeration pipework

General

Conform to equipment manufacturer's recommendations for the refrigerant used.

Deemed to comply: Split system manufacturer's standard pre-charged piping kit.

Pipe insulation

Insulate all refrigerant and drain piping that may sweat with chemically blown closed cell nitrile rubber in tubular form to ASTM C534. Apply to manufacturer's recommendations. Protect insulation from sunlight and mechanical damage.

Insulation thickness: 13 mm for pipes < DN 20, 19 mm otherwise.

Condensate drains

Provide trapped \geq DN 20 condensate drains from each indoor coil and safety tray. Provide drains from each reverse cycle outdoor coil unless casing freely drains to a roof or other location where condensate will not cause damage or pond.

22.13 Unit installation

General

Supply all components and install to manufacturer's recommendations.

Outdoor equipment: Provide clearance around units for condenser air flow and maintenance access. Ensure discharge air does not short-circuit to condenser intake.

Equipment at ground level: Mount on 100 mm high concrete plinth or equivalent impervious material.

Duct connections: Provide internal or external flexible duct connections at indoor unit.

Vibration isolation

Suspended units: Provide \geq 4 metal spring or rubber-in-shear isolation mountings with \geq 25 mm static deflection and 98% isolation efficiency.

Floor mounted units: Provide neoprene waffle pads. Bolt in place.

Safety trays

If leaks or condensation from equipment could cause nuisance or damage to the building or its contents, provide a galvanized steel safety tray under the equipment.

22.14 Completion

Commissioning

Commission the systems to manufacturer' recommendations. Check ductwork for leaks. Test all safety controls by simulating fault.

Air quantities: Balance systems to accord with design air quantities.

Tolerance on air quantities: +10%, -0%.

Check list: Submit signed commissioning check list on completion.

Cleaning

Clean filters, outdoor coils, grilles and diffusers on completion.

Operating and maintenance instructions

Provide written operating and maintenance instructions containing:

- Contractor's contact details for service calls.
- Manufacturer's maintenance and operation literature.
- Manufacturer's warranty certificates if the manufacturer's warranty period is greater than the defects liability period.
- Description of day to day operation.
- Schedule of recommended maintenance.

Record drawing: Provide a drawing of the system as installed.

22.15 Maintenance

General

Provide corrective maintenance on the installation.

Maintenance period: 6 months from the date of commissioning of the systems or the duration of the Defects Liability Period if greater than 6 months.

Warranty: Warrant the installation for the whole of the maintenance period.

Corrective maintenance: Attend site and undertake corrective maintenance within 24 hours of receipt of verbal or written advice.

Maintenance reports: Provide a signed maintenance report setting out the work done and any measured values after each visit.

CHAPTER 23
Water Services

23 General

23.1 Aims

Responsibilities

Provide water services systems subject to the site and other constraints below:

- Cold water services: Connect the cold water supply system to the water source with a stop valve at the connection point. Provide the water source if required to suit the particular conditions as defined on the drawings. Provide the cold water installation to the draw-off points or connections to other services.
- Hot water services: Provide the hot water installation from the cold water connection points to the draw-off points or connections to other services.
- Hose reel system: Provide the hose reel system where defined on the drawings and in the BOQ.
- Sanitary plumbing and drainage: Provide the plumbing and drainage system where defined on the drawings and in the BOQ.
- Stormwater: Provide the stormwater system where defined on the drawings and in the BOQ.
- Subsoil drainage: Provide the subsoil drainage system where defined on the drawings and in the BOQ.

23.2 Inspection

Notice

Give sufficient notice so that inspection may be made of the following:

- Underground pipework prior to concealment.
- Above ground pipework prior to concealment.

23.3 Submissions

Execution details

Before starting the respective portions of the installation, submit the following for approval from the Employers representative:

- Embedded services: Proposed method for embedding services in concrete walls or floors or chasing into concrete or masonry walls.
- Fixing of services: Typical details of locations, types and methods of fixing of services to structure.
- Inaccessible services: If services will be enclosed and not accessible after completion, submit proposals for location of service runs and fittings.
- Proposals for location of exposed piping.

Samples

Provide samples listed in the **Water services samples schedule**.

23.4 Execution

Refer to the **Water system piping schedule** for details of all pipe types.

23.5 Installation generally

Accessories

Provide the accessories and fittings necessary for the proper functioning of the systems, including taps, valves, outlets, pressure and temperature control devices, strainers, gauges and pumps.

Isolating valves: provide valves so that isolation of parts of the system in the event of leaks or maintenance causes a minimum of inconvenience to building occupants.

Arrangement

Services and equipment: Locate and arrange so that:

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- Failure of plant and equipment (including leaks) does not create a hazard for the building occupants and causes a minimum or no damage to the building, its finishes and contents.
- maintenance operations can be carried out in a safe and efficient manner, with a minimum of inconvenience and disruption to building occupants and without damaging adjacent structures, fixtures or finishes.

Embedded pipes

Do not embed pipes that operate under pressure in concrete or surfacing material of a building without prior written approval. If embedding is approved:

- Install in continuous lengths without fittings wherever possible.
- Do not lay across joints between adjoining sections of concrete through which reinforcement does not extend.
- Pressure test and rectify leaks before the concrete is poured.

Penetrations and fixing

Limitations: Do not penetrate or fix to the following without prior approval:

- Structural building elements including external walls, fire walls, fire doors and access panels, other tested and rated assemblies or elements, floor slabs and beams.
- Membrane elements including damp-proof courses, waterproofing membranes and roof coverings.

Fire rated building elements: Seal penetrations with a system that maintains the fire rating of the element.

Membranes: If approval is given to penetrate membranes, provide a waterproof seal to the approval of the Employers representative between the membrane and the penetrating component.

Piping

Install piping in straight lines, plumb and to uniform grades. Arrange and support the piping so that it remains free from vibration and water hammer, while permitting movement in both structure and services. Keep the number of joints to a minimum. Prevent direct contact between incompatible metals.

Concealment: If practicable, conceal piping and fittings requiring maintenance or servicing so that they are accessible within non-habitable enclosed spaces such as roof spaces, subfloor spaces and ducts. Provide at least 25 mm clearance between adjacent pipelines (measured from the piping insulation where applicable).

Cover plates: Where exposed piping emerges from wall, floor or ceiling finishes, provide cover plates of stainless steel or non-ferrous metal finished to match the piping.

Pipe support materials: To be the same as the piping or galvanized or non-ferrous metals, with bonded PVC or glass fibre woven tape sleeves where needed to separate dissimilar metals.

Pits

Location: Install below-ground water meters, control valves and gas regulators in concrete access pits with removable pit covers.

Internal dimensions: To give 300 mm clear space all around the fittings in the pit.

Concrete: Grade M-200, 100 mm thick, with reinforcement fabric.

Pit covers: To be minimum of 5mm thick steel covers with finger holes for easy removal.

Installation: Grade floor to a point on one side and drain to the stormwater drainage system. Carry the pit walls up to 50 mm above finished ground level. Cast in the pit cover frame flush with the top. Trowel the top smooth.

Valve boxes

Location: Install underground isolating valves in concrete access pits with removable pit covers.

Identification: Mark the box covers with the name of the service.

23.6 Installation of fixtures

General

Accessories: Use manufacturer's brackets and accessories where these are available and suitable for the mounting substrate.

Protection: Deliver fixtures to site protected from damage under site conditions by coatings, coverings and packaging. Remove only sufficient protection to permit installation.

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Installation

Connections: Connect to each fixture supply and waste services. Install plumb and level.

Cutting and fitting: If it is necessary to cut and/or fit substrate to install an item carry out this before the surface is finished or painted. Remove items when required for painting and protect until re-installed. Reinstall when painting and finishing is complete. Cap or plug the open ends of pipes.

Substrate and fixings: Before installation make sure that the substrate to which the fixtures are to be installed is adequate. In solid walls confirm adequacy of the material at fixing locations.

23.7 Painting, finishes and marking

Exceptions

Do not paint chromium or nickel plating, anodised aluminium, glass reinforced plastic, stainless steel, non-metallic flexible materials and normally lubricated machined surfaces.

Finishes

Finish exposed piping, including fittings and supports, as follows:

- In internal locations such as toilet and kitchen areas: Chrome plate copper piping with bright finish.
- Externally and steel piping and iron fittings internally: Paint.
- In concealed but accessible spaces (including cupboards and non-habitable enclosed spaces): Leave copper and plastic unpainted except for identification marking. Prime steel piping and iron fittings.

Valves: Finish valves to match connected piping.

Marking and labelling

Mark services and equipment to provide a ready means of identification.

- Locations exposed to weather: Provide durable materials.
- Pipes, conduits and ducts: Identify and label.

Consistency: Label and mark equipment using a consistent scheme across all services elements of the project.

23.8 Hot and cold water services

Fittings and accessories

Provide the fittings necessary for the proper functioning of the water supply system, including taps, valves, backflow prevention devices, temperature control devices, strainers.

Line strainers

Type: Low resistance, Y-form bronze bodied type, with screen of dezincification resistant brass, stainless steel or monel.

Screen perforations: 0.8 mm maximum.

Piping insulation

Application: Fit insulation tightly to piping surfaces without gaps. Minimise number of joints. Insulate fittings for the same thermal resistance as the piping insulation. Install the insulation on unions and other items requiring service so that it is readily removable. Provide supports formed to fit around the insulation so the insulation thickness is reduced by < 10%.

Material: Select from the following:

- Polyester in moulded tubular sections faced with factory bonded aluminium foil laminate or integral polyester scrim.
- Polyolefin foam: Cross linked closed cell polyolefin foam faced with factory bonded aluminium foil laminate.

Tapware

Provide the tapware in accordance with the **Sanitary fixtures schedule**.

Metal heads and handles: Provide brass fittings or suitably bush to prevent electrolysis and growth.

Plastic heads and handles: Provide break-resistant fittings of a compact nature, to prevent fracture and exposure of jagged or rough edges.

Tap positions: Locate hot tap to the left of or above, the cold tap.

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Thermostatic mixing valves

Water temperature regulated by a single hand control, capable of delivering water at the temperature of either of the supply systems and at any temperature in between and suitable for controlling single or multiple outlets, as appropriate. Refer to the **Sanitary fixtures schedule**.

Controls: Incorporate the following:

- A temperature sensitive automatic control which maintains temperature at the pre-selected setting and rapidly shuts down the flow if either supply system fails or if the normal discharge water temperature is exceeded.

23.9 Water heaters

Standard electric systems

Provide standard electrical water boilers as identified in the BOQ to locations identified on the drawings. Refer to the **Water heater schedule**.

Solar water systems

Provide a proprietary automatic water heater comprising solar collector and storage container, with or without supplementary heating unit and including connections, controls and necessary fittings.

23.10 Hose reels

General

Provide hose reels with swivel hose guides in accordance with the **Fire hose reels schedule**.

23.11 Storm water

Cleaning

During construction, use temporary covers to openings and keep the system free of debris.

Downpipe connections

Turn up underground drainage pipelines to finish 50 mm above finished ground or pavement level.

Access Pits

Cover levels: Locate the top of covers or gratings, including frames as follows:

- In paved areas: Flush with the paving surface.
- In landscaped areas: 25 mm above finished surface.

Storm water drains

Provide storm water drains to connect downpipes, surface drains, subsoil drains and drainage pits to the outlet point or discharge point.

Downpipe connections: Turn up underground drainage pipelines with bends to meet the downpipe, finishing 50 mm (nominal) above finished ground or pavement level. Seal joints between downpipes and drains. Alternatively, terminate downpipe minimum of 100mm above adjacent ground level and discharge water to surface run off area. Allow for scour protection to bottom of downpipe.

Lined surface drains-grated trenches

Provide precast or cast in situ concrete lined trenches with painted or galvanized steel gratings.

23.12 Subsoil drains

General

Provide subsoil drains to intercept groundwater seepage and prevent water build-up behind walls and under floors and pavements. Connect subsoil drains to surface drains or to the storm water drainage system as applicable.

Connection: Connect subsoil drains to the storm water drainage system.

Filters: UV resistant geotextile material with a permeability ≥ 10 times that of the native soil and capable of retaining particles of 0.25 mm size. Securely fit or join the sock at each joint.

Subsoil drains: Provide proprietary perforated plastic pipe.

23.13 Sanitary plumbing and drainage

Vent pipes

Staying to roof: If fixings for stays penetrate the roof covering, seal the penetrations and make watertight.

Terminations: Provide bird-proof vent cowls of the same material and colour as the vent pipe.

Sanitary fixtures

Provide sanitary fixtures in the **Sanitary fixtures schedule** complete with all accessories necessary for correct installation and use.

23.14 Completion

Testing

Hydrostatic tests: Do not install insulation until the piping has been tested. Pressure test cold and hot water services to ensure that all pipework is free from leaks. Include pipe joints, valve seats, tap washers and strainers. Repair as necessary, replace if damaged and retest.

Completion

Hot and cold water services: On completion, flush pipelines using water and leave them clean.

Storm water and wastewater services: On completion, flush the system using water and leave clean.

Charging

On completion of installation, commissioning, and testing, fill the hot and cold water systems with water, turn on control and isolating valves and the energy supply and leave the water supply system in full operational condition.

Operation and maintenance manuals

Provide written operating and maintenance instructions containing:

- Contractor's contact details for service calls.
- Manufacturer's maintenance and operation literature.
- Description of day-to-day operation.

Record drawings

Provide a drawing of the system as installed. Show dimensions, types and location of the services in relation to permanent site features and other underground services. Include all changes made during commissioning and the maintenance period.

Diagrams: Include diagrammatic drawings of each system.

Services below ground: Where pipes and fittings are below ground show the depth and dimensioned references that will allow the future location of the service for maintenance or expansion.

CHAPTER 24 SEWERS

24.01. Generals

This section covers the requirements for constructing gravity sanitary sewers and service connections.

Non pressure sewer pipe shall be Ductile Iron pipe (DIP), unplasticised polyvinyl chloride (uPVC), Reinforced Concrete Pipe (RCP), Vitrified Clay pipe (VCP), or high density polyethylene pipe (HDPE).

Sewer construction shall conform to applicable local Standards for construction and testing of drains and sewers. In the absence of appropriate local Standards, International Standards shall apply. This reference to Standards shall apply throughout this specification.

24.02 Materials

24.02.1 Ductile iron

DI pipe will be used for all branch sewers crossing roads or railways, for all inverted siphons at stream crossings, and in all above ground installations.

Pipes and fitting shall be cement lined and bituminous seal coated inside.

24.02.2 uPVC pipe and fittings

BS EN 124

BS EN 681-2: 2000

BS EN 1277: 2003

BS EN 1401: 2009

uPVC pipes and fittings are intended for the use on all non pressure branch sewers less than 280mm in diameter.

Smooth wall uPVC pipe and fittings with locked-in gasket and integral bell system, pressure class 600 shall be used

The Contractor shall be responsible for the compatibility of fittings with the uPVC pipes offered.

The Contractor shall furnish copies of certificates of quality control tests carried out during manufacture of the pipes and fittings and shall if required by the Employers Representative undertake such additional tests as he considers necessary at the Contractor's expense.

Gasketed Saddles

Sewer saddles shall be moulded uPVC 'Tee' or 'Wye' with bolt on straps. The straps, bolts and nuts shall be of stainless steel.

Sewer saddles shall be gasketed and leak proof. The "O" ring material shall be of elastomeric material.

Couplings

uPVC coupling shall be injection moulded, slip over or similar type suitable for working pressure of 12 bars, unless otherwise specified.

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Joint rings shall be of elastomeric material.

24.02.3

Reinforced concrete pipes

Reinforced concrete pipe shall be used for trunk sewers, and all sewers ranging from 300mm to 1000 mm in diameter.

The pipe interior shall be smooth and even, free from roughness, projections, indentations, offsets, irregularities of any kind. The concrete mass shall be dense and uniform. Concrete pipes shall be free from fracture, large or deep cracks, and surface roughness. The planes of the ends of the pipe shall be perpendicular to the longitudinal axis

Reinforced concrete pipes shall have a minimum nominal length of 2.0 m except as otherwise specified or required for special purposes such as curves, closures or built in pipes. The maximum nominal length shall be 6m.

Pipe joints shall be spigot and socket type with flexible water tight confined "O-ring" synthetic rubber gasket with neoprene elastomer. Joint details shall be submitted to the Employers Representative for review and approval before commencement of pipe manufacture.

All reinforced concrete pipe shall be spun and lined with 12.5 mm thick high alumina lining consisting of 12.5 mm of sulphate resistant type V Portland Cement (one part), Granite dust passing no. 100 BS sieve and 2 1/2 parts of fine aggregate with sufficient clean water to ensure maximum density.

Interior surfaces shall be covered with two coats of an approved bituminous coating. Coating shall be applied by the manufacturer at the plant.

24.02.4

High Density Polyethylene (HDPE) pipes

Corrugated PE pipes shall not be installed for sewers.

HDPE pipes will be used for branch sewers 280 mm in diameter or less installed in areas with high groundwater table or on steep slopes.

High density polyethylene pipes for non-pressure sewers shall be class PE100, pressure rated PN8.

All polyethylene pipes and fittings are to be joined by means of thermal fusion in accordance with the recommendations of the manufacturer. Gasketed jointing systems and couplers are not accepted.

24.03 Execution

24.03.1 Preparation

Clean pipes and fittings of debris and water before installation. Inspect materials for defects before installing.

Remove defective materials from site.

24.03.2 Trenching and backfilling

Do trenching and backfill work shall be carried out in accordance with Section 2.4 of the General Specification

Trench line and depth as well as condition of trench bottom require approval prior to placing bedding material and pipe.

Do not backfill trenches until pipe grade and alignment have been checked and accepted and infiltration and exfiltration test results are within the limits specified. If the pipe is backfilled for any reason prior to testing, the Contractor must accept responsibility to meet the tests or to re-excavate and repair the line at his expense.

24.03.3 Concrete bedding and encasement

Do concrete work in accordance with Sections 3.1, 3.2 and 3.3

Pipe may be positioned on concrete blocks to facilitate placing of concrete. Rigidly anchor or weight pipe to prevent flotation when concrete is placed if necessary.

Do not backfill over concrete within 24 hours after placing.

24.03.4 Granular bedding

Place granular bedding materials in accordance with details specified or directed.

Shape bed true to grade and to provide continuous, uniform bearing surface for barrel of pipe. Do not use blocks when bedding pipe.

Shape transverse depressions as required to within bell if bell and spigot pipe is used.

Compact full width of bed to at least 95% of corrected maximum dry density.

Fill excavation below bottom of manholes or structures with specified bedding material or common backfill according to standard drawings and specifications.

24.03.5 Installation

Lay and join pipes in accordance with manufacturer's recommendations.

Handle pipes only with approved equipment. Do not use chains or cables passed through the pipe bore so that weight of pipe bears upon pipe ends.

Use laser-type instrument to control line and grade for sewers.

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Lay pipes on prepared bed, true to line and grade, with pipe invert smooth and free of sags or high points. Ensure barrel of each pipe is in contact with shaped bed throughout its full length.

Commence laying at outlet and proceed in upstream direction with bell ends of pipe facing upgrade.

Check alignment between manholes as each portion is laid by means of a strong light shone through the pipe from manhole to manhole. If less than half the full pipe cross-section at the light source is visible at the other end, realign pipes at no additional cost.

Do not allow water to flow through pipe during construction.

Whenever work is suspended, install a removable watertight bulkhead at the open end of the last pipe laid to prevent entry of foreign materials.

Position and join pipes by approved methods. Do not use excavating equipment to force pipe sections together.

24.03.6 Joining

24.03.6.1 uPVC Pipe Joining:

- Install gaskets as recommended by manufacturer.
- Support pipes with hand slings or crane as required in order to minimize lateral pressure on gasket and maintain concentricity until gasket is properly positioned.
- Align pipes carefully before joining.
- Maintain pipe joints free from mud, silt, gravel and other foreign material.
- Avoid displacing gasket or contaminating with dirt or other foreign material. Remove disturbed or dirty gaskets; clean, lubricate and replace before joining is attempted. Use only manufacturers recommended lubricant.
- Complete each joint before laying next length of pipe.
- Minimize joint deflection after joint has been made to avoid joint damage.
- Apply sufficient pressure in making joints to ensure that joint is complete as outlined in manufacturer's recommendations.
- At rigid structures, install pipe joints not more than 600 mm from side of structure.

Make watertight connections to manholes or other structures. Provide details of proposed method of installing pipe stubs in structure walls to ensure a watertight joint. In the case of pre-cast manhole bases an integral joint gasket may be cast in the manhole wall to receive the pipe stub. In the case of cast-in-place manhole bases the exterior pipe surface in contact with the structure wall shall be roughened or treated to provide a bond with the concrete. Any grout used to be non-shrink type.

24.03.6.2 Concrete pipe joints:

- Pipe Interior: Circular pipes 700 mm in diameter and larger, and arch or elliptical pipe equivalent to 900 mm diameter or larger shall have interior gap between ends of adjacent pipes filled with mortar. Apply mortar a minimum 7 days after backfilling has been completed to allow pipe settlement to occur. Finish interior surface of joints smooth.

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- Pipe Exterior: For bell and spigot pipe, mortar to be used for caulking outside of joints. Press and caulk mortar into place. Allow mortar to set minimum of one hour before backfilling.

Block pipes as directed when any stoppage of work occurs to prevent creep during down time.

Ensure completed joints are restrained by compacting bedding material alongside and over installed pipes. Backfill to prevent flotation as required.

Cut pipes as required for special inserts, fittings or closure pieces in a neat manner, as recommended by pipe manufacturer, without damaging the pipe or its coating and to leave a smooth end at right angles to axis of pipe.

Make watertight connections to manholes or other structures. Provide details of proposed method of installing pipe stubs in structure walls to ensure a watertight joint. In the case of pre-cast manhole bases an integral joint gasket may be cast in the manhole wall to receive the pipe stub. In the case of cast-in-place manhole bases the exterior pipe surface in contact with the structure wall shall be roughened or treated to provide a bond with the concrete. Any grout used to be non-shrink type.

Where a pipe enters the manhole it shall be cradled with class B concrete half the diameter of the pipe to a joint in the pipe, distance 1.8 m from the manhole. Place non-shrink grout in the remaining space between the concrete cradle and the manhole wall filling the void between the pipe, the seal gasket and the manhole wall.

When placing sewers on steep slope of 20% or greater, they shall be anchored securely with concrete anchor blocks.

Where pipe enters a manhole with precast seal, and is bedded on undisturbed (not over-excavated) earth, the cradle is not necessary. The connection shall be sealed on the manhole exterior with a non-shrinking grout material and painted with a bituminous sealant.

Use prefabricated saddles or approved field connections for connecting pipes to existing sewer pipes. Joint of saddle to pipe shall be structurally sound and watertight.

Leave joints and fittings exposed for ex-filtration testing. Provide protection when required. If it is necessary to backfill sections of the sewer prior to testing, take full responsibility and bear all costs for any additional excavation and backfill to expose pipe, fittings or joints that may be necessary.

When the infiltration and ex-filtration test results are acceptable to Employers Representative, backfill the remainder of trench in accordance with Section 2.4.

Hand place granular material in uniform layers not exceeding 150 mm thick to minimum 300 mm over top of pipe. Dumping of material directly on top of pipe is not permitted.

Place layers uniformly and simultaneously on each side of pipe to prevent lateral displacement of pipe.

Compact each layer to at least 95% maximum density.

All exterior surfaces of concrete pipes that will remain exposed shall be coated by the pipe manufacturer with a minimum 650 microns dry thickness of a heavy duty, 100 percent solid coal-tar epoxy durable abrasion resistant and especially designed for production line application on moist concrete.

FIELD TESTING

24.04.1 General

After the gravity sewers have been laid and backfill has been placed to 600mm above the pipe, a light will be flashed between manholes, or if the manhole has not yet been constructed, between the location of manholes, by means of a flashlight or mirrored light, to determine whether the alignment of the main is true and whether any pipe has been displaced subsequent to laying. If alignment is correct and no other defects are disclosed, backfilling may be continued. If the test shows poor alignment of the main, misplaced pipes or other defects, such defects shall be remedied by the Contractor, as required by the Employers Representative, before the work of backfilling proceeds.

After backfilling has been done, the Contractor shall make tests to ascertain if joints are tight. Leaky or poor joints shall be repaired, or removed at once by the Contractor to the satisfaction of the Employers Representative.

No section of gravity sewer lines shall be tested for leakage before backfilling in that section has been completed. If this condition has been fulfilled, the sewer lines shall be tested for leakage between manholes as the work progresses.

The Contractor shall perform the tests and shall furnish all apparatus and materials including water required for the tests.

The tests will be witnessed by the Employers Representative.

24.04.2 Tests

The following tests shall be made:

- All sewers shall be tested by making exfiltration or infiltration tests
- Smoke test shall be required in lieu of exfiltration or infiltration tests, or airtests, only where conditions are not appropriate for these tests. Smoke testing shall be done prior to the placement of any paving material. Repair or replace pipe, pipe joint or bedding found defective.

Perform infiltration or ex-filtration testing as soon as practicable after jointing and bedding are complete, and service connections have been installed.

Do infiltration and/or ex-filtration testing as directed. Perform tests in presence of Employers Representative. Give notice of tests in accordance with the Conditions of Contract.

Carry out tests on each section of sewer between successive manholes including service connections.

Install watertight bulkheads in suitable manner to isolate test section from rest of pipeline.

24.04.3 Filtration testing

Ex-filtration test:

- Fill test section with water in such a manner as to allow displacement of air in line.

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- Immediately prior to test period add water to pipeline until there is a head of 1 metre over interior crown of pipe measured at highest point of test section or water in manhole is 1500 mm above static ground water level, whichever is greater.
- Duration of ex-filtration test shall be one hour.
- Water loss at end of test period shall not exceed maximum allowable ex-filtration over any section of pipe between manholes.

Infiltration test:

- Conduct infiltration test in addition to ex-filtration test.
- Install a watertight plug at upstream end of pipeline test section.
- Discontinue pumping operations for at least 3 days before test measurements are to commence and during this time keep thoroughly wet at least one third of pipe invert perimeter.
- Prevent damage to pipe and bedding material due to flotation and erosion.
- Place a 90o V-notch weir, or other measuring device approved by the Employers Representative in invert of sewer at each manhole.
- Measure rate of flow over a minimum of 1 hour, with recorded flows for each 5 min interval.

Infiltration/ex-filtration shall not exceed 4.63 litres per millimetre of internal pipe diameter per kilometre per 24 hours which are the following limits in litres per hour per 100 m of pipe, including service connections.

Table 24.04.3 Gravity Sewer Pipe Maximum Allowable Leakage

Internal Pipe Diameter (mm)	Maximum Amount (litre/hr)
100	1.93
150	2.89
200	3.86
250	4.83
300	5.79
350	6.75
400	7.72
450	8.68
500	9.65
550	10.61
600	11.58
700	13.51
800	15.44
900	17.37

This allowance shall include leakage in manholes along the length of the line.

Repair and retest sewer line as required, until test results are within limits specified at no additional cost to the Contract. Repair visible leaks regardless of test results.

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24.04.4 Television inspections:

- Prior to TV inspection remove foreign material from sewers and related appurtenances by flushing with water
- Television equipment shall consist of a self-contained colour camera and a monitoring unit connected by a 3 wire coaxial cable. The camera shall be small enough to ensure passage through a 150 mm sewer, shall be waterproof, and shall have a self-contained remotely controlled lighting system of varying the illumination of the interior of the sewer line for inspection and photographic purposes. Picture quality shall be such as to produce a continuous 600-line resolution picture showing the entire periphery of the pipe. All video must be in DVD format. An audio description of the inspection must also be provided. The monitor used shall be not less than a 13 inch colour monitor.
- Carry out inspection of installed sewers by television camera.
- If defective work is found by such inspections, repair sewer line and repeat television inspections as required until all defective work has been corrected, at no additional cost to the Employer.
- All DVD of television inspections are to be submitted to the Employers Representative as a permanent record.

A sewer section is defined as the length of pipe between successive manholes.

24.04.5 DEFLECTION TESTS

Deflection Test for PVC, HDPE, DI and Plastic pipes

- Carry out a deflection test on all sections of the sewer. The maximum allowable deflection under fully backfilled and compacted trench conditions shall not exceed 5% before 30 days and 7.5% after 30 days.
- Locations with excessive deflection shall be repaired and/or the pipe replaced at the Contractor's expense. The equipment used for the deflection test shall be that as recommended by the manufacturer, and may include an Electronic Deflectometer or a Rigid "Go-No-Go" Device. For the purpose of deflection measurement, the base inside diameters and the deflection mandrel dimensions are provided in the following table. To ensure accurate testing the lines shall be thoroughly cleaned. The 5% and 7.5% deflection mandrel against nominal size of pipe shall be in accordance with the relevant standards.
- For nominal sewer sizes not shown in above table the Mandrel dimensions shall be calculated as follows:

$$\text{Mandrel O.D.} = \frac{(100-Y)}{100} \times \text{Base I.D.}$$

Where Y = Deflection Limit in %

24.04.6 ADDITIONAL TV INSPECTION

Additional Television inspection of the sewers

The Contractor shall perform television inspection of sewers within 30 days of the expiry of the defects liability period to compare the condition of collection system before and after

STANDARD TECHNICAL SPECIFICATION

defects rectification. The Contractor shall remedy defects in compliance with the relevant clause of the Conditions of Contract. Emptying and cleaning of the facilities shall be done by the Contractor. The inspection procedure and the submittal requirements for additional television inspection shall be same as that of item (3) above.

24.05 Sewer Manholes

24.05.1 General

This section specifies requirements for constructing new manholes and service connection manholes.

24.05.2 Materials

Concrete and reinforcement

Refer to Sections 3.1, 3.2 and 3.3 of the specification.

Concrete mix design to produce 30 MPa for pre-cast manholes, catch basins and ditch inlets and 25 MPa for cast-in place manholes. Maximum size aggregate shall be 40 mm except 28 mm for pre-cast units.

24.05.3 CONCRETE MANHOLES

Pre-cast manhole sections

Walls of manholes shall be constructed of reinforced concrete ring sections with a minimum inside diameter of 900 mm. Riser sections shall have tongue and groove ends (tongue on top of section) and a minimum wall thickness of 125mm. Top sections shall be of eccentric cone or flat slab top design as indicated by the Contract drawings. Eccentric cones shall have the same minimum wall thickness and area of circumferential steel reinforcement as the round riser sections. Flat slab tops shall have a minimum thickness of 150 mm and shall be reinforced with steel in accordance with the appropriate design standard. Top sections shall have a top width of such design and dimensions as to properly support the required manhole frame and cover and the lower joint shall be of tongue and groove design.

Top sections of eccentric cones or flat tops shall have an offset opening of 750 mm for vertical ladder installation. Top sections shall have four (4) anchoring devices, equally spaced to receive 75 mm frame anchor bolts on flange B.C. pattern.

The entire exterior surface of all manholes shall be coated with two (2) coats of an approved bituminous coating, minimum 2.3 mm in thickness.

All sections shall contain factory installed lifting keys or lugs.

All sections shall be cured by the manufacturer not less than 7 days before transporting and date stamped with the casting date.

Reinforced concrete manhole bases

Pre-cast reinforced concrete bases shall normally be used in lieu of cast-in-place concrete bases.

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The base, for either type, shall extend 150 mm beyond the outside face of the manhole wall and shall be at least 200 mm thick.

Cast-in-Place bases for up to 400 mm sewers shall have one mat of No. 4 deformed Grade 60 reinforcing steel on 300 mm centres placed midway in minimum 200 mm thick base.

Pre-cast bases shall have factory installed pipe seals.

Pre-poured flow lines in base will be approved only after inspection of a completed example.

Pre-cast Joints: to be made watertight using rubber ring gaskets.

24.05.4 Pre-cast grade rings

Pre-cast concrete grade rings of 50, 75, 100 and 150 mm height shall be manufactured in accordance with ASTM C-478.

Rings shall have pre-cast bolt holes matching cone or flat top sections and be of diameter to support full manhole frame.

Field moulding of grade rings will not be permitted.

24.05.5 Manhole steps

Ladder rungs/steps shall be of 19 mm dia (minimum), polypropylene coated galvanized steel.

Place all steps on 300 mm centres.

Portion of steps embedded in concrete shall be given a coat of heavy bodied bituminous paint.

24.05.6 Pipe opening seals

Pipe opening seals shall be cast integrally with manhole section, sized to fit pipe specified, and set at correct elevation and location.

24.05.7 Preformed plastic sealing compound

Sealing compound shall be of either bituminous or butyl rubber base.

Material shall be in rope form, supplied with a two-piece cover to prevent adhesion until use.

24.05.8 Water stops

Water stops shall be composed of virgin Polyvinyl chloride (PVC) or rubber with stainless steel bolts and nuts, sized for respective pipe.

24.05.9 Manhole frames and covers

Heavy duty ductile iron pre-locked circular manhole cover in hexagonal frame, suitable for road surfaces. Non-'rock' nylon cushion insert for stability under load.

Cover cast without perforations and complete with two 25 mm sealed keyways. Clear opening to be 600 minimum, or such larger size as required. Frame is 100 mm deep.

Provide a minimum of 18 lifting keys.

Frames shall contain four (4) 25 mm holes equally spaced to match manhole inserts for fastening.

All manhole covers shall bear the wording required by the Employer and described in the drawings.

STANDARD TECHNICAL SPECIFICATION

24.05.10 Watertight manhole frame and cover

This item shall be same as specified above except that the cover shall have a neoprene gasket contained in a factory machined dovetail or rectangular groove in the bearing side of cover.

Cover shall have hold-down bolts and washers of stainless steel or bronze.

24.05.11 PE manholes

a) Manhole design

The PE manholes are made with concentric, eccentric and full open tops. Manholes in highway traffic areas require a reinforced concrete pad to distribute vehicle load to surrounding soil. The DI manhole cover complying with the relevant Standard shall be installed in such a way to transfer vertical loads directly to the ground all in accordance with manufacturers' recommendations. The manholes shall have PE coated metal runs or protected ladder attached firmly to the vertical wall. The benched bottom is required to facilitate undisturbed flow. The inlet, outlet, cleaning and vent pipes to PE manholes shall be attached around the circumference of the manhole. The extrusion welding is recommended for pipe connections. Welded gussets or ribs to inlet and out let pipes provide strong connection.

The proper anchoring of PE manhole against flotation and thermal expansions due to variation in Ground Water Table and ambient temperature should be carried out. The Contractor shall propose an appropriate anchoring option to the Employers Representative for approval.

b) Submittals

The Contractor shall submit test certificates, drawings, calculations of PE manhole designs, (ring compression, combined ring compression, buckling, axial strain, features and thickness of base) fabrication procedure etc to the Employers Representative for approval.

1Manholes, Execution

24.06.1 Excavation and backfill

Excavate and backfill is to be in accordance with Section 2.4 of the Specification.

The Employers Representative is to inspect and approve excavations before the installation of outfall structures, manholes, catch basins, valve chambers or ditch inlets.

Do not backfill any manhole or other structure for which a leakage test is required, prior to completion of testing and acceptance of test by the Employers Representative.

24.06.2 Concrete work

Do concrete work in accordance with Sections 3.1, 3.2 and 3.3

24.06.3 Installation

Construct units in accordance with details indicated, plumb and true to alignment and grade.

Complete units as pipe laying progresses. Maximum of three units behind point of pipe laying will be allowed.

STANDARD TECHNICAL SPECIFICATION

Pump excavation free of standing water and remove soft and foreign material before placing base. Fill any excavation below level of bottom of specified bedding as outlined in Section 2.4

Cast base directly on undisturbed ground or set a pre-cast concrete base on 150 mm minimum of well compacted granular material.

- (1) Bases for pre-cast units:
 - (i) Make each successive joint watertight with approved rubber ring gaskets. Each lifting ring hole shall be grouted with non-shrink grout.
 - (ii) Clean surplus grout and joint compounds from interior surface of unit as work progresses.
 - (iii) Flow channels shall be placed after pipe placement.
- (2) Bases for cast-in-place units:
 - (i) Place stub outlets and bulkheads at elevations and in positions indicated.
 - (ii) Bench to provide a smooth U-shaped channel. Side height of channel to be full diameter of sewer. Slope adjacent floor at 1 on 5. Curve channels smoothly. Slope invert to establish sewer grade.
 - (iii) Apply two coats of cement rendering to manhole benching. Cement rendering shall consist of one part cement and two parts sand with sufficient mixing water. Surface to be rendered shall be roughened before concrete has fully set, and immediately before rendering is applied, cleaned of all oil, grease, laitance or foreign matter. Keep surface moist. Roughen between coats. Work into surface and give last coat smooth, steel trowel finish.
 - (iv) Flow channels shall be formed directly in the concrete of the manhole base and shall be smooth and accurately shaped to a semi-circular bottom conforming to the inside of the adjacent sewer sections. Changes in the direction of the sewer and entering branches shall have a true curve of as large a radius as the size of the manhole will permit.
 - Complete concrete placement around pipe openings, working well into water stop. Finish flush on outside.
 - All slopes (benches) outside flow channels shall be sloped gradually towards the invert.
- (3) Manhole Sections
 - (i) All pre-cast concrete ring sections and top sections shall fit together readily to permit effective jointing. Joints between adjacent sections of all manholes shall be made with two (2) strips of approved preformed joint sealing compound. All material squeezed out on inside shall be cut off.
 - (ii) Adjoining riser and conical top sections shall be fitted together in such a manner as to assure true vertical alignment of manhole steps.
- (4) Manhole Frame and Covers
 - (i) Set manhole frame to proper elevation and to cross-section slope where required. Set in a bed of Portland cement and silica sand, and bring mortar up over frame.
 - (ii) Where adjustment is required [maximum one 300 mm], use pre-cast concrete grade rings. Set in two (2) strips of preformed plastic sealing compound, taking care to align bolt holes. Paint exterior surface with two (2) coats bituminous paint. Recheck elevation due to possible sealant compression.

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- (iii) Tighten down manhole frame using bolts long enough to reach insert in cone or flat top section.
- (iv) The Contractor shall be responsible to see that all such items as mentioned under this Section are adjusted to the new paving elevation to provide a smooth even transition from pavement to manhole cover.

Clean units of debris and foreign materials. Remove fins and sharp projections. Prevent debris from entering system.

(5) Drop Manholes

- (i) Drop connection shall be made where the invert of any inlet pipe is 600 mm or more higher than the invert out of the manhole.
- (ii) Pre-cast manhole sections shall have openings with integrally cast pipe seals to fit design elevations for new installations.
- (iii) Connection configuration to manhole shall be made in accordance with Standard Detail Drawings.
- (iv) Entire configuration of piping shall be encased in Class B concrete to a minimum thickness of 150 mm.
- (v) Paint entire surface of encasement, when dry, with an approved bituminous coating.

24.06.4 Infiltration and exfiltration test

Install watertight plugs or seals on inlets and outlets of each new sanitary sewer manhole and fill manhole with water. Keep manhole full for 24 hours to allow maximum absorption. Leakage must not to exceed 0.3% per hour of volume of manhole.

If permissible leakage is exceeded:

- (i) By up to 0.03% per hour of the volume of the manhole defects may be corrected on site by the manufacturer's representative using injected polyurethane. Concrete mortar grouting is not acceptable. Repeat testing until acceptable.
- (ii) By more than 0.03% per hour of the volume of the manhole, the manhole must be replaced at the Contractor's expense.

In areas of high ground water the allowable infiltration shall not exceed 0.3% per hour of the volume of the manhole.

Test any water retaining structure or special manhole in accordance with this section.

CHAPTER 25

ANTI - TERMITE PRE - CONSTRUCTION CHEMICAL TREATMENT IN BUILDINGS

SCOPE:

This specification covers the general requirements for anti-termite constructional measures, chemical treatment of soils for the protection of buildings from attack by subterranean termites, chemicals to be used with their minimum rates of application and procedure to be followed while the building is under construction.

GENERAL:

The contractor shall furnish all tools, plants, instruments, qualified supervisory personnel, labour, materials, any temporary works, consumables, any and everything necessary whether or not such items are specifically states herein for completion of the job in accordance with specification requirements.

All work shall be done in the order of progress required by Owner's construction programme. The contractor shall take all necessary precautions to prevent any accident in connection with the performance of the work. On final completion of all the work, the contractor shall leave the entire premises within the site of his operation clean and free from all rubbish resulting from his operation.

The employer's representative reserves the right to inspect, check and direct any or all operations at any stage of the work and to required unsatisfactory work to be remedied at the contractor's expense. No work shall be carried out under unsuitable weather conditions viz. when raining or when the soil is wet due to rain or sub-soil water.

Chemicals shall be brought to site of work in sealed original containers. The materials shall be brought in, at a time, in adequate quantity to suffice for the work. The materials shall be kept in cool and locked stores. The empties shall not be removed from the work site till the relevant item of work has been completed and permission granted by Owner / Engineer.

Chemicals available in concentration forms with concentration indicated on the sealed containers only shall be used. Chemicals shall be diluted with water in required quantity before use, using graduated containers to achieve the desired percentage of concentration:

Examples : Aldrin 20 - 1 Lt. is diluted to 40 lts. to give 0.5% emulsion.

Aldrin 18 - 1 Lt. is diluted to 35 lts. to give 0.5% emulsion.

Chlordane 20 - 1 Lt. is diluted to 20 lts. to give 1.0% emulsion.

PRE - CONSTRUCTIONAL CHEMICAL TREATMENT:

ESSENTIAL REQUIREMENTS:

Hand operated pressure pump with graduated containers shall be used to ensure uniform spraying of the chemicals. Continuous check shall be kept to ensure that the specified quantity of chemical is used for the required area during the operation.

CONDITION OF FORMATION:

The treated soil barrier shall be complete and continuous under the whole of the structure to be protected. All foundations shall be fully surrounded by and in close contact with the barrier of treated soil. Each part of the area treated shall receive the specified dosage of chemical.

TIME OF APPLICATION:

Soil treatment shall start when the foundation trenches and pits are ready to receive mass concrete in foundations. Laying of mass concrete shall start when the chemical emulsion has been absorbed by the soil and the surface is quite dry. Treatment shall not be carried out when it is raining or soil is wet with rain or sub-soil water. The foregoing earth surface within the plinth before laying the sub-grade for the floor.

DISTURBANCE:

STANDARD TECHNICAL SPECIFICATION

The treated soil barriers shall not be disturbed after they are formed. If by chance, treated soil barriers are disturbed immediate steps shall be taken to restore the continuity and completeness of the barrier system.

CHEMICALS, METHOD AND RATE OF APPLICATION:

a. MOUND TREATMENT :

Termite mounds within the plinth and contingent apron area shall be destroyed by means of insecticides in the form of water suspension or emulsion which shall be poured into the mounds at several places after breaking open the earthen structure and making holes with crow bars. For a mound volume of about one (1) cum, four (4) litres of an emulsion in water of one of the following shall be used.

- i. 0.25 % Aldrin
- ii. 0.25% Heptachlor
- iii. 0.5% Chlordane

b. SOIL TREATMENT :

Any one of the following chemical (conforming to Indian Standards) in water emulsion shall be applied uniformly over the area to be treated.

CHEMICAL CONCENTRATION BY WEIGHT %

Aldrin 0.5
Heptachlor 0.5
Chlordane 1.0 316

TREATED OF COLUMN - PITS, WALL TRENCHES AND BASEMENT EXCAVATION :

a. The bottom surface and the sides (up to a height of about 300mm) of the excavation made for column pits, wall trenches and basements shall be treated with the chemical at the rate of 5 litres per Sq.M. of the surface area.

b. After the column foundations and the retaining walls of the basement come up, the backfill in immediate contact with the foundation structure shall be treated at the rate of 15 litre / Sq.M. of the vertical surface of the sub-structure for each side. If water is used for ramming the earth-fill, the chemical treatment shall be carried out after the ramming operation is done by rodding the earth at 150mm centres close to the wall surface and spraying the chemical with the above done. The earth shall be returned in layers and the treatment shall be carried out in similar stages. The chemical emulsion shall be directed towards the concrete or masonry surface of the columns and wall so that the earth in contact with these surfaces is well treated with the chemical.

c. In the case of RCC framed structures with columns and plinth beams and RCC basements, with concrete mix 1:2:4 or richer, the treatment shall start at the depth of 500 mm below ground level for columns and plinth beams. From this depth the back-fill around the columns, beams and RCC basement walls shall be treated at the rate of 15 litres / Sq.M. of vertical surface. The other details of treatment shall be as laid down in clause (b) above.

TREATMENT OF TOP SURFACE OF PLINTH FILLING:

The top surface of the filled earth within plinth beams / walls shall be treated with chemical emulsion at the rate of 5 lts./Sq.M. of the surface before the sand bed/subgrade is laid. Holes upto 50 to 70mm deep

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at 150mm centres both ways shall be made with 12mm dia crow-bar on the surface to facilitate saturation of the soil with chemical emulsion.

TREATMENT OF JUNCTION OF WALL AND FLOOR:

To achieve continuity of vertical chemical barrier to inner wall surfaces from the ground level, small channel 30 x 30 mm shall be made at all the junctions of wall and columns with the floor (before laying the subgrade) and rod holes made in the channel upto ground level 150mm apart and the chemical emulsion poured along the channel at the rate of 15 litres / Sq.M. of the vertical wall or column surface so as to soak the soil right to the bottom. The soil be tamped back into place after this operation.

TREATMENT OF SOIL UNDER APRON ALONG EXTERNAL PERIMETER OF BUILDING

The top surface of the consolidated earth over which the apron is to be laid shall be reacted with chemical emulsion at the rate of 5 litres / Sq.M. of the surface before the apron is laid, by making rod holes 75 mm deep at 150mm centres both ways.

These chemicals are usually brought to site in the form of emulsifiable concentrates. The containers should be clearly labelled and should be stored carefully so that children and pet cannot get at them. They shall be kept securely closed.

Particular care shall be taken to prevent skin contact with concentration. Prolonged exposure to dilute emulsions shall also be avoided. Workers shall wear clean clothing and wash thoroughly with soap and water, especially before eating and smoking. In the event of severe contamination, clothing shall be removed at once and the skin washed with soap and water. If chemicals splash into eyes they shall be flushed with plenty of soap and water and immediate medical attention shall be sought.

The concentrates are oil solutions and present a fire hazard owing to the use of petroleum solvents. Flames shall not be allowed during mixing.

Care shall be taken in the application of chemicals to see that they are not allowed to contaminate wells or springs which serve as source of drinking water.

MEASUREMENTS:

The measurements shall be made in sq.ft.on the basis of plinth area of the building at ground floor only for all operations described above. Nothing extra shall be measured.

RATE :

The rate shall include the cost of all materials and labour involved in all the operations described above including making holes and refilling and making good the same.