# GOVERNMENT OF WEST PAKISTAN

# SHEDULE OF RATES

## VOLUEME I

## PART 1. (SPECIFICATIONS FOR MATERIALS OF CONSTRUCTION)

## 1964

West Pakitan Standing Rates Committee, Lahore

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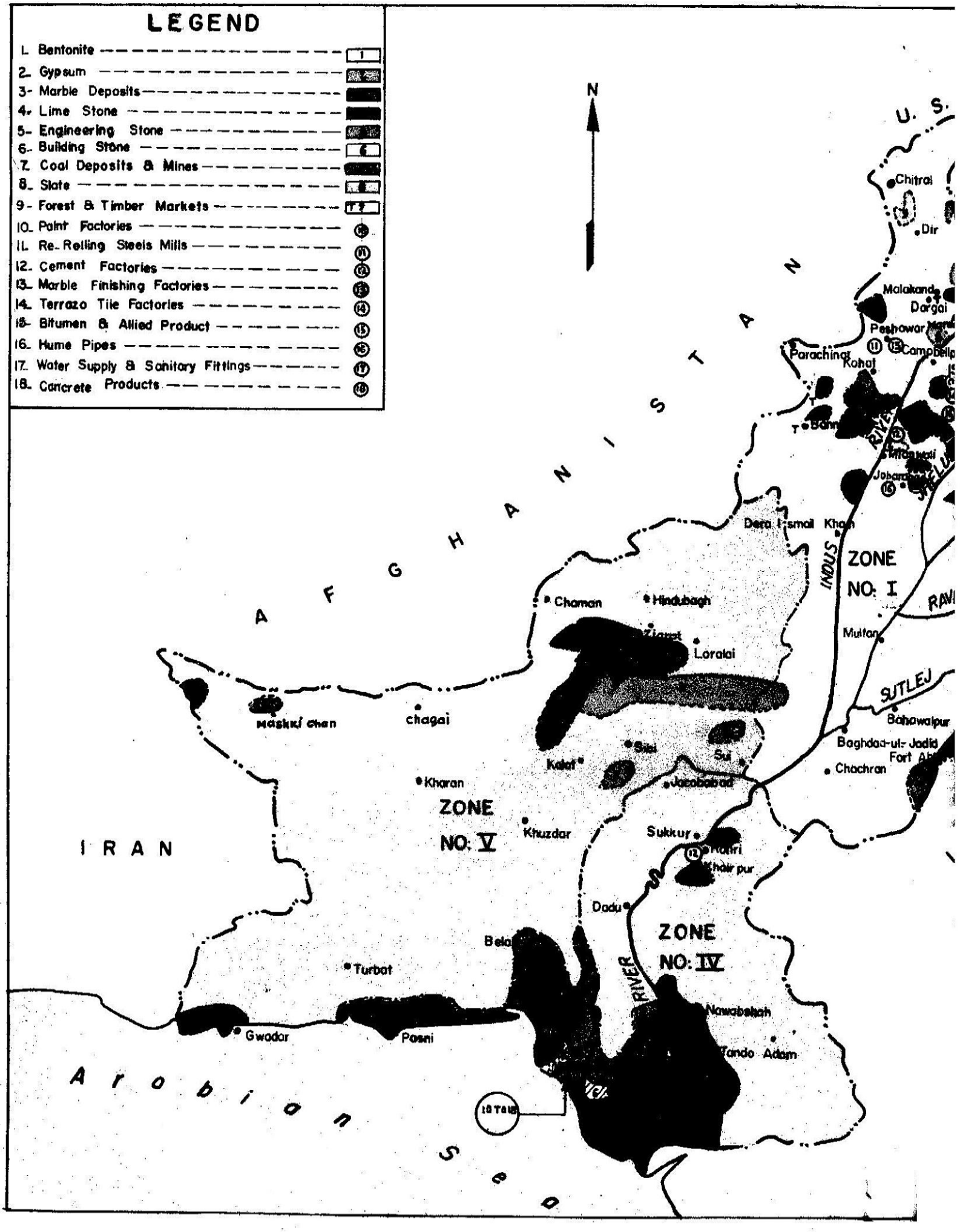
Publication No. I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3- Marble Deposits
4- Lime Stone
5- Engineering Stone
6- Building Stone
7. Coal Deposits & Mines
8. Slate
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Tando Adam
10 Tons


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2. Mardan.
3. Peshawar.
4. Kohat.
5. Malakand Agency.
6. Mohmand Agency.
7. Khyber Agency.
8. Kurram Agency.
9. Dera Ismail Khan.
10. Bannu.
11. North Waziristan.
12. South Waziristan.
13. Campbellpur.
14. Rawalpindi.
15. Jhelum.
16. Gujrat.
17. Sargodha.
18. Mianwali.
19. Lyallpur.
20. Jhang.
21. Lahore.
22. Gujranwala.
23. Sheikhupura.
24. Sialkot.
25. Dera Ghazi Khan.
26. Muzaffargarh.
27. Multan.
28. Montgomery.
29. Bahawalpur.
30. Bahawalnagar.
31. Rahimyar Khan

## ZONE NO: II

1. Karachi. 2. Las Bela

## ZONE NO: III

1. Hyderabad.
2. Thatta.

## ZONE NO: IV

1. Jacobabad.
2. Sukkur.
3. Khairpur.
4. Dadu.
5. Larkana.
6. Nawabshah.
7. Sanghar.
8. Mir Pur Khas.
9. Thar Parkar.

## ZONE NO: V

1. Quetta.
2. Sibi.
3. Loralai.
4. Zhob.
5. Chagai.
6. Kalat.
7. Makran.
8. Kharan.

50 0 50 100

Scale in Miles

# WEST PAKISTAN MAP

## SHOWING

## LOCATION OF ENGINEERING MATERIALS

PREPARED FOR

STANDING RATE COMMITTEE

BY

TECHNICAL SUB COMMITTEE

Mr. N. A. Haroon,
Secretary Finance & Chairman of the Standing Rates Committee,
Government of West Pakistan, Lahore.

Dear Mr. Haroon,

We transmit herewith volume I—Part I of the Schedule of Rates (Specifications for Materials of Construction) as finalised by the Technical Sub-Committee and edited by Mr. Abdul Hamid Sheikh of "The Pakistan Times", and recommend that it be published.

As you know, the Technical Sub-Committee was constituted in November 1961 and by May 1962, the first draft of this volume was ready. During this period of 6 months, the Sub-Committee met 115 times, putting in approximately 250 hours of combined labour. This is besides the time taken by the individual members to present to the Sub-Committee the original write up of various chapters for its consideration, review and recasting. The Sub-Committee with its research staff had to sift a hor'd of literature available on the subject in order to select relevant material. Full consideration has been given to the local practices and usages. The text has also been reviewed by senior engineers in the country and their observations have been quite encouraging. Some very valuable suggestions received through these reviews have been incorporated into this final draft.

This book is intended to replace the large number of other compilations currently in use in various departments, none of which has been considered adequate for the needs of all the engineering departments of the province. It represents, therefore, a pooling of interests and efforts on the part of all the departments concerned with the engineering works. It will serve as a useful guide in the selection of the right type of materials by the construction engineers, especially by the young and inexperienced ones who enter the profession without any practical knowledge of works and materials.

We hope and recommend that this book be brought into use in all departments of the Government of West Pakistan as well as autonomous bodies in order to ensure uniform engineering practices in the country.

Yours sincerely,

Jamaluddin

THE TECHNICAL SUB-COMMITTEE.

1. Mr. A. A. Jamal-ud-Din.
2. Mr. Irshad Ahmad.
3. Syed Manzoor Hussain Bokhari,
(Convenor)

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*5. Syed Manzoor Hussain Bokhari, P.S.E.I. (Convener)

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Note: —*Indicates the existing members of the Committee.

## PREFACE

The Standing Rates Committee was constituted by the Government of West Pakistan, vide Gazette Notification No. 844-F.D (W)-61, Dated 20th July 1961 which reads as follows:—

"The Governor of West Pakistan is pleased to constitute a Standing Rates Committee consisting of the following to prepare a common Schedule of Rates for Irrigation works being carried out by the Irrigation Department of the Provincial Government and the Water and Power Development Authority.

1. Joint Secretary to Govt. of West Pakistan, Finance Department —Chairman
2. Representative of Irrigation Department of the Provincial Govt. to be nominated by the Chief Engineer, Irrigation, West Pakistan —Member
3. A representative of West Pakistan Water and Power Development Authority to be nominated by the Authority. —Member

The Standing Rates Committee will have the authority to revise the Schedule prepared by it from time to time so as to keep it up-to-date on the basis of market conditions."

The scope of this Committee was extended to Communication and Works (B & R) Department and Public Health Engineering Department vide Gazette Notification No.V (95) 1276-S.O.D. (TD)-61, dated 8-8-61 which reads as:—

"The Governor of West Pakistan is pleased to order that the Standing Rates Committee constituted under Notification No. 844-F.D (W)-61, dated the 20th July 1961, shall also be responsible for preparing a Schedule of Rates for B & R and Public Health Engineering Works. The Committee will have the following additional members:—

1. A representative of the B & R to be nominated by the Chief Engineer, P.W.D. (B & R) —Member
2. A representative of the Public Health Department to be nominated by the Additional Chief Engineer/Chief Engineer, Public Health Engineering Department" —Member

Later on Pakistan Western Railways also joined the Committee vide Gazette Notification No. 1722-F.D. (W) 61, dated 2nd February 1962, which reads as:—

"The Governor of West Pakistan is pleased to appoint a representative of Pakistan Western Railways Department as an Additional Member on the Standing Rates Committee constituted vide No. 844-F. D. (W)-61, dated 20th July 1961".

The Committee is bringing out a complete schedule in three volumes. Volume I consists of 2 parts. Part I contains specifications for materials of construction and Part II contains specifications for execution of works. Volume II also consists of two parts. Part I contains an analysis of labour rates and Part II contains an analysis of material quantities. Volume III consists of three parts. Part I contains the daily and monthly wages of different categories of labour. Part II contains item rate schedule on labour rate basis and Part III contains composite schedule of rates.

As the main reason for the prevalence of different schedule of rates in different departments was the varying sets of specifications in vogue in each, it was felt necessary to revise them and introduce uniform specifications. The current volume entitled "Specifications for Materials of Construction (Volume I, Part I)" contains the qualitative as well as the contractual requirements of all types of materials usually required for various types of engineering works. These specifications shall come into force from 1-7-64 and will supersede all specifications in use in the various Government Departments and autonomous bodies to which it applies.

In the compilation, drafting and publication of the present volume, Mr. A. A. Jamal-ud-Din, Mr. Irshad Ahmad, Members and Syed Manzoor Hussain Bokhari, the Convenor of the Technical Sub-Committee, have rendered invaluable services and have made a material contribution in this truly engineering endeavour. Mention must also be made of the other members of the Committee in general and Mr. H. J. Asar in particular who took pains in improving this publication. The dedication with which every one has worked is really commendable.

(N. A. Haroon),
Chairman,
Standing Rates Committee.

## ACKNOWLEDGMENTS

The Standing Rates Committee wishes to acknowledge the helpful advice and suggestions received from the following persons in regard to the Specifications for Materials of Constructions:—

1. Mr. A. Rashid Kazi, S.Q.A., S.S.E.I.
2. Mian Abdul Aziz, T.Pk., P.S.E.I.
3. Sheikh Mohammad Akram, S.S.E.I.
4. Mr. Sarwar Jan Khan, P.S.E.I.
5. Mr. A. M. Akhoond, P.R.S.
6. Mr. Ahmad Hassan, P.S.E.I.
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20. Mr. A. G. Sheikh, S.S.E.I.
21. Pir Mohammad Ibrahim, I.S.E.
22. Khwaja Abdul Ghafoor, I.S.E.
23. Mir Bashar Khan, P.S.E.I.

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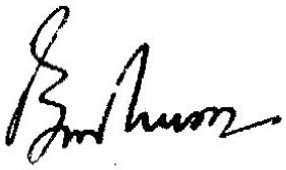
# INTRODUCTION

Like other branches of engineering the technique of Building is progressing rapidly. All the latest innovations in construction and modern designs call for investigations and research into their feasibility before they are generally accepted. This fact, together with the complexity of inventions and research in the field of materials, may require revision of this book from time to time in order to incorporate any new development into its frame-work. It includes the latest developments in the engineering field. But this is only a starting point. As more experience is gained in the application of these specifications, modifications may become necessary which will be embodied in later editions.

Its preparation involved the collection and compilation of data from a large number of publications mentioned in the bibliography and it also required a number of original investigations. In May 1962, its first draft was released to the Chief Engineers of all the departments concerned and other senior engineers in the country with a specific request for constructive criticism. By July 1962 suggestions from 23 Chief Engineers were received which were consolidated by the Sub-Committee and submitted to the Standing Rates Committee alongwith its own extensive review for further modifications. The Committee discussed this amended draft in detail and approved of it after making substantial additions and amendments. As the various chapters were drafted by different persons, it was decided to have them properly edited by an editor of repute.

It is not possible for an abridged departmental book of small size to replace a comprehensive text book on materials of construction. The scope of this publication is limited to only the qualitative and contractual requirements of those materials which are commonly used on most of the engineering works. Each chapter of this book has been divided into two parts, (1) Introduction, and (2) Specifications. The introductory part very briefly contains various characteristics of the materials intended mainly for the benefit of the young and inexperienced engineers and has no legal sanctity attached to it. The second part, namely, Specifications, contains qualitative and contractual requirements of the materials and its enforcement is obligatory.



(Syed Manzoor Hussain Bokhari),
P.S.E.I.,
Secretary,
Standing Rates Committee.

# CHAPTER 1

## DEFINITIONS AND TERMINOLOGY

# Definitions and Terminology

## DEFINITIONS

In these specifications the following words and expressions shall have the meanings herein assigned to them unless the context otherwise requires:—

(i) **Contractor.** The word contractor means the person, firm or company whose tender has been accepted by the employer and includes the contractor's legal personal representatives, successors and permitted agents.

(ii) **Department.** The word department means the respective department of the Government of West Pakistan undertaking the work.

(iii) **Engineer-in-charge.** The word Engineer-in-charge means the official of the department made incharge of the work and who is responsible for the execution of works and payment to the contractor. Each contract agreement will clearly lay down the designation of the official who has to act as Engineer-in-charge.

(iv) **Engineer's representative or authorized subordinate.** It means the person duly appointed for the time being by the department under the Engineer-in-charge to watch and supervise the work and to test and examine any materials to be used or workmanship employed in connection with the works. He shall have any of the powers and authority vested in the Engineer-in-charge which the latter may for the time being delegate in writing to him. This delegation of power can be done by a general order from a higher authority also.

(v) **Contract.** The word contract means the agreement contained and set out in the contract and documents forming part thereof.

(vi) **Works.** The word works means all the works to be executed in accordance with the contract.

## MEANING AND INTENT OF THESE SPECIFICATIONS

These specifications shall be used as a guide for drawing up the contract documents. If any doubt or dispute arises as to the meaning and intent of any portion of the specifications and drawings, the decision thereupon will lie with the Engineer-in-charge only, and will be recorded in writing; this decision will be subject to an appeal, in writing (within 7 days of such decision being intimated to the contractor) to the next higher officer, who shall have the power to correct any error, omission or discrepancies in the specifications and drawings and whose decisions in the matter under dispute or doubt shall be final and conclusive.

## RATES TO COVER ALL CHARGES

The Rates to be entered in the contract schedule shall in all cases provide for work duly and properly completed in accordance with the specifications and drawings incorporated in the contract documents or with such modifications of the same as may be directed in writing by the Engineer-in-charge during the currency of the work. The said Rate shall, unless it is specifically stated to the contrary in the contract, include and cover the cost of management, labour and materials required to complete the works in accordance with the contract.

Payment for supply of any materials shall be made only if a separate contract is drawn up for the purpose or it has been clearly stipulated in the contract.

## SITE OF WORK

The Site of each work shall be clearly defined in the contract documents.

Note—Site of work is at times very extensive. In such cases it should be defined precisely specifying the exact limits.

# CHAPTER II

## WATER

# Water

## INTRODUCTION

### USE

Water as a construction material has a wide range of utility and is in general used for:

(i) Cleaning and washing,
(ii) Preparation of clay and in all types of mortar and concrete,
(iii) Soaking bricks before use in pucca masonry,
(iv) Curing mortars and concretes,
(v) Staunching, puddling and compacting earthern embankments, and
(vi) Miscellaneous industrial and manufacturing processes.

### QUALITY

Water fit for drinking is generally suitable for use on all types of construction jobs. It should be free from organic or inorganic impurities, earth, salts and any other substance likely to cause efflorescence or interference with setting of mortars or otherwise prove harmful to work.

Even traces of tannic acid and sugar are harmful to concrete.

Marsh water containing humic acid or free carbonic acid is harmful but water containing dissolved carbonic acid is not. Effluents from sewerage works, gas and printing works can be detrimental while effluents from oil refineries, breweries and soap factories may or may not be harmful.

Water containing acids, sulphates, chlorides, carbon dioxide are harmful and should not be used.

Sea water, though not particularly detrimental to the strength of concrete should not be used on account of the danger of corrosion of reinforcement and efflorescence.

Contamination in water can be detected by inspection, taste and smell. If contamination is suspected water should be tested in a laboratory before its use is permitted.

### TESTS

The following field tests may be carried out to determine the quality of water:—

(i) **Tests for acidity or alkalinity.** Litmus paper test is the simplest test and gives a fairly good approximation of the quality of water.

(ii) **Sulphate.** The water is acidified with dilute sulphuric acid and then a little barium chloride solution is added. Formation of white precipitate indicates the presence of sulphates. This should be compared with the local tap water similarly treated.

(iii) **Carbon dioxide.** By adding a few drops of dilute hydrochloric acid, a rapid evolution of carbon dioxide will take place.

### STORAGE

Water is required to be stored at the Site of Work in watertight tanks or containers in sufficient quantity so that work is not held up at any stage for want of water. These storages shall be covered, so that no dust or impurities are imparted to the water. Long storage should be avoided, to eleminate stagnation and weed growth.

## SPECIFICATIONS

### No. 2.1 WATER

**Source**

1. Water for construction shall be obtained from an approved source.

**Quality**

2. Water shall be free from earth, vegetable, organic impurities and any other substance likely to cause efflorescence or interfere with setting of mortars or otherwise prove harmful to the work. Broadly speaking any water which does not show an intensive odour or brackish taste shall be considered suitable for building works, whereas water fit for drinking shall be accepted as suitable for all engineering works. P. H. value of water shall range between 6 and 8.

**Storage**

3. Water shall be stored in watertight tanks or containers so as to be adequately protected from the admixture of dust and other foreign matter.

**Measurement**

4. Water shall be measured in bulk; the unit of measurement shall be 1000 gallons or 100 Cft.

**Rate**

5. The unit rate shall include procurement, delivery and storage at Site of Work to be defined in the Conditions of Contract.

# CHAPTER III

## CEMENTING MATERIALS

## CLAY

## LIME

## CEMENT

# Clay

(For mud mortar and brick making)

## INTRODUCTION

### FORMATION

Clays were formed by the weathering of rocks especially the older igneous rocks, such as granite. Occasionally they are found on what appears to be the site of their formation and are then called primary clays; deposits of kaolin (china clay which results from decomposition of the felspars are usually of this character). More often, however, clays have been moved far from their places of origin by wind, water or ice; they are then called secondary clays. Clays settle slowly in water and may therefore travel a longer distance in suspension than sand and silt; but a river may vary a great deal in speed and turbulence according to the amount of rainfall received by it so that in time of flood it will carry sand and silt lower down its course than usual and deposit them on the finer sediments already there. This is the reason why most of the clays found in nature are mixtures of one kind or another.

### COMPOSITION

The following chemical composition is an approximation of a good building clay—(Silica three-fifth; alumina one-fifth, oxides of iron, calcium, magnesium, manganese, sodium and potassium forming the remaining fifth).

Clay or aluminium silicate consists of particles so small (less than 0.005 m.m.) that they cannot easily be seen or felt. They are subject to marked volume change on wetting and drying. They are highly cohesive but possess little internal friction.

### PROPERTIES

Clay possesses the property of plasticity when damp but upon the application of sufficient heat it gives off its water, loses its plasticity and becomes permanently rigid. It contracts and warps during the process of burning. The liquid limit of clay is the minimum amount of water required to be added, expressed as a percentage of the dry weight of the clay that will just make it flow, like a liquid, when jarred slightly. The plastic limit of clay signifies the percentage of moisture at which the clay changes with decreasing wetness, from a plastic to a semi-solid state, or with increasing wetness from the semi-solid to the plastic state. Plasticity index of clay is the numerical difference between the liquid and the plastic limit. Presence of silica in clays produces hardness, resistance to heat, durability and prevents shrinkage and warping.

## SPECIFICATIONS

### No. 3.1—CLAY

**Source**

1. Clay shall be obtained from good earth containing 20 to 30% fine sand.

**Quality**

2. Clay shall not contain more than 0.5% soluble salts: more than 0.2% sulphate; and more than 4% organic contents. It shall not contain any gravel, coarse sand, kankar, roots of grass and plant.

**Preparation**

3. Clay before use shall be dug up and left to weather for a week. It shall be thoroughly watered, turned over for at least 48 hours and tempered until free from lumps and it is stiff.

**Measurement**

4. Clay shall be measured in bulk. The unit of measurement shall be one hundred cubic feet.

**Rate**

5. The unit rate shall include excavation, loading, unloading and carriage of clay, if any, up to the Site of Work to be defined in the Conditions of Contract.

# Lime

## INTRODUCTION

### SOURCE

Lime is obtained by suitable calcination of naturally occurring forms of calcium carbonate. (Lime Stone or Kanker).

### CLASSIFICATION

Lime may be classified in two main groups, namely **Non-hydraulic Limes** and **Hydraulic Limes**

**(I) The Non-hydraulic Limes.**

The non-hydraulic limes depend solely upon the absorption of carbon dioxide from the atmosphere for setting and hardening. These may be of the following two kinds:—

(a) **High Calcium Lime** also called stone, white or fat lime. It contains from 95% upwards of calcium oxide. It exhibits a high degree of plasticity and sets and hardens slowly entirely on absorption of carbon dioxide from the atmosphere. It is most suitable for plastering. When used for mortar, however, it should be gauged with a proportion of cement.

(b) **Poor Lime.** It is relatively impure lime containing from about 10% to 40% of impurities insoluble in acid, otherwise it possesses the general properties of rich lime though to a lesser degree.

**(II) Hydraulic Limes**

The hydraulic limes set and harden under water due to the presence of constituents like silica and alumina which enable them to be independent of atmosphere. These limes are obtained from kanker or clayey limestones. Properties of hydraulic limes depend upon the proportion of clay present which may vary from 5 to 30%. The larger the proportion of clay, the more sluggish the slaking and the greater the hydraulic property. Hydraulic limes are suitable for works under water and for all positions where strength is required as they have much less tendency to shrink or crack than non-hydraulic limes.

Semi-hydraulic limes contain silica and alumina in proportions intermediate between non-hydraulic and hydraulic limes.

### CALCINATION

Calcination may be effected by two methods, namely, **Intermittent burning** and **Continuous burning.**

1. The Intermittent burning method consists in firing and burning a kiln full of a mixture of limestone and fuel each time. The complete operation of filling, burning, cooling and emptying the kiln takes a week. The quality of lime produced is generally good but the method is laborious and uneconomical from the point of view of fuel consumption.

2. The Continuous burning system can be followed in three main types of kilns as follows:—

(a) A vertical kiln in which a mixture of limestone is charged in alternate layers into the top of the kiln, the lime being removed gradually from the bottom. The lime suffers from the disadvantage of being mixed with ash which must be removed if a good quality of lime is required.

(b) A kiln in which the limestone and fuel are separate, the fuel being burnt in external furnaces. This type of kiln should be used when pure lime is required.

(c) A Rotary Kiln consists of a sloping rotating cylinder of up to 200 feet length. These kilns are heated by injecting air and fuel at the lower end, combustion takes place in the cylinder and the hot gases pass out to a chimney. The limestone introduced is converted to quicklime while passing down the length of the kiln.

**STORAGE**

Lime is stored in dry and weatherproof sheds in compact heaps so as to expose as small an area as possible to air to prevent air slaking. It should be used as fresh as possible because long storage results in deterioration.

## SPECIFICATIONS

### No. 3.2—LIME

**Definition**

1. Unless otherwise stated 'Lime' shall mean 'Stonelime' or 'Kanker lime'.

**Source of Stone Lime**

2. Stone, fat or white lime shall be manufactured from limestone containing at least 90% pure carbonate of lime. Limestone shall be obtained from an approved source, as specified in the Conditions of Contract.

**Source of Kankar Lime**

3. Kanker lime shall be burnt from good quality kanker nodules having a blue grey fracture free from sand grains. The kankar shall be quarried from an approved source as specified in the Conditions of Contract.

**Calcination of Stone Lime**

4. The limestone shall be broken into pieces so that it will pass through a ring of 2½" diameter before placing it in the kiln. For firing the kiln, coal, charcoal, wood or screened cinders shall be used (as specified in the Conditions of Contract); under no circumstances shall upla (cowdung) be used. The lime when slaked shall be free from unburnt lumps and shall increase to not less than 1.8 times its original bulk. In drawing it from the kiln care shall be taken to remove as much ash as possible.

**Calcination of Kankar Lime**

5. The Kankar lime shall be broken up to 2" guage and shall be burnt in the same way as specified in the paragraph 4 above. The kankar when burnt shall be carefully handpicked so as to exclude all over and under burnt pieces and shall then be ground fine and passed through a screen of 12×12 meshes to the square inch.

**Storage**

6. Lime shall be stored in dry and weather-proof sheds, in a compact heap so as to expose as small an area as possible to air to prevent air slaking. Lime shall not be stored for a long period after burning but used as fresh as possible.

**Measurement**

7. Stone Lime, freshly burnt shall be measured by weight before slaking. The unit of measurement shall be one maund of 40 seers. Kankar Lime, freshly burnt and ground shall be measured in bulk before slaking. The unit of measurement shall be one hundred cubic feet.

**Rates.**

8. The unit rate shall include furnishing, grinding and screening, of lime as per above specifications, delivery, stacking and slaking at Site of Work to be defined in the Conditions of Contract.

# Cement

## INTRODUCTION

### VARIETIES OF CEMENT

Cements in common use are of the following types:—

(a) **Ordinary Portland Cement.** It is manufactured by intimately mixing together calcarious and argillaceous and/or other silica and alumina or iron oxide bearing materials, burning them at a clinkering temperature and grinding the resulting clinker so as to produce a cement capable of complying with British Standard Specification No. 12, 1958. No materials other than gypsum (or its derivatives) or water, or both, shall be aded after burning. To comply with B.S. 12, 1958, the requirements of (i) Fineness of grinding (ii) Chemical Composition (iii) Strength (iv) Setting time and (v) Soundness should be as shown in the Table No. T 3.3. This is used normally for all ordinary mortars and concrete.

(b) **Rapid-Hardening or High Early Strength Cement.** Rapid Hardening Portland Cement is a true Portland cement complying with the British Standard Specification No. 12, 1958, but made with such refinements in manufacture as to produce superlative quality. Not only is it notable for high early strength but also its ultimate strength is considerably greater than that of an ordinary Portland Cement

(c) **Quick Setting Cement.** When cement is required to be placed under running water it is necessary that it should start setting within a few minutes after being mixed with water and that it should complete its setting action within half an hour and become hard. Such cements contain a higher percentage of alumina which hydrates quickly to form calcium aluminate and calcium alumino-ferrite. They also contain smaller percentage of retarder. It is very difficult to work with a quick setting cement as all the mixing and placing of concrete has to be done before the initial setting starts.

(d) **Low Heat Cement.** In large masses of concrete the hydration of cement continues for a long period and generally the rate of generation of heat is more than could be dissipated ordinarily. In order to avoid the installation of complicated devices for conducting the heat from the interior to the exterior, cements with Low Heat of Hydration are used. These cements contain a lower percentage of tricalcium silicate, the constituent which hydrates quickly, and a higher percentage of dicalcium silicate that hydrates slowly. Thus low heat cements are virtually those that have a very slow and a controlled rate of hydration. The proportion of tricalcium aluminate is also reduced. The composition of ordinary cement and low heat cement is shown below:—

| Type of Cement | $3CaO.SiO_2$ | $2CaO.SiO_2$ | $3CaO_2Al_2O_3$ |
|---|---|---|---|
| Ordinary Cement | 40 p.c. | 30 p.c. | 10 p.c. |
| Low Heat Cement | 30 p.c. | 40 p.c. | 7 p.c. |

(e) **High Alumina Cement.** This cement has a high proportion of aluminates, usually well over 35 per cent. It developes strength very rapidly and becomes as strong in 24 hours as ordi-

nary cement does in 28 days. The setting action is mainly due to the formation of calcium aluminates which are first to hydrate in any cement. A rapid process of hydration is necessarily accompanied by an equally rapid liberation of heat, which is not desirable at ordinary temperatures. In fact, it is necessary that with any cement (i) the gaining in strength with age (ii) the corresponding rate of hydration (iii) the liberation and the dissipation of heat during the curing period should all balance in such a way that concrete does not shrink and develop cracks subsequently. Tricalcium aluminate is liable to high volume changes after setting which is necessarily a disadvantge in using high alumina cement. High alumina cement is manufactured by calcinating a mixture of lime and bauxite. It is more resistant to attack by sulphurous acids and also to the action of frost.

(f) **Portland Blast Furnace Cement.** Blast furnace slag is used to the extent of 60 to 65 per cent in making cement. It is ground with clinker but before it is mixed with clinker for grinding, the slag has to be crushed to a granulated form. Virtually slags are rapidly cooled (igneous) rocks and when finely ground, blast furnace slag, in particular, possesses cementing properties. Usually one ton of blast furnace slag is produced as a by-product in the manufacture of every ton of pig iron. Blast furnace slag contains all the basic elements of cement, viz., silica, alumina and lime; their exact proportions depend upon the basic or acidic type of the slag used in the blast furnace. The cement produced from the blast furnace slag possesses the same properties as the normal setting cement. It is equally strong and durable and its use is economical as it is a waste product of the iron industry. However, if an excess of sulphides is present in slags their cement develops a tendency to disintegrate on exposure to the weather. This is a usual drawback in using slag freely.

(g) **Coloured Cements.** Colours are imparted to ordinary cements by mixing colouring matter to it in the form of mineral pigments. Usually 5 to 10 per cent of the colouring matter is added to obtain the required shade. The mineral oxides used as pigments are rather costly. Iron oxide gives red, yellow or brown colour; chromium oxide gives green colour; cobalt gives blue colour. For black or brown colour manganese dioxide is used. White cement is prepared with raw materials almost free from iron; it is the normal setting or ordinary cement, except for the absence of any colour but white.

(h) **Special Varieties.** Besides the above-mentioned varieties there are certain types of cement which can be obtained by adding materials like calcium chloride or Pozzolanic sands to ordinary cement.

(i) **Calcium Chloride and Cement.** Calcium chloride acts as an accelerator and the rate of development of strength is increased by the addition of about 2% of calcium chloride to the ordinary cement. A higher per cent of calcium chloride causes excessive shrinkage of concrete and at the same time it is detrimental to the reinforcement of R.C.C. work. Cements to which chlorides are added show better setting and hardening properties in cold water.

(j) **Pozzolana Cement.** The name Pozzolana is derived from Pozzouli, a town in Italy on the Bay of Naples, near Mount Vesuvius. The sand around this town when mixed with hydrated lime was found to possess hydraulic properties. These sands are of volcanic origin. The silicious spray which once issued from the volcano suddenly cooled and came down as drops and droplets which formed these sands. Pozzolanic materials have varying composition. Lime and magnesia contents are very low, usually 2 to 10%, while silica is present even to the extent of from 40 to 60%. The rest is made up of oxides of alumina and iron.

## TESTS

To control the quality and properties of cement and to assure that it conforms to respective B.S. Specifications the following tests are carried out:—

(i) **Fineness of Grinding.** The principal result of finer grinding is to hasten the early development of strength. Final strength may also be increased provided favourable curing conditions are maintained over a period of time. Another advantage of finer grinding is the reduction of the amount of bleeding of concrete or mortar in which the cement is used.

(ii) **Chemical Composition.** The purpose of this test is to determine:—

(a) Lime saturation factor.
(b) Alumina iron ratio.
(c) Loss on ignition.
(d) Insoluble residue, and
(e) Magnesia and sulphuric anhydride in a given sample of cement.

(iii) **Strength.** The purpose of this test is to determine the tensile and compressive strength of a given sample of cement.

(iv) **Setting time.** Cement is tested for (a) Initial setting time and (b) Final setting time. It is necessary that the setting time should be sufficient to allow freshly mixed mortar or concrete to be deposited and worked in position. Any disturbance after the initial setting has commenced is fatal to the strength of the set mortar or concrete. As the setting and hardening of the cement compound depends upon the presence of water, precaution should be taken against drying until the setting action is completed. Vicate apparatus method is usually employed to determine the setting time.

(v) **Soundness.** The purpose of the soundness test is to determine if there is anything in the cement that will cause disintegration of the concrete or mortar in which the cement is used This test is carried out by the Le Chatlier apparatus; the cement is subjected to an increased rate of hydration and its behaviour observed.

## SAMPLE FOR TESTING

For carrying out tests mentioned above it is essential that the sample for the test should be taken with considerable care. It should be taken within one week of the delivery of the cement, stored in a dry and clean air tight container and tested within 4 weeks of delivery. It should be at least 15 lbs in weight and truly representative of the consignment, or part of a consignment sampled. It should consist of a mixture of at least 12 equal sub-samples taken from places evenly spaced throughout the consignment, or part of a consignment sampled. Sub-samples of bulk cement should be taken from the bulk container, or containers during filling or emptying. For cement in bags, drums or other packages, not more than one sub-sample should be taken from any one bag, drum or other package. Where there are fewer than 12 bags, drums or other packages to be sampled, one sample should be taken from each.

## STORAGE

Cement must be stored in a weatherproof shed or godown. The storage of Portland cement has never been free from difficulties and as the cement of today is more finely ground than ever, the difficulties of storing without damage are increasing. Portland cement has a great avidity for water and will readily absorb moisture from the atmosphere or from damp materials in contact with it. The absorption by cement of 1 per cent or 2 per cent of water has no appreciable effect but further amounts of absorption retard the hardening of the cement and reduce its strength. If the absorption exceeds 5 per

cent the cement is, for all purposes, ruined. The more finely cement is ground, the more active it is, and consequently the more rapidly does it absorb moisture from damp surroundings; naturally the finely ground modern cements are more susceptible to damage than the cements of twenty years ago.

The best methods of storage is that adopted by the cement manufacturers, viz., in bulk; and bins of loose cement 6 feet or more in depth can lie intact for longer than a year with no more damage than the formation of a crust about two inches thick which must be removed before the cement is taken for use. It need hardly be added, that the walls and floor of the cement bin must be damp-proof. Hence, if prolonged storage of cement is seen to be unavoidable it is better to empty it from the sacks and stock it,in as deep a heap as possible in a building of which the walls and floor are nonporous and damp-proof, the latter being preferably of concrete, or of timber raised by a foot or so from the ground with an air-space below. When cement is stored in sacks absorption of moisture takes place from the air through the sack on all sides which are not in contact with other sacks. It is then only a matter of time before sufficient water is absorbed to injure the cement. Indications of damage by storage are given by the cement becoming lumpy and when this happens the lumps should be screened out unless they are soft enought to be crumbled between the fingers. When stored in sacks in a shed such as would be used by a contractor, the strength (as averaged at all ages) may decrease as follows, the figures showing the percentage compressive strength (of a mixture of 1 part of cement to 5 parts of aggregate) as compared with the cement before storage:—

| | |
|---|---|
| Cement as received fresh | 100 per cent. |
| Cement after 3 months storage | 80 per cent. |
| Cement after 6 months storage | 72 per cent. |
| Cement after 1 year storage | 60 per cent. |
| Cement after 2 years storage | 46 per cent. |

Thus the cement after two years storage has less than half the strength of the original cement.

Multiple paper sacks have been found quite suitable packing for transport of materials by rail or road and are strong enough for shipping in ocean lines, while as a means of protection from atmospheric moisture they are superior to jute sacks.

The following precautions should be taken if cement has to be stored in sacks:—

(i) Reduce the time of storage as much as possible.

(ii) The sacks should be stacked closely on a damp-proof floor or on timber raised a foot or so from the ground with air space below. There should be a similar air space between the stack and walls and roof of the building, which should have sound weatherproof walls and roof.

(iii) To avoid bursting of bags and setting under pressure the height of the stacks should be limited to 8 bags.

## LIMITATION OF USE

No cement stored through a monsoon or for more than six months should be used in reinforced concrete unless the abovementioned tests have been applied and cement found up to the requisite standard.

## WEIGHT

Cement is usually packed in a bag of 1.25 Cu. ft., weighing 1 cwt (112 lbs).

## SPECIFICATIONS

### No. 3.3. CEMENT

**Quality**

1. Cement shall conform in respect of chemical composition, manufacture, fineness of grinding, strength, setting time and soundness to the British Standard Specifications mentioned below (Refer Table No. T—3.3.):—

| | |
|---|---|
| (i) Ordinary Portland Cement | B.S. 12-1958 |
| (ii) Rapid Hardening | B.S. 12-1958 |
| (iii) Portland Blast Furnace | B.S. 146-1958 |
| (iv) Low Heat Portland | B.S. 1370-1958 |
| (v) High Alumina | B.S. 915-1947 |

**Storage**

2. Cement shall be stored in a dry place on a raised platform and guarded from sun, wind and rain in a waterproof shed or godown. Cement bags shall be stacked on a damp proof floor or on timber raised at least one foot from the ground with air space below. There shall be similar air space between the stack and walls and roof of the building. The maximum height of stack shall not exceed eight bags.

**Measurement**

3. Cement shall be measured by weight. The unit of measurement shall be one cwt.

**Rate**

4. The unit rate shall include supplying cement conforming to the above specification and stacking at the Site of Work to be defined in the Conditions of Contract.

TABLE NO. T 3.3

PROPERTIES OF CEMENT

| Type of Cement | | Ordinary Portland Cement | Rapid Hardening Portland Cement | Portland Blastfurnace Cement | Low-Heat Portland Cement | High Alumina Cement |
|---|---|---|---|---|---|---|
| I. STANDARD | | B. S. No. 12 | B. S. No. 12 | B. S. No. 146 | B. S. No. 1370 | B. S. No. 915 |
| II. Fineness | Minium Specific Surface Sq. cm. per gm (A.P. method) | 2250 | 3250 | 2250 | 3200 | 2250 |
| III. Chemical composition | Lime saturation factor | $LSF = \frac{(CaO)-0.7\,(SO_3)}{2.8\,(SiO_2)+1.2\,(Al_2O_3)+0.65\,(Fe_2O_3)}$ = Not more than 1.02 = Not less than .66 | | | | Alumina contents not less than 32 per cent by weight of whole. The ratio of the percentage by weight of alumina to the percentage by weight of lime shall not be less than 0.85 and not more than 1.3. |
| | | $MgO$ = Not more than 4 per cent. $SO_3$ = Not more than 2.75 per cent | | Not more than 5 per cent. Not more than 2.75 per cent. | | |
| | Insoluble Residue | .....Not more than 1.5 per cent. | | | | |
| | Loss on Ignition | .....Not more than 4 per cent. | | | | |
| | Alumina Iron ratio | .....Not less than 0.66..... | | | | |
| IV. Minimum Tensile Strength Lb. per sq. in. | 1 day | — | 300 | — | — | |
| | 3 days | 300 | 450 | 300 | — | |
| | 7 days | 375 | — | 375 | — | |
| Minimum Compressive strength Lb. per sq. in. | 1 day | — | — | — | — | 6000 |
| | 3 days | 2200 | 3000 | 1600 | 1100 | 7000 |
| | 7 days | 3400 | 4000 | 3000 | 2000 | — |
| | 28 days | — | — | 5000 | 4000 | — |
| V. Setting Times (Hrs) | Initial | 45 minutes | 30 minutes | 45 minutes | 1 hour | Not less than 2 hrs. and not more than 6 hrs. |
| | Final | 10 hours | 10 hours | 10 hours | 10 hours | Not more than 2 hrs. after the initial set. |
| VI. Soundness Expansion (Le Chatelier) | | (.....Not more than 10 mm .....) | | | | Not more than 1 mm. |

# CHAPTER IV

## CLAY BRICKS AND TILES

# Bricks and Tiles

## INTRODUCTION

### DEFINITION

A clay brick is a building unit made of a size that can be conveniently handled with one hand, rectangular in form and of such proportions that the length equals twice the width plus one mortar joint, whilst the depth is less than the width. It is, however, termed a tile when it is used for special purposes such as canal lining, roof covering, etc. In such cases the sizes in use are $12'' \times 6'' \times 2''$, $12'' \times 6'' \times 1\frac{1}{4}''$ and $9'' \times 9'' \times 2''$ or any other size to give a desired decorative shape.

### SELECTION OF CLAY

The clay for brick making should conform to Specification No. 3.1. An excess of silica in clay causes the brick to be brittle. Presence of limestone or chalk acts chemically in burning as flux causes the particles of brick to unite, producing greater molecular strength and in small quantities diminishing contraction. An excess of calcium carbonate causes the bricks to melt in burning and lose their shape. Magnesia in clay tends to give a yellowish tint to the bricks. Oxide of iron lends the bricks its peculiar red colour but if it occurs in clays as iron pyrities it should be removed carefully, otherwise it will oxidize in the brick, crystallize and split it to pieces. Salt in excess causes the brick to warp and twist and in addition causes efflorescence when the brick work is exposed to weather. Clay should never be obtained from a locality where there are white ants.

### TESTS FOR GOOD BRICK CLAY

The brick making quality of clay is usually ascertained by making brick out of the given clay and treating it exactly as other bricks are treated, by firing it in a brick kiln. If the brick does not come up to the required standard, chemical analysis will suggest what might be added to improve the clay.

### PREPARATION OF CLAY

The clay is dug up and left to weather. The stones and roots, etc. are picked out carefully by hand or by screening. It is then thoroughly watered, repeatedly turned over and tempered for at least 48 hours before use until it is homogeneous and stiff enough for moulding. Soft clay may be tempered by treading. Machinery has, however, made it possible to crush and grind and temper much harder material obtained from the older geological formations in which clay has been consolidated into shale by earth pressure. When soil is too clayey, sand or chopped straw may be added to improve its quality.

### MOULDING

The object of moulding is to give the clay a definite shape. It may be done in the following different ways:—

(i) **Hand Moulding.** Hand moulding requires clay to be soft and easy to work. An iron mould without top or bottom, about 1/10th bigger in size in all directions than that of the required brick (as clay shrinks about one tenth in all directions) is placed over a stock board with a fillet forming a projection fixed upon it. The purpose of the fillet is to form a frog in the brick. The mould is either wetted or sanded so as to prevent the surface of the raw brick from adhering to its sides. The moulder then dashes and presses a clot of tempered clay, which he has immediately before kneeded with his hands and from which he has removed any stone which may have escaped previous detention. He then takes the strike which is usually a pine fillet about $16'' \times 1\frac{1}{2}'' \times 3/8''$ and draws and pushes off any superfluous clay over and above the level of the sides of the mould. The mould is then lifted up leaving behind the brick on the ground for drying.

(ii) **Mechanical Moulding.** Mechancial moulding is carried out either by wire-cut process or by press-moulding process.

(a) **Wire cut process** derives its name from the fact that the clay is extruded in the form of rectangular column and cut into the proper size by means of wire stretched on a frame. The extrusion machine takes the form of a cylinderical barrel with a central shaft extending the greater part of its length. This shaft carries either a series of blades set at an angle (pugmill) or a continuous work (auger machine) to force the clay forward to the tapered mouth piece on the extremity of which is the die that gives the clay column its shape. Stiffer clay can be used in this process than that required for hand moulding.

(b) **Press Moulding.** In Press Moulding process clay is used in a still stiffer condition than in the wirecut process. It is forced into moulds forming clots which have roughly the shape of a brick. These clots are then automatically brought under a press which gives them the exact shape and size required.

**DRYING**

After moulding the process of drying commences. The object of drying is to evaporate the superfluous moisture without damaging the brick and to render it sufficiently hard to be handled without injury and to enable the raw brick to possess the requisite strength to withstand the pressure caused by stacking in the kiln during the process of burning. Immediately after moulding the raw brick is placed on its bed on a drying floor which is slightly convex; the bricks are then sprinkled with sand to absorb superfluous moisture. After one day's exposure the raw bricks are placed on their sides in parallel lines with about half an inch of space between them. When they are sufficiently hard to stand four to six feet high piling they are built up in open stacks to allow them to dry quickly. The bricks so dried are also termed 'Sundried bricks'.

**BURNING**

The objects of burning is to drive the water from the clay and thus cause it to lose its plasticity and to fuse the constituents into a homogeneous body so as to impart strength and durability to the brick. The operation of burning is conducted in a kiln. Kilns may be classified into the following three categories:—

(i) **Intermittent kilns.** These are chambers of brickwork either round or rectangular, with grates in the side walls and an arrangement of flues leading to a stack which draws the hot gases from the fires through the bricks to be burnt. The bricks from the driers are set in the kiln, the entrances (wickets) are bricked up and sealed with clay, fires are lighted and their heat gradually increased until the necessary temperature is reached and held for a certain time (soaking time) when the whole kiln is allowed to cool. This process is more expensive than the continuous kilns and is used for producing small quantities of bricks.

(ii) **Continuous kilns.** The continuous kiln was invented by Hoffmann in 1862. It consists of a series of connected chambers in a circular, or more commonly rectangular arrangement, which allows the fire to be led gradually round the whole circuit, burnt bricks being drawn and raw bricks set in the chambers furthest from the fire. The continuous kilns are much more economical in fuel than intermittent kilns because the fuel is dropped in through feed holes in the roof and burns among the bricks and because a large part of the heat set free by the burnt bricks in cooling from red heat to a temperature at which they can be handled is used in heating the air passing to the fires and in drying and warming the newly set raw bricks.

(iii) **Car Tunnel Kilns.** In this type of kiln the bricks are moved through stationery fire on cars travelling on rails. A kiln car has a deck made of fire bricks and metal aprons on either side

run in channels filled with sand to seal the bottom of the tunnel and prevent the wheels and axles of the cars from being damaged by the fire. Car tunnel kilns are usually about 300 feet long and the very considerable weight of the cars loaded with bricks is moved by a hydraulic ram which pushes a fresh car into the kiln every hour or so. The cars of burnt bricks are pulled out at the opposite end and unloaded outside the kiln, the working conditions thus being far better than in any other types of kilns where the drawers have to work inside the chambers which may be unpleasantly hot.

## CLASSIFICATION OF BRICKS

Bricks as they come from the kiln are stored and stacked in stacks of one or two thousands separately, accordingly as they are First Class, Second Class, Third Class (underburnt or 'pilla' and overburnt or 'Jhama').

## PROPERTIES OF BRICKS

The main properties that are of practical significance are outlined below:—

(a) **General Physical Characteristics.** A good clay brick should have a fine, compact and uniform texture. It should be sound, hard and well burnt, and should give a metallic tinkle when struck with a hammer or another brick. It should be of uniform colour and free from cracks, fissures, holes, air bubbles, lumps, pebbles and stones and particles of lime, etc. It should not contain soluble salts in excess of 0.5%

(b) **Size.** Bricks required in building for architectural work usually measure $9'' \times 4\frac{3}{8}'' \times 2\frac{1}{16}''$ so that every four courses laid in mortar measure a foot in height. Brick used for road work as soling measure $9'' \times 4\frac{1}{2}'' \times 3''$ as no mortar is used in their laying. Bricks used in irrigation works, for canal lining and similar uses besides the above two dimensions measure $10'' \times 4\frac{7}{8}'' \times 3''$. Bricks used for special works shall measure according to the special needs.

(c) **Compressive strength.** The average compressive strength of a good clay brick varies from 2000 to 3000 lbs per square inch.

(d) **Water absorption.** This test is significant as it gives an index of the durablity of the clay brick. This test is carried out in the laboratory in the following manner:—

The weights of samples of bricks are taken:—

(i) when dry at room temperature;

(ii) after immersion in water at room temperature for 24 hours; and

(iii) after boiling in water for 5 hours and cooling in water overnight. In each case the weight of water absorbed is expressed as percentage of the corresponding weight of dry bricks. Water absorption by dry weight of an average first class brick varies from 10 to 15 per cent and that of a second class brick varies from 15 to 25 per cent.

Saturation coefficient is the ratio of the absorption in (ii) above by immersion in (cold) water to the absorption in (iii) above by immersion in boiling water. Saturation coefficient is used in conjunction with other properties of the bricks to assess their frost resistance. Water absorption and saturation coefficient of bricks are not constant for any one type of brick. Like strength they vary from brick to brick in the same group and make.

## SPECIFICATIONS

### No. 4. 1. CLAY BRICKS

**Clay**

1. Clay for bricks shall conform to specifications No. 3. 1.

**Tempering**

2. The clay as selected and approved shall be thoroughly watered, repeatedly turned over for at least 48 hours and tempered until homogeneous and stiff enough for moulding. Any stone found shall be picked out by hand. The tempering shall be done in a pug mill, or by treading. When ready for moulding the clay shall be of such consistency (Plasticity Index 7 to 10 for hand moulding) so as to give a homogeneous brick which shall not bulge or become misshapen in anyway.

**Moulding**

3. Hand moulding shall be carried out in wrought iron moulds having a size which shall give the required size of the brick after burning. All bricks shall be sand moulded unless specifically stated that water moulding is required.

**Frog**

4. Each brick shall have a 'frog' 1/4" deep on the upper face and, trade marks or initials stamped in it as approved by the Engineer-in-charge.

**Handling of Raw Bricks**

5. The raw bricks handled for drying and then taken to kiln for burning shall be handled with great care so that the corners or edges or other parts of the bricks are not damaged.

**Burning**

6. Bricks when loaded in kilns shall be burnt to specified standard.

**First Class Bricks**

7. The size of bricks shall be as specified. They shall be well burnt without being vitrified. They shall be of uniform colour, regular in shape and size, with sharp and square corners and parallel faces. They must be homogeneous in texture and emit a clear ringing sound when struck. They shall be free from flaws and cracks. They shall not absorb more than 1/6th of their weight of water after being soaked for one hour, and shall show no signs of efflorescence on drying. Compressive strength shall not be less than 2000 lbs per square inch.

**Tiles**

8. Tiles shall conform to clause No. 7 above for quality. The size shall be (i) $12'' \times 6'' \times 2''$; (ii) $12'' \times 6'' \times 1\frac{1}{4}''$; (iii) $9'' \times 4\frac{1}{2}'' \times 2''$; (iv) $9'' \times 9''$ or as specially specified.

**Second Class Bricks**

9. Second class bricks shall be as well burnt as first class, or slightly overburnt but not vitrified in any part and must give a clear ringing sound when struck. In this class of bricks slight irregularities in size, shape, or colour will be accepted but not such as to give irregular or uneven courses when used. Second class bricks may have slight chips or flaws. They shall not absorb more than 1/4th their weight of water after one hour's immersion. Their compressive strength shall not be less than 2000 lbs per sq. inch.

**Third Class or Underburnt or Pilla Bricks**

10. These bricks are not so fully burnt as first or second class bricks. Any defects in uniformity or shape must not be such as to cause difficulty in obtaining uniform courses with their use. The use of third class bricks is prohibited except as substitutes for sundried bricks.

**Jhama Bricks**

11. Jhama bricks are bricks so overburnt as to get vitrified or distorted and are useless for exact work. They may be broken up for ballast provided the vitrified mass has not become porous or spongy in the process of being overburnt.

**Sundried Bricks**

12. Sundried bricks shall be unburnt bricks. Any defects in uniformity or shape must not be such as to cause difficulty in obtaining uniform courses with their use.

**Stacking**

13. The bricks shall be sorted and arranged in stacks of one or two thousands as specified. Each stack shall be 10 courses high and two bricks thick so that at least one end of every brick is visible. At least two feet space between the stacks shall be left for the purpose of inspection. Each class of bricks shall be stacked separately.

**Sampling**

14. The bricks or tiles required for carrying out the tests laid down in these specifications shall be taken by one of the methods given below:—

(a) **Sampling bricks or tiles in motion.** Whenever practicable samples shall be taken whilst the bricks or tiles are being moved; for example, during loading or unloading. In this case the bricks or tiles shall be taken at random from each of a number of convenient portions of the consignment or batch. The portion chosen should be small enough in relation to the whole to provide the minimum number of samples specified below.

(b) **Sampling bricks or tiles from a stack.** Samples shall be taken each at random from a stack of bricks or tiles. The number of bricks required for the tests shall be taken from across the top of the stack, the sides accessible and from the interior of the stack by opening the trenches from the top.

Whichever method is employed a sample of 50 bricks/tiles shall be taken at random from every consignment of 50,000 bricks/tiles or part thereof.

The samples thus taken shall be stored in a dry place not in contact with the ground until the tests are made. The bricks for tests shall be taken at random from the sample.

**Measurement**

15. Measurement of bricks or tiles shall be in numbers. The unit of measurement shall be one thousand bricks. Before measurement, the stacks will be checked to determine the quality. If more than 10% bricks in the stacks do not conform to specifications the whole consignment shall be rejected. If the percentage of such bricks is less than 10% the consignment shall be accepted after deducting the percentage of such bricks which shall not be paid for in the consignment.

**Rate**

16. The unit rate shall include cost of clay, its preparation, moulding, drying of bricks or tiles, burning, sorting, delivery and stacking of burnt bricks or tiles at Site of work to be defined in the Conditions of Contract.

## SPECIFICATIONS

## No. 4.2 CLAY ROOFING TILES.

**Description**

1. Clay roofing tiles shall be either hand moulded or machine moulded as specified.

**Manufacturing**

2. Roofing tiles shall be manufactured from well prepared clay (Specification No. 3.1) and properly burnt.

**Quality**

3. The tiles shall be free from fire cracks, true in shape, dense, tough, shall show a clean fracture when broken and shall be well burnt throughout.

**Colour**

4. The colour of the tiles shall be uniform throughout and as specified.

**Nibs**

5. Tiles shall have not less that (a) two nibs of not less than 3/4 in. width at the base, measured across the tiles or (b) one continuous nib. The projection of the nib shall be not less than $\frac{1}{4}$ in. and not more than $\frac{1}{2}$ in. The hanging side of the nib shall be such that the tile will support itself when suspended vertically from a batten.

**Size**

6. The nominal size of standard tiles shall be $10\frac{1}{2}$ ins. $\times$ $6\frac{1}{2}$ ins. with a permissible plus or minus variation not exceeding 1/8 in. on the width and length (see fig. 1.)

**Thickness**

7. Tiles shall not be less than 3/8 in. nor more than 5/8 in. thick.

**Camber**

8. The longitudinal camber of tiles shall be not less than half their thickness and not greater than half their thickness plus 1/8 in.

**Nail hole**

9. Two nail holes shall be provided. The holes shall be pierced so that their centres shall be not less than 1 in. nor more than $1\frac{3}{4}$ ins. from the side of the tile and not less than $\frac{1}{2}$ in. nor more than 5/8 in. from the underside of the nib and shall be not less than 3/16 in. nor more than 1/4 in. in diameter.

**Sampling**

10. The tiles required for carrying out the tests laid down in this standard shall be taken by one of the methods given below:—

(a) **Sampling tiles in motion.** Whenever practicable samples shall be taken whilst the tiles are being moved, for example, during loading or unloading. In this case a tile shall be taken at random from each of a number of convenient portions of the consignment or batch. The portions chosen should be small enough, in relation to the whole, to provide the minimum number of samples specified below.

(b) **Sampling tiles from a stack.** Samples shall be taken out at random from a stack of tiles. The number of tiles required for the test shall be taken from across the top of the stack, the sides accessible and from the interior of the stack by opening trenches from the top.

Whichever method is employed a sample of 25 tiles shall be taken at random from every consignment of 10,000 tiles or part thereof.

**Transverse Strength Test**

11. The average breaking load, applied along the width of the tile midway between the supports, shall ce not less than 175 lbs. when determined in the manner described in Appendix I.

**Water Absorption Test**

12. The average water absorption, when determined in the manner described in Appendix II shall not exceed 10.5 per cent.

**Rejection**

13. If the tiles taken in accordance with the clause 'Sampling' fail to meet any of the requirement of this standard, the consignment from which the tiles were sampled may be rejected.

**Eaves-tiles and Top Course Tiles**

14. Eave tiles and Top Course tiles shall be 6½ ins. wide and 7½ ins. long with a plus variation not exceeding 1/8 in. on the width and 1/4 in. on the length. They shall have two nail holes and not less than two nibs or one continuous nib (see fig. 2a).

**Tile and-a-half Tiles**

15. Tile and-a-half tiles shall be 9¼" ins. wide and 10¼" ins. long with plus variation not exceeding 1/4 in. on the length and 3/16 in. on width. They shall have not less than two nail holes and not less than three nibs or one continuous nib (see fig. 2b).

**Hip Tiles**

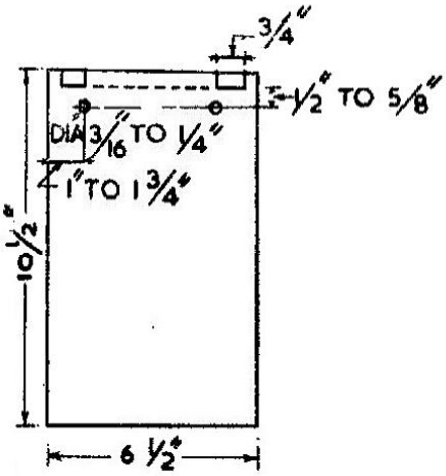
16. The various patterns of hip tiles are illustrated in figs 3 to 5. They shall be made so that the sides AF and CD shall be parallel to the uncut edges of the abutting plain tiles with a tolerance of ¼" The diameter of nail holes shall be not less than ¼ in. and not more than 3/8 in. The lengths of the lines XD and XF shall be 10½" with a plus variation of 1/4 in. and the angle AFE and CDE shall be 90° with a tolerance of 1½°.

The lengths of the lines AF and CD for all hip tiles shall be not less than 8 ins., whilst the length of line BG shall be not less than 1 in. and not more than 1½ ins. **Angular hip tiles** shall be made so that the lower edges FE and ED shall, when laid be horizontal and shall extend the lines of adjacent courses of plain tiles with a variation not exceeding 1/4 in. either way. (Fig. 3).

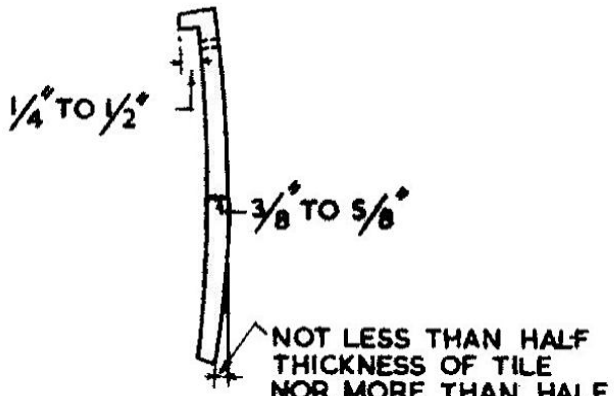
**Round Pattern Hip Tiles** shall be made on similar lines to angular hip tiles except that on plan the lines FE and ED will be rounded about E2 and on section will be rounded about Y2. (Fig. 4).

**Angular and Round Pattern Hip Tiles** shall be of such shapes that when laid they shall lie reasonably well in the same planes as those adjoining courses of plain tiles on each side and shall fit reasonably well on the hip tile below.

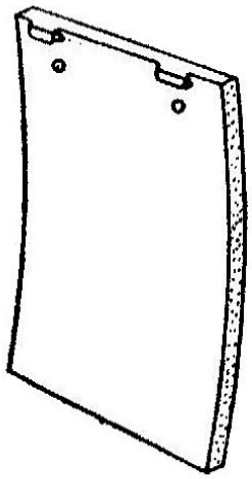
**Bonnet Hip Tiles** shall be designed so as to allow room for bedding to fill up the space between one hip tile and the next, but as they have a smaller dihedral angle than that of angular hip tiles for the same pitch of roof they will not lie in the same planes as the adjoining plain tiles on each side. Table 4.2 shows variants which shall apply to angular and round pattern hip tiles but not to bonnet hip tiles. (Fig. 5).




DIMENSIONAL DIAGRAM

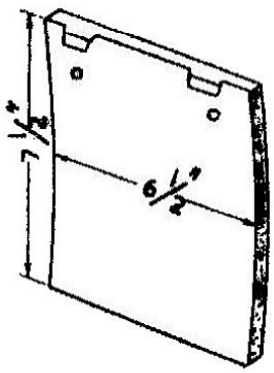



SECTION

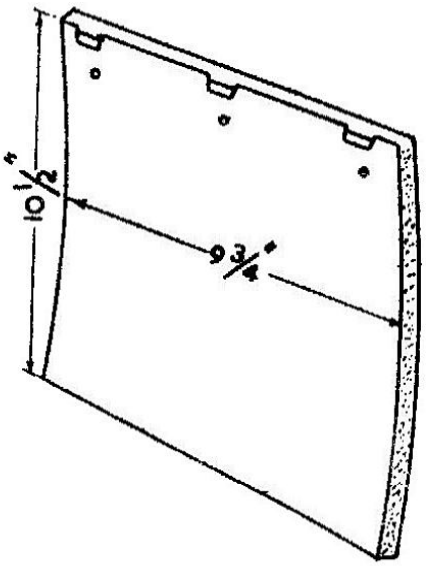


ISOMETRIC VIEW

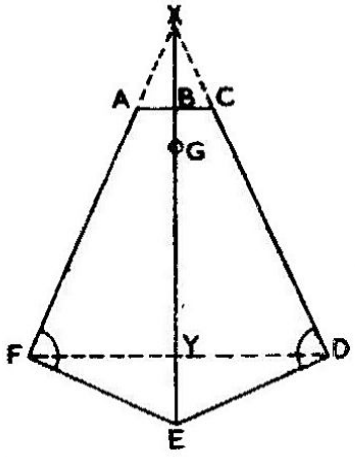
PLAIN TILE
FIG: 1 (4.2)



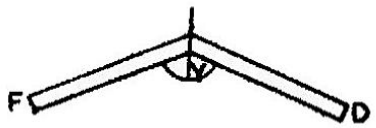

EAVES AND TOP COURSE TILE
FIG: 2 A (4.2)



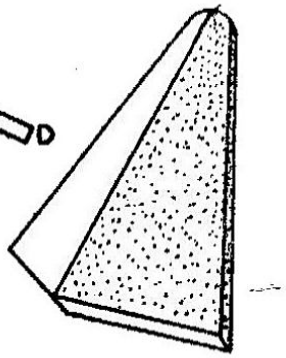

TILE-AND A HALF TILE
FIG: 2 B (4.2)




DIMENSIONAL DIAGRAM

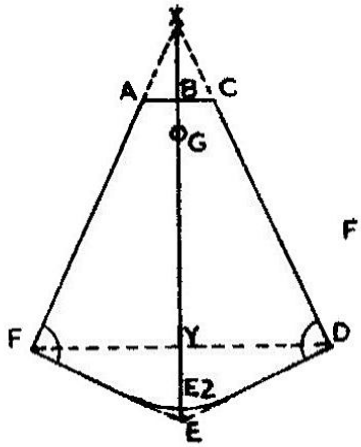



SECTION



ISOMETRIC VIEW

ANGULAR HIP TILE
FIG: 3 (4.2)

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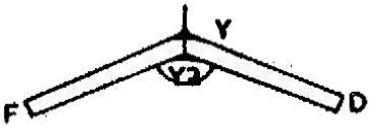


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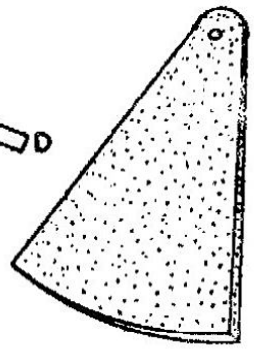
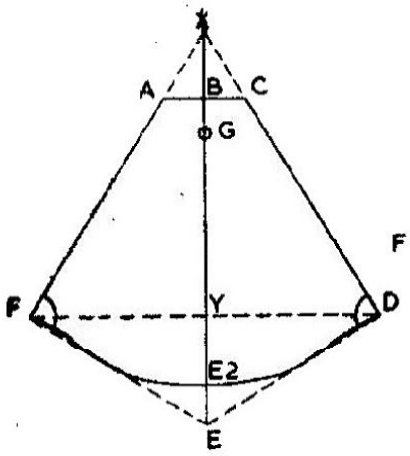
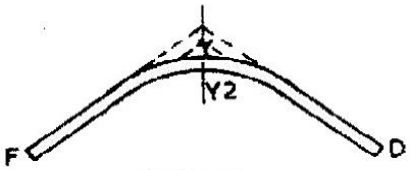


ISOMETRIC VIEW

ROUND PATTERN HIP TILE
FIG: 4 (4.2)




DIMENSIONAL DIAGRAM

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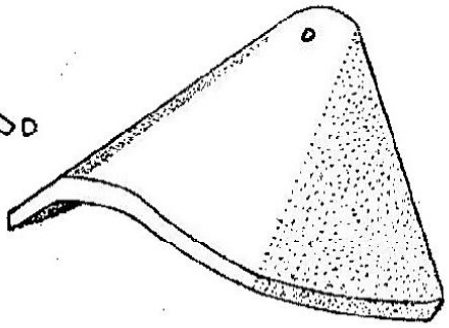
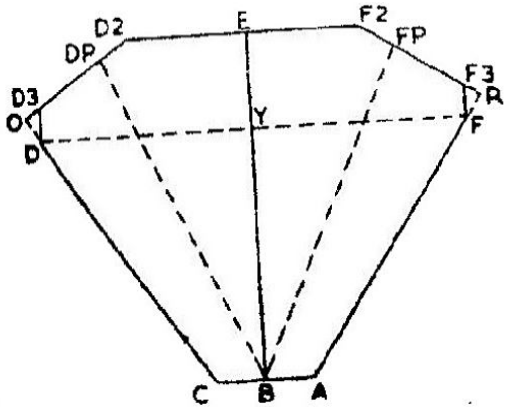
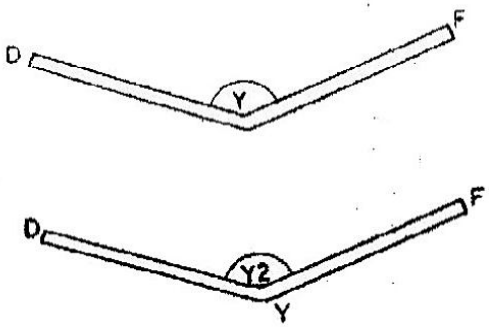


ISOMETRIC VIEW

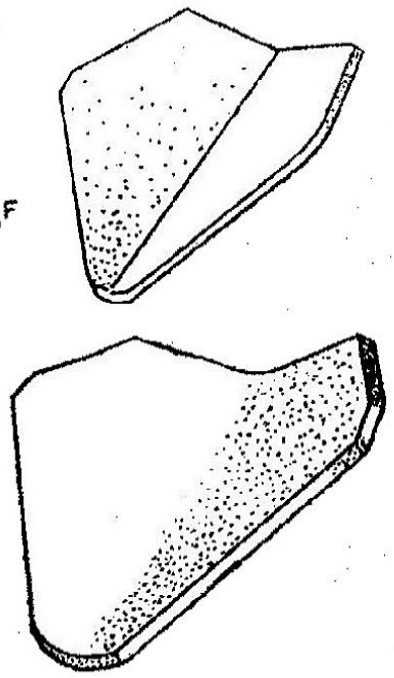
## BONNET HIP TILE
FIG: 5 (4.2)




DIMENSIONAL DIAGRAM




SECTIONS



ISOMETRIC VIEW

## ANGULAR AND CURVED VALLEY TILES
FIG: 6 (4.2)

Table No. T.—4.20.

| Pitch of roof | Dihedral Angle | Angles EXF and EXD | Tolerances |
|---|---|---|---|
| 40° and | 136° | | Minus 3° |
| 42½° | | 40⅓° | 1½° |
| 45° and | 129½° | — | Minus 3° |
| 47½° | | 39° | 1½° |
| 50° and | 123° | — | Minus 3° |
| 52½° | — | 36¾° | 1½° |

**Valley Tiles**

17. The various patterns of valley tiles are illustrated in fig. 6. They shall be of such a shape that when laid they shall lie reasonably well in the same planes as those of the adjoining courses of plain tiles on each side and shall fit reasonably well on the valley tile below. They shall not be holed for nailing. They shall be designed so that the sides AF and CD shall be parallel to the uncut edges of the abutting plain tiles with a tolerance of 1/4 in. and the line BE shall be the centre line of the valley where the two sides meet. The point DP shall be 3¼" from the point O and not less than 1 in. from D2 nor less than 2 in. from D3. whilst the point Fp shall be similarly placed along the line F2 to F3 in relation to the point R. Both these points Dp and Fp shall be not less than 11½ ins. measured in straight lines from the point B.

The upper edge of the valley tile may be curved, provided that the curve does not pass inside the straight lines DD3, D3D2, D2E, EF2, F2F3 and F3F.

**Angular Valley Tiles** shall be made so that the lengths of the lines CO and AR shall be 10¼ ins. with a plus variation of 1/4 in., whilst the angles EBC, EBA, BED2, BEF2, COD2 and ARF2 shall be 90°, with a tolerance of 1½°. The lines AB and BC shall be not less than 3/8 in. nor more than 1½ ins., whilst the lines AF, CD shall be not less than 9½ ins.

Table 4.21 sets out the variants for angular valley tiles.

Table 4.21

| Pitch of roof | Dihedral angle | Angles BCD an BAF | Tolerances |
|---|---|---|---|
| 40° and 42½° | 139 | — | 3° |
| | — | 131° | ±1½° |
| 45° and 47½° | 132½° | — | ±3° |
| | — | 129½° | ±1½° |
| 50° and 52½° | 126° | — | —3° |
| | — | 128° | ±1½° |

**Rounded Valley Tiles** shall be designed on similar lines to angular valley tiles except that the angle FYD will be rounded about Y2.

**Ridge Tiles**

18. The various patterns of Ridge Tiles are illustrated in figs. 7 to 10. They shall be either 12 ins. or 18 ins. long with a tolerance of ½ in. and shall be not less than 5/8 in. thick. They may have capped joints if required, but the effective covering capacity for length shall remain as stated herein.

**Half-round ridges** shall be made so that the internal diameter XXZ shall be not less than 7½ ins. (Fig. 7).

**Segmental ridges** shall be of such a diameter that the chord of half the arc XYZ shall be not less than 5½ ins. (Fig. 8).

**Plain angle ridges** shall be designed so that each wing shall be not less than 5½ ins. wide measured internally from X to Y and Y to Z. (Fig. 9).

**Hog back ridges** shall have an internal girth of not less than 11½" ins. measured along the line XYZ. (Fig. 10).

**Vertical Angle Tiles**

19 The various patterns of Vertical Angle Tiles are illustrated in figs 11 to 14. These tiles are made 'right handed' and 'left handed'. An angle tile which provides the larger area on the right side when fixed shall be known as 'right handed' and that which provides the larger area on the left shall be known as 'left handed'. Alternatively, these tiles may be made 'large' or 'small'.

All Vertical Angle Tiles shall be of such shapes that when laid they shall lie reasonably well in the same planes as those of the adjoining courses of plain tiles on each side, and shall fit reasonably well on the angle tile below. The lower edges shall continue the line of the plain tiles with which they are to be fixed with a tolerance of ¼ in. the sides AF and CD shall be parallel to the uncut edges of the abutting plain tiles with a tolerance of ¼ in. They shall be not less than 10 ins. nor more than 10¾" ins, long and the nail holes shall be not less than 9⅝ ins. and not more than 9⅛ ins. from the lower edge of the tile when measurd at right angles, whilst the diamter of the nail holes shall be not less than ¼ in. nor more than ⅜"

**Square Angle Tiles,** shall have three nail holes, two in the larger side and one on the smaller side. (Fig. 11).

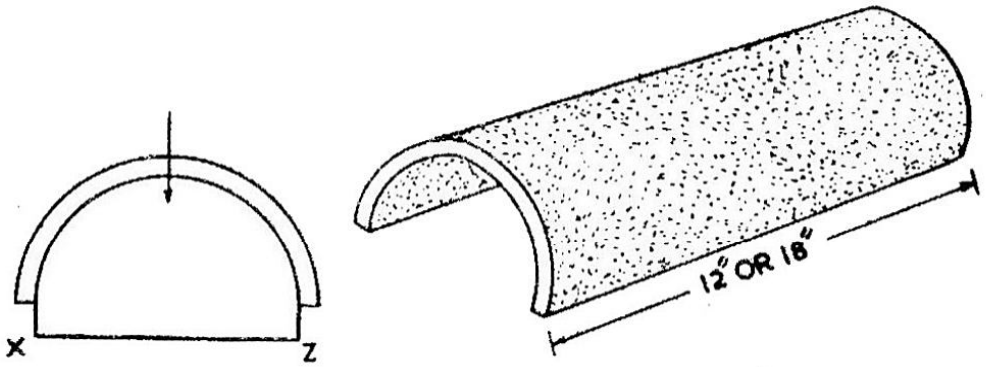
**Hexagonal and Octagonal Angle Tiles** shall have two nail holes in the larger side only. (Fig. 12)

**External Angle Tiles** shall be made so that the angles BAF, BCD, AFE and CDE shall be 90° with a tolerance of 1½°. (Fig 13)

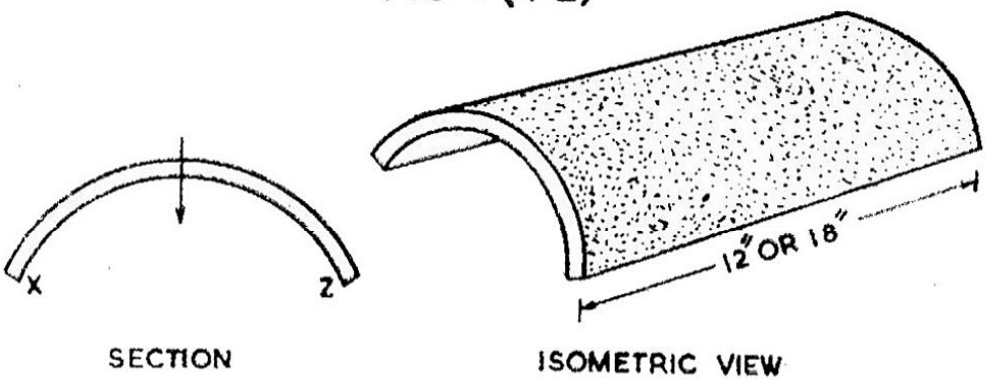
Table T 4.22 gives the variants for handed external angle tiles and table T 4.23 the variants for large and small.

Table No. T—4.22

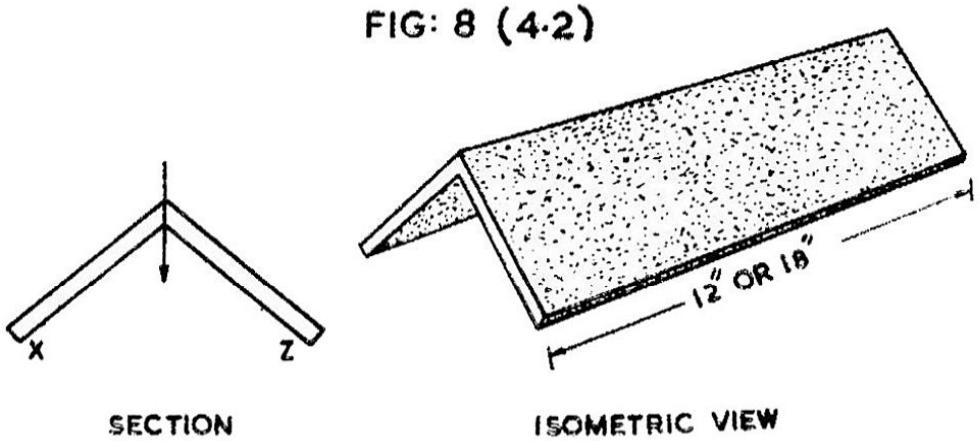
| Type | Angles in degrees | | Lengths in inches | | | | Tolerance |
|---|---|---|---|---|---|---|---|
| | | | Right hand | | Left hand | | |
| | Dihedral | BED & BEF | DE | EF | DE | EF | |
| Rectangular | 91½ | 80 | — | — | — | — | ±1½° |
| | — | — | 6½ | 3¼ | 3¼ | 6½ | ±¼" |
| Hexagonal | 121½ | 84 | — | — | — | — | ±1½° |
| | — | — | 5¼ | 2 | 2 | 5¼ | ±¼" |
| Octagonal | 136½ | 85¼ | — | — | — | — | ±1½" |
| | | | 5¼ | 2 | 2 | 5¼ | ±¼" |



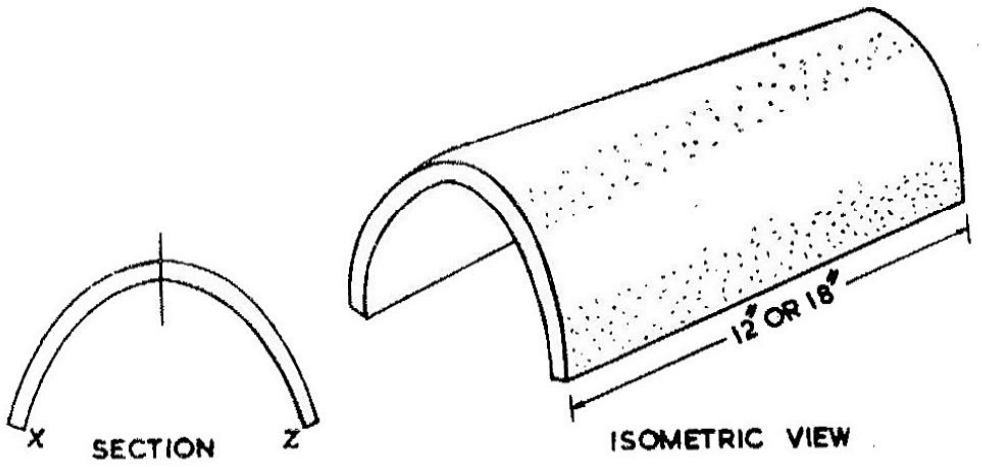

HALF ROUND RIDGE TILE
FIG: 7 (4.2)



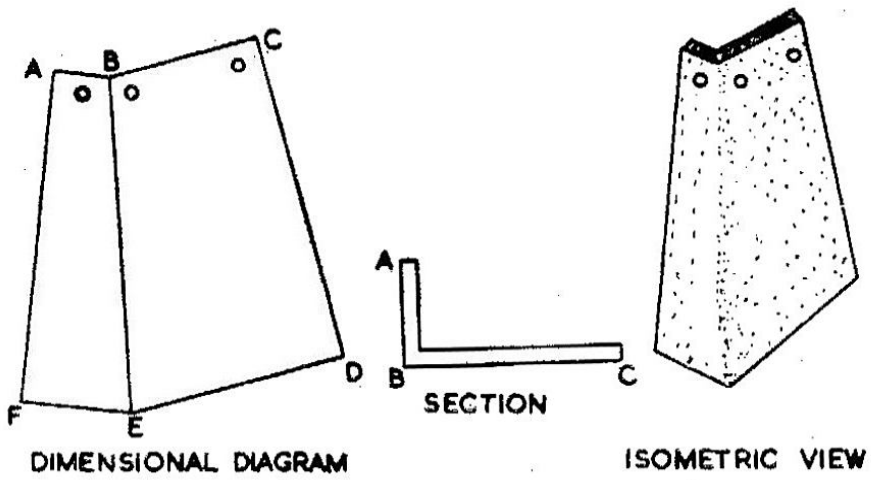

SEGMENTAL RIDGE TILE
FIG: 8 (4.2)



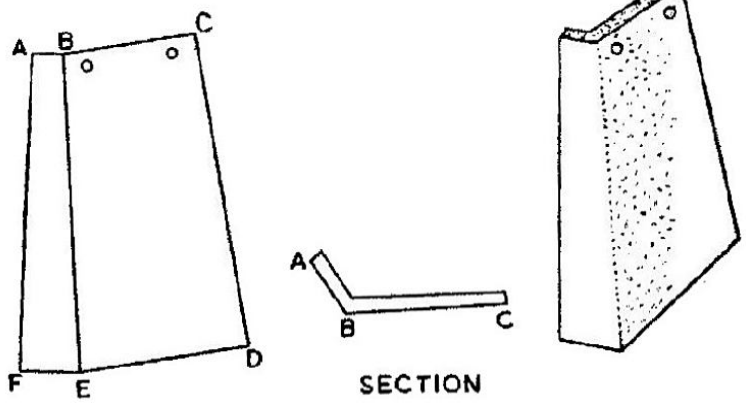

ANGLE RIDGE TILE
FIG: 9 (4.2)




HOG BACK RIDGE TILE
FIG: 10 (4.2)

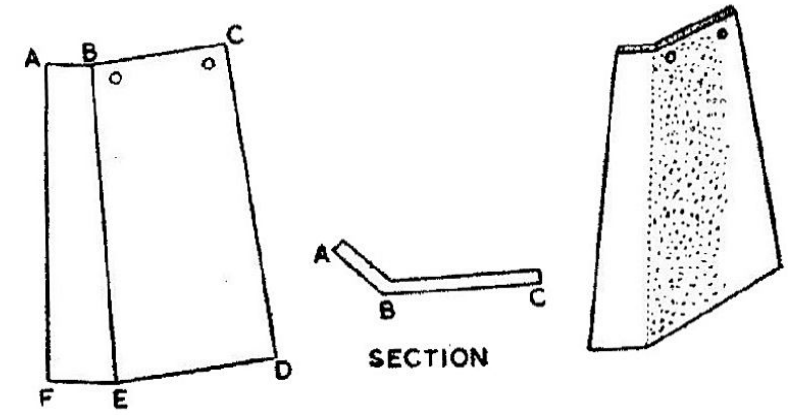



EXTERNAL VERTICAL SQUARE ANGLE TILE
FIG: 11 (4.2)



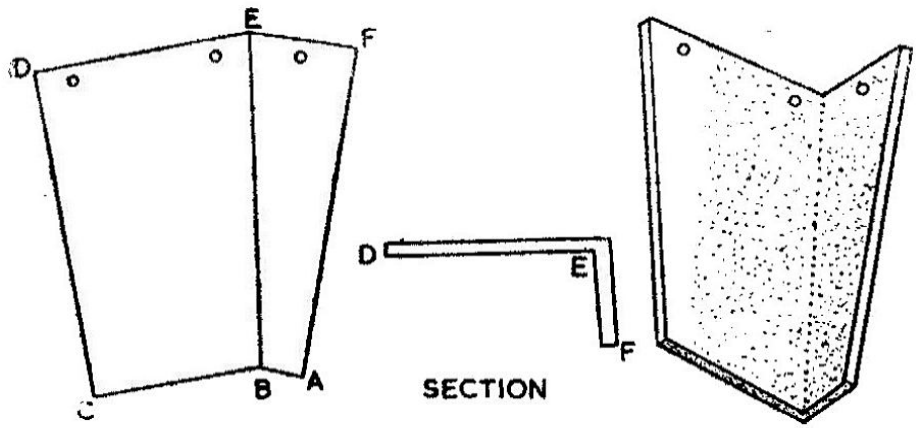

EXTERNAL VERTICAL HEXAGONAL ANGLE TILE

FIG: 12 (4·2)




EXTERNAL VERTICAL OCTAGONAL ANGLE TILE

FIG: 12 (4·2)




INTERNAL VERTICAL SQUARE ANGLE TILE

FIG: 13 (4.2)

Table No. T—4.23

| Type | Angles in degrees | | Lengths in inches | | | | Tolerance |
|---|---|---|---|---|---|---|---|
| | | | Small | | Large | | |
| | Dihedral | BED & BEF | DE | EF | DE | EF | |
| Rectangular | 91½ | 80 | | | | | ±1½° |
| | | | 3¼ | 3¼ | 6½ | 6½ | ±¼″ |
| Hexagonal | 121½ | 84 | | | | | ±1½° |
| | | | 2 | 2 | 5¼ | 5¼ | ±¼″ |
| Octagonal | 136½ | 85½ | | | | | ±1½° |
| | | | 2 | 2 | 5¼ | 5¼ | ±¼″ |

**Internal vertical angle tiles** shall be designed on the same general lines in regard to shapes and sizes as corresponding external angle tiles except that when the camber shall be reversed, the finished surface shall be on the opposite side of the tile and the nail holes shall be at the other end.

**Measurement**

20. Clay roof tiles or fitting shall be measured in numbers. The unit of measurement shall be one thousand.

**Rate**

21. The unit rate shall include the cost of specified tiles or fitting, sorting, delivering and stacking at the Site of Work, to be defined in the Conditions of Contract.

## SPECIFICATIONS

### No. 4. 3 ALLAHABAD ROOF TILES

**Manufacture**

1. Allahabad Tiles as flat, semi hexagonal, half round, ridge tile and ridge half round tile shall be manufactured from well prepared clay (specification 3.1) and properly burnt.

**Size of Tile**

2. The length of tile shall be 15 ins. Breadth at front and back faces shall be 10″ and 12″ respectively. Side studs shall be 1½″ high 12″ long and 3/4″ wide. These shall form the integral part of the tile as shown in fig. 1 (4.3).

**Semi-Hexagonal Tiles**

3. Overall length of hexagonal tile shall be 15 ins. with a tolerance of ½ in. The base width at

front face and side AB of the tile shall be 5 ins. and 3.3 ins. respectively. Two triangular studs shall be provided on both sides of the tile at a distance of 12 ins. from the front face as shown in fig 1 (4.3). The overall height of the tile shall be 4 ins. and $3\frac{1}{4}$" at the front and back faces respectively. The back face section shall be uniform up to studs as to form 3/4 in. recesses in the lower edges for fittings of flat tile.

**Half-round Tile**

4. Overall length of the half round tile shall be 15 ins. Base width and overall height at the front face shall be 5 ins. and 4 ins. respectively. To a distance of 3 ins. from back face, a recess of 3/4 in. shall be provided in the lower edges to fit in the flat tile. The overall height in this length of 3 ins. from back face shall be 3.25".

**Ridge-half-round Tile**

5. Ridge-half-round tile shall be uniform in section throughout it lengths. The section shall be the same as that of front face of the half round tile. The pitch angle shall vary between 45° to 60° according to the pitch of the roof.

**Ridge Tile**

6. The width of ridge tile shall be 10 ins. Length of sides DM, MN shall be 7 ins, each. The section of the tile shall be the same as that of flat tile. The pitch angle shall vary between 60° to 45° according to the pitch of the roof. A ridge half round tile with the base width as 3 ins. and overall height as 2 ins. shall be mounted over the flat ridge tile forming its integral part as shown in fig. 1 (4.3).

**Quality**

7. It shall be of uniform colour, free from cracks, twisting and other imperfections. Tiles shall ring clearly when struck.

**Thickness**

8. It shall not be less than 3/8 ins. nor more than 5/8 in. thick.

**Colour**

9. It shall be of dark-red colour.

**Test**

10. It shall not absorb more than 1/6th its weight of water when immersed for one hour.

**Measurement**

11. Allahabad roof tiles or the tile fittings shall be measured in numbers. The unit of measurement shall be one thousand.

**Rate**

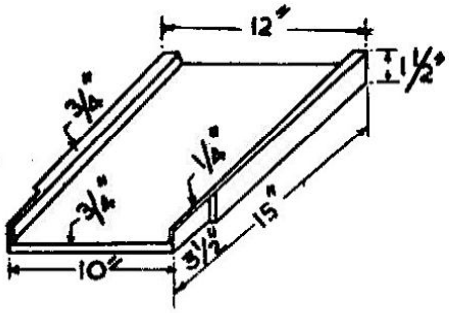
12. The unit rate shall include the cost of the specified tile or the fitting, sorting, delivering and stacking at Site of Work to be defined in the Conditions of Contract.

## SPECIFICATIONS

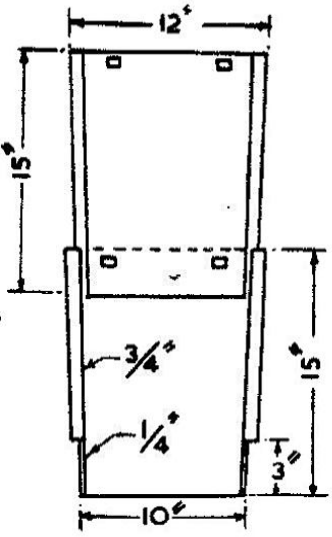
## No. 4.4 MANGALORE ROOF TILES

**Manufacture**

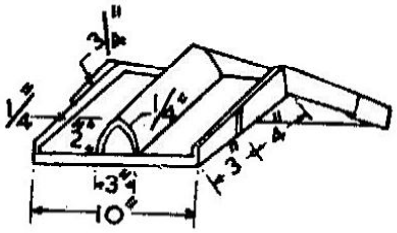
1. Mangalore tiles shall be manufactured as flat pattern tiles with suitable keying and projections from well-prepared clay (Specification 3.1) made from double channelled 'Basel Mission Pattern' and properly burnt.



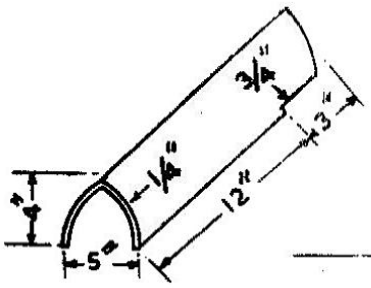

ISOMETRIC VIEW OF FLAT TILE



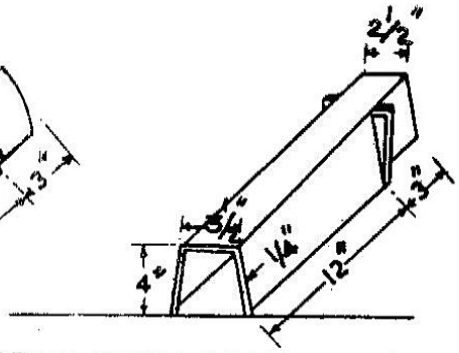

FLAT TILE



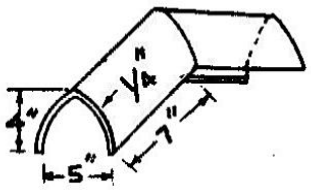

RIDGE TILE




HALF ROUND TILE




SEMI-HEXAGONAL TILE

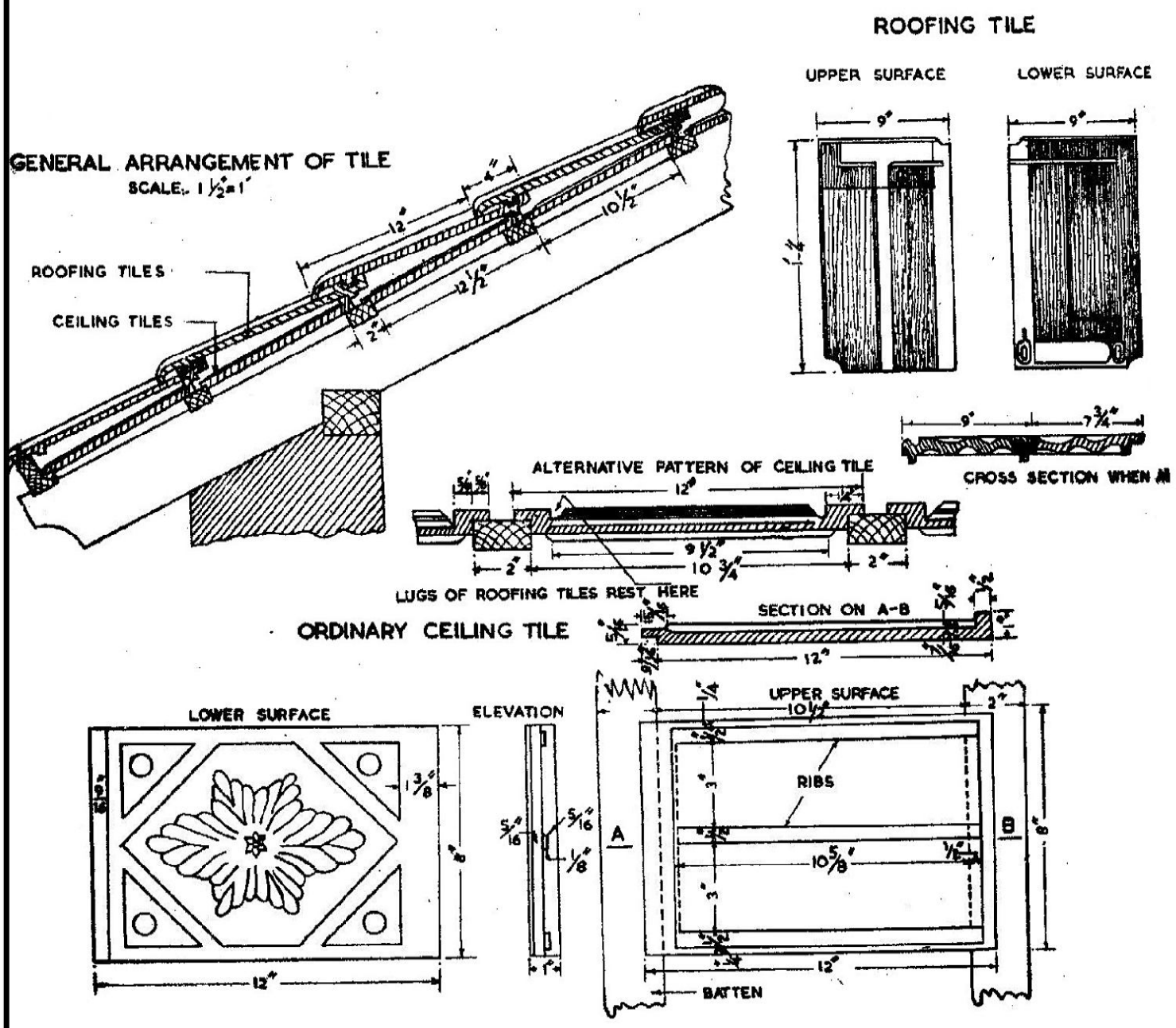



RIDGE HALF ROUND TILE

# ALLAHABAD TILE

SCALE:- 1"=1'

FIG: 1 (4.3)




# MANGALORE TILING

FIG: 1 (4.4)

**Size**

2. The size shall be 9″ × 14″ Keying and projections shall be as shown in fig. 1 (4.4).

**Thickness**

3. It shall not be less than 3/8 in. nor more than 5/8 in. thick.

**Quality**

4. It shall be of uniform colour, free from cracks, twisting and other imperfections. Tiles shall ring clearly when struck.

**Test**

5. It shall not absorb more than 1/6th its weight of water when immersed for one hour.

**Measurement**

6. Tiles shall be measured in numbers and the unit of measurement shall be one thousand.

**Rate**

7. The unit rate shall include the cost of tile, sorting, delivering and stacking at Site of work to be defined in the Conditions of Contract.

## SPECIFICATION

## No. 4.5 SIALKOT PATTERN ROOF TILES

**Manufacture**

1. Sialkot tiles shall be manufactured as flat, elevator and ridge ventilator tiles from well prepared clay (Specification 3.1) and properly burnt.

**Size of Tile**

2. The size of tiles shall be 13″ × 12¾″. The sizes of side groove, central groove and the studs shall be as shown in fig. 1 (4.5).

**Thickness**

3. The tile shall not be less than 3/8 in. nor more than 5/8 in. thick.

**Elevator**

4. The various dimensions of the elevator shall be as given in fig. 1 (4.5).

**Ridge ventilator**

5. The section of the ridge tile shall be the same as that of flat tile. Pitch Angle shall be between 60° to 45° as specified.

**Quality**

6. The tile shall be of uniform colour, free from cracks, twisting and other imperfections. Tile shall ring clearly when struck.

**Test**

7. The tile shall not absorb more than 1/6th its weight of water when immersed for one hour.

**Measurement**

8. Sialkot roof tiles and the tile fitting shall be measured in numbers and the unit of measurement in each case shall be one thousand.

**Rate**

9. The unit rate shall include the cost of Sialkot tile special fitting, conforming to above specification, sorting, delivering and stacking at Site of Work, to be defined in the Conditions of Contract.

## APPENDIX I

## TRANSVERSE STRENGTH TEST

Six tiles shall be tested. The tiles shall be soaked in water at 10 C-25 C (50 F to 77 F) for 24 hours prior to testing and shall be tested wet. Each tile to be tested shall be evenly supported upon two self-aligning steel bearers, which shall be of 1½" diameter, so placed that their centres are 7½ ins. apart. The load shall then be applied centrally at a uniform rate of 100 to 150 lb. per minute through a third steel bearer, also of 1½ ins. diameter placed midway between and parallel to the supports upon the upper surface of the tile. The length of all bearers shall exceed the maximum width of the tile under test. The average of the six tiles tested shall be taken. Should the tiles fail to pass the requirement of Clause (4.2) II, a further six tiles shall be tested and the average of the 12 tiles taken for the breaking load for the purpose of this standard.

---

## APPENDIX II

## WATER ABSORPTION TEST

**A. Method of carrying out the test.**

Six tiles shall be dried to constant weight in a ventilated oven at 110°—115° C.(230°—239° F). When cool the dry specimens shall be completely immersed in clean water at 15.5°C—30° C (60°—86° F) for 24 hours. Each specimen shall then be removed, the surface water carefully wiped off with damp cloth and the specimen weighed.

The balance used shall be sensitive to within 1 % of the weight of the specimen and weighing of any one specimen shall be completed within three minutes after removing the specimen from the tank.

**B. Calculation of water absorption.**

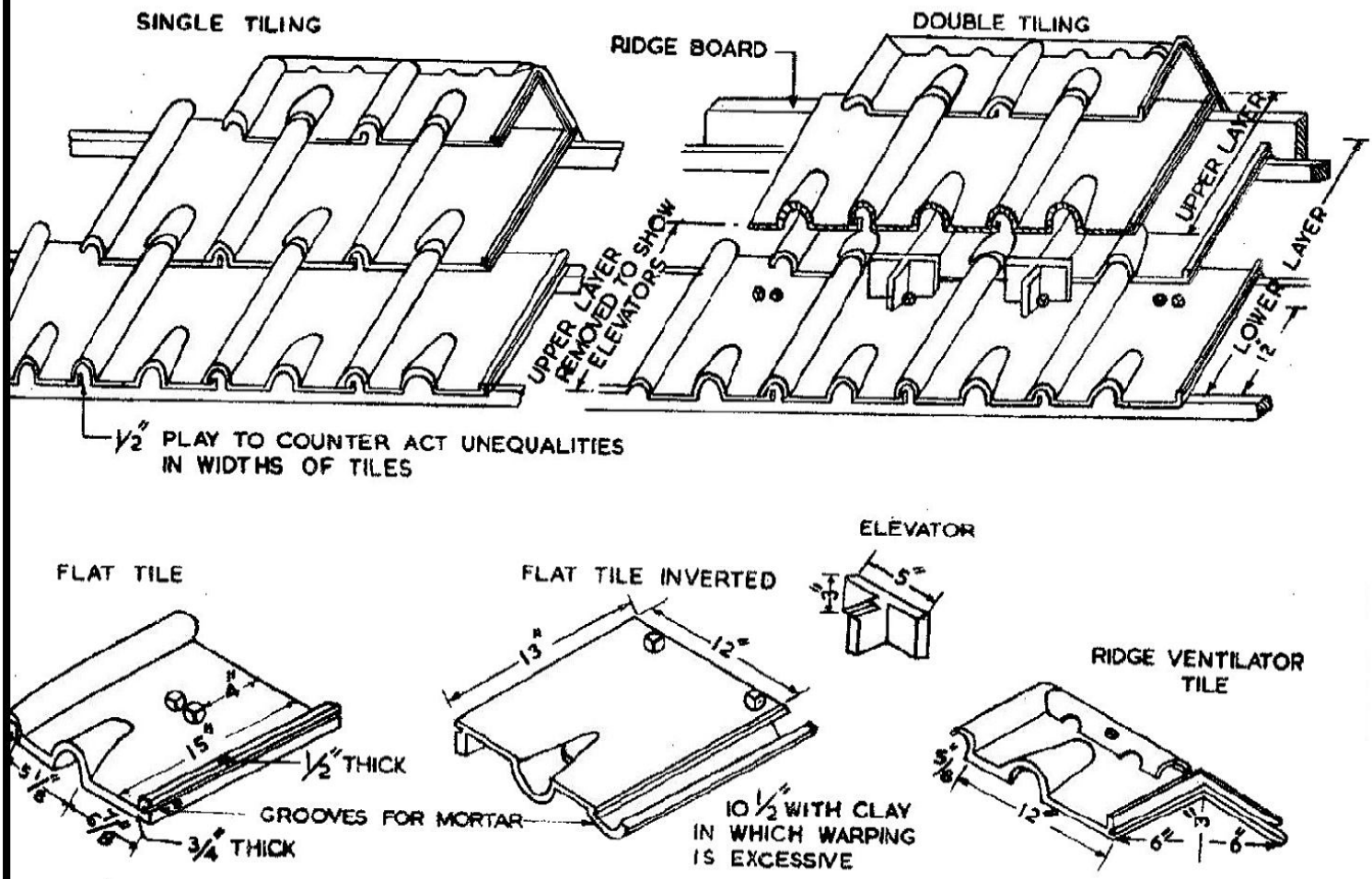
The results shall be reported in terms of percentage by weight and shall be calculated as follows:—

If A = weight of the dry specimen.

B = weight of the specimen after 24 hours' immersion in cold water. Then absorption per cent by weight after 24 hours' total immersion is

$$= \frac{100 \ (B-A)}{A}$$

Should the test fail, a further six tiles shall be tested. Should the second test fail the consignment may be rejected.




## SIALKOT PATTERN ROOF TILING

SCALE FOR GENERAL VIEW. ¾" = 1'

" " DETAILS. 1" = 1'

FIG: 1 (4.5)

# CHAPTER V

## SPECIAL TILES

## CONCRETE TILES

## GLAZED TILES

## SLATE TILES

# Cement Concrete Floor Tiles

## INTRODUCTION

### USE

Precast Cement concrete floor tiles are now being used extensively for paving floors of modern buildings. They provide clean, sanitary and fire-resisting flooring material. They are easy to maintain and can be conveniently replaced.

### TYPES

Cement concrete tiles may be divided into three types, namely, pattern tiles, single colour tiles and tiles with special aggregate facing (Mosaic).

### MANUFACTURE

Concrete tiles are manufactured either by dry process or wet process. The former is the better process partly owing to its simplicity and partly because the outlines of the designs in tiles can be more clearly defined by this process than by the wet process. Tiles with smooth face finish are generally manufactured by the wet process and those with recessed designs, mosaic or tasselated patterns are manufactured by the dry process.

(i) **Dry Process.** It involves two types of mixtures, the "facing" and the "backing". The facing can be one part of suitable cement colour and 8 to 20 parts of cement, according to the staining power of the colour used. It is advisable to use the best colour with the greatest staining power. As the colour tends to weaken the strength of the concrete the less the colour added to the cement the better the result. A still better result is obtained if the facing mixture is not made of cement and colour only but a quantity of finely ground quartz or clean sharp silica sand screened to pass No. 100 sieve is added. Usually 2 parts of cement and one part of quartz or sand are mixed and the required cement colour added to this mixture. Thus a coloured cement mixed in the proportion of 1 to 12 would consist of one part of colour to 4 parts of ground quartz or sand and 8 parts of cement. This is slightly damped after being thoroughly mixed in its dry state so that if a quantity of it is dropped from a height of 12 inches no dust escapes from the materials. Care must be taken not to add too much water, otherwise the facing mixture will adhere to the polished steel plate during the processing. The backing mixture consists usually of 3 parts (or 2½ parts) of clean sharp sand to 1 part of cement, with as much water added as the materials will take without distortion.

(ii) **Wet Process.** This involves three types of mixtures, namely (a) the facing, (b) the dry backing and (c) the wet backing.

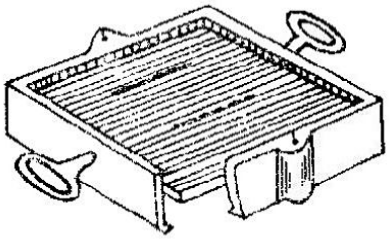
The facing mixture consists of the same materials as used in the dry process, except that a good deal of water is added so that the consistency of the mixture is that of a thin syrup.

The dry backing mixture consists of the same materials as the backing mixture for the dry process except that very little water is added to it—just sufficient to make the mixture earth damp.

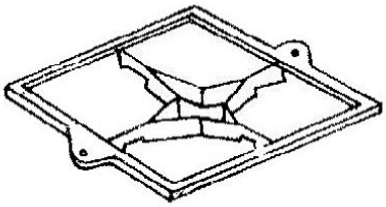
The wet backing mixture is the same as the dry backing except that it contains more water though less than that used for the backing mixture in the dry process.

### PATTERN-TILES.

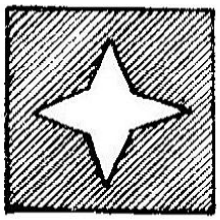
(a) **Dry Process.** Suppose that a two coloured tile is to be made with a green base and a red star



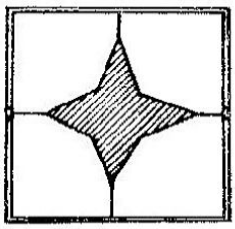
THE MOULD



THE PATTERN STENCIL



STENCIL PLATE NO. 1
STAR PORTION OPEN



STENCIL PLATE NO.2
STAR PORTION COVERED

FIG: 5.1

pattern in the centre. The facing mixtures, i.e. one red, the other green, and the backing mixtures will be prepared as described under dry process. Following are the different operations involved in the process of manufacture.

The polished steel plate known as the matrix (usually plain but sometimes with a raised design on it, or a mosaic like raised design, to give the finished tile the appearance of mosaic) is placed in one of the mould boxes so that its surface is about 1/4" below the top edges of the mould box as shown in the sketch. A stencil (generally made of brass strips) for the required design is then placed in the mould box, its knife like edges resting firmly on the surface of the steel plate (Matrix) and is held in position by the sides and studs.

In one of the two steel plates of the stencil is the star pattern and in the other the back ground is cut out. The first of the two stencil plates is placed over two studs of the stencil so that the cut open star in this plate coincides exactly with the star of the stencil. This plate keeps the star gap open, covering the background completely. The red colour of the facing mixture is then evently distributed over the star portion through a sieve so as to avoid lumps getting in. The first plate is then removed and replaced by the second. This covers the star portion of the stencil keeping the back ground open. The green colour facing mixture is filled in as above and the second stencil plate is then removed.

The facing mixture having been filled in, the stencil is lifted out of the mould box. This operation is the only one that requires skill, or at least care; if care is not taken to lift the stencil evenly the clear lines of the pattern in the surface of the tile will not be maintained. The mould box is now lifted up and the steel plate automatically sinks to the bottom of the mould box. The latter is then filled with backing mixture and levelled off.

A press stamp is then placed on top of the mould box and the latter pushed under the head tamper. Pressure is applied and the mould box pulled forward away from the press head. The method of removing the pressed tile from the mould box varies with the different kinds of presses. In some cases the tile is pushed out of the mould box, in others the mould box is drawn upwards over the tile. As soon as the tile is free from the mould box, a steel pallet is placed on top of the tile (which is readily the underside as it is pressed face downwards) and by a special arrangement all the three (the steel plate, the tile and the pallet) are turned over. Then the steel plate is lifted up and the tile, resting on its pallet, is placed on wooden racks holding four to six tiles.

**(b) Wet process.** Practically the same plant is used for "Wet" process as in the dry process with the exception of the apparatus used for filling in the facing mixture. Instead of using sieve boxes for sifting the dry facing mixtures into the various compartments of the stencil, specially shaped ladles are used by means of which the wet facing mixtures are poured in those compartments.

The steel plate is placed in the mould box exactly as is done in the dry process. The stencil is placed in position in the same way and mixture (a) of various colours is poured into the several compartments of the stencils by means of the ladles already mentioned. The mould box is lightly tapped and the stencil withdrawn vertically. Next mixture (b) is sifted into the mould box to the depth of about half an inch. This tends to absorb a certain amount of surplus moisture from mixture (a). The mould box is then filled with mixture (c) and levelled off. The remainder of the operation is practically the same as the dry process.

**SINGLE COLOUR TILES** are always hydraulically pressed and manufactured in the same fashion as pattern tiles.

**TERRAZZO TILES** The surface finish of tiles in which aggregates are exposed to obtain the surface finish is made very much like the pigment tile except that other materials are chosen for the surface layer. In making these tiles the surface layer consists of some specially selected aggregate, usually crushed marble or granite or prepared aggregate, mixed in the proportion of 1 part of cement to 2 parts of aggregate. The facing aggregate should be well graded from 1/4" to 1/2"

maximum size down to material that will just be retained on a sieve having 8 meshes per linear inch. The facing material is mixed rather wet and the backing dry. The final finish is given by grinding the surface with sand on a wheel and polishing with carborundum wheels. It is importat that the mould is always filled exactly to the same level and that the same pressure is applied to each tile. If this is not done, tiles of varying thicknesses will be produced and they complicate the work of the tile setter. Various kinds of hardeners and admixtures are often used to give the tiles greater strength and harder wearing surface.

**WORKSHOP**

It is essential that the manufacture of coloured cement floor tiles should be carried on in a well-constructed and properly ventilated building which should be free from draught and the direct rays of the sun. A plant with an output of 90 sq. yds., per day would require approximately 1500 sq.ft. area for manufacturing and stacking the freshly made tiles; 50′×30′ are good dimensions. To that must be added the storing room for the finished tiles which should also be free from draught and direct light.

**CURING**

Although it has a very important bearing on the strength and soundness of concrete, the subject of curing in relation to concrete products has not received proper attention in our country. Careless or improper curing will defeat all the efforts made to obtain the best results.

Tiles should be completely immersed in water as soon as they are hard enough to be handled safely. (Generally after 6 to 8 hours of moulding). With a thin product such as a tile, made with semi-dry concrete, it is practically certain that a very brief total immersion in water say of 12 hours, will cause the water to soak right through the tile. After this the tiles should be kept moist resting on their edges in racks for one week. It is safer to keep the tiles under cover for one week more before their curing is considered complete.

**POLISHING**

Polishing the mosaic or inlaid tiles is done after thorough curing. Various types of machines are available for the purpose. Before polishing, the mosaic or inlaid tiles are levelled off on smoothing and levelling machine and are retouched with fluid binding cement. They are then placed in the recesses provided in the revolving table of the polishing machine. The polishing stone or block (generally a piece of carborundum) is held in a special holder and is kept in contact with the tiles by the application of light pressure by the workman; a jet of water continually plays on the revolving tiles. Polishing starts with a very coarse type of carborundum stone and finishes with the finest type to get a good polish.

**SIZE**

The common sizes of cement concrete tiles are (i) 6″×6″ (ii) 8″×8″ (iii) 9″×9″ and (iv) 12″×12″. The 9″×9″ and 12″×12″sizes are used primarily in large floor areas such as hotels and club lobbies and store rooms. The smaller sizes are used in bathrooms, kitchen floors and walls.

## SPECIFICATIONS

### No. 5.1 CEMENT CONCRETE TILES

**Source**

1. Cement concrete tiles shall be obtained from an approved source. If manufactured departmentally through a contractor, the method of manufacture shall be approved by the Engineer-in-charge.

**Quality**

2. Tiles shall be hydraulically pressed and fully cured. They shall be uniform in colour, free from cracks and other defects like efflorescence and crazing, the arises to be sharp and true. Pattern tiles shall bear the approved pattern on their faces. Mosaic tiles shall have polished surfaces. The constituent materials shall be as specified by the Engineer-in-charge.

**Shape**

3. Tiles shall be true and even on face and of even thickness throughout. The backs shall be with bond under-cut key sufficient to ensure a good grip of the fixing medium. For wall tiling, tiles shall have holes formed in the edges to take galvanized or copper cramps.

**Size**

4. The size of the tile shall be as specified.

**Test**

5. A fully dried tile when immersed in water for any length of time shall not absorb water more than 2.5 per cent of the weight of dry tile.

**Measurement**

6. The measurement of tiles shall be in numbers. The unit of measurement shall be one hundred.

**Rate**

7. The unit rate shall include the cost of tile, sorting, packing and delivery in stacks at Site of Work, to be defined in the Conditions of Contract.

**TABLE NO. (5.1)**

**TABLE SHOWING MIXES FOR COLOURS**

| Colour desired | Commercial name of colours for use in cement | Pounds of colour required for each bag of cement to secure Light shade | Medium Shade |
|---|---|---|---|
| Greys, blue-black and black. | Germantown lamp black* or Carbon black* or black. | ½ | 1 |
| | Oxide of manganese or | 1 | 2 |
| | Mineral black | 1 | 2 |
| Blue | Ultramarine blue | 5 | 9 |
| Brownish red to dull brick red. | Red oxide of iron | 5 | 9 |
| Bright red to vermillion | Mineral turkey red | 5 | 9 |
| Red sandstone to purplish red | Indian red | 5 | 9 |
| Brown to reddish-brown | Metallic brown (oxide) | 5 | 9 |
| Buff, colonial tint and yellow | Yellow ochre or<br>yellow oxide | 5<br>2 | 9<br>4 |
| Green | Chromium oxide or | 5 | 5 |
| | Greenish blue ultramarine | 6 | — |

*Only first quality lamp black shall be used. Carbon black is of light weight and requires very thorough mixing. Black oxide or mineral black is probably advantageous for general use. For black, use 11 pounds of oxide for each bag of cement.

## SPECIFICATIONS

## No. 5.2 CONCRETE INTER-LOCKING

## ROOF TILES

**Composition**

1. Concrete roof tiles shall be manufactured from cement and aggregate conforming to specifications No. 3.3 and 6.1 respectively.

**Pigment**

2. The pigment incorporated in tiles shall be as per instructions of the Engineer-in-charge.

**Quality**

3. Tiles shall be true to shape, even on face and of even thickness, shall interlock and shall be free from cracks and other defects. On being fractured, the interior of the tile shall show uniform structure.

**Colour**

4. The colour of the tile shall be as specified.

**Nibs**

5. In case the tile has two nibs, these shall be not less than 1¼" wide and 1½" thick at the base. In case the tile has one nib, this shall be not less than 2" wide and ½" thick at the base. The Nibs measured from the underside of the tile shall be not less than ½" and not more than 3/4". There shall be at the lower edge of each tile one projection that shall reasonably fit into profile of the tile immediately below.

**Size**

6. The size of the tile shall be 15"×9" or as specified.

**Thickness**

7. The tile shall be not less that 3/8" and not more than 9/16" thick except in inter-locking portion which shall be not less than 5/16" thick and the side lap shall be not less than 1".

**Sampling**

8. The Engineer-in-charge may select 25 sample tiles from every batch of 10,000 tiles.

**Transverse Strength Test**

9. The average breaking load applied along with the width of tile between the supports clear span of 10' shall not be less than 145 lbs. and 200 lbs. for wet and dry conditions respectively.

**Measurement**

10. The measurement of tile shall be in numbers and unit of measurement shall be one hundred.

**Rate**

11. The unit rate shall include the cost of tile, sorting, packing, delivery and stacking at Site of Work, to be defined in the Conditions of Contract.

# Glazed Tiles

## INTRODUCTION

### MATERIALS

The body materials are Ball Clay, China Clay, China Stone and Flint.

### MANUFACTURE

The manufacture of glazed tile involves two processes; the first process being the preparation of body material, shaping the tile and initial firing, the result being known as "Biscuit" and the second of coating the biscuit with glaze decoration and final firing. The clays and China Stone of body materials are decomposed granite, silica and alumina with alkalies and sodium potassium. The flint is incorporated to produce intense whiteness. Because of its small contraction and to control shrinkage and shape, each of the clay is mixed with water separately, until it reaches a creamy consistency. The flint is in calcined condition, in the shape of white brittle calcined stone. These stones are ground with water in iron cylinders lined with granite setts, to prevent the flint coming in contact with the material. The clays and flint are made into a slurry, mixed together, sieved, passed over electromagnets that extract fine particles of iron. The slurry known as "slip" is run to a storage tank. The water is extracted from the slip by pressure in fitter presses, changing the liquid to a plastic clay. The packs of clay leaving the presses are dried in ovens where the last drop of the moisture is driven off. The dry clay slabs are crushed to dust, moistened slightly so that the dust will bind under pressure, but remain sufficiently dry to pass through wire gauze sieves. The dust is formed into tiles in heavy presses having dies, a little larger than the finishing size, to allow any shrinkage in the backing process. The tiles are then packed in boxes which are placed in kilns and fired for 10 days until a heat of 1200° C is reached; five days are allowed for cooling. Tiles are then taken out, sorted and stored.

### GLAZING

Glazes are of two kinds, i. e. earthenware glaze and colour enamels.

The earthenware glazes are white and cream coloured only.

Colour enamels are of two types, i. e. with bright or glossy surface and those with eggshell vellum, or mat surface. The glaze is applied as a liquid to the face of the tiles; these being absorbent suck out the moisture, leaving the glaze as a powdery crust on its face. Tiles are laid on a separate shelf or crank on a fire clay truck which is passed on rails into gas heated tunnel oven where the glaze is fused. The oven is about 75 yards long and the heat zone is 10 yards long near its middle. The truck is propelled through the oven at a speed of 1 inch per minute. Different glazes fuse at different temperatures and are obtained by careful positioning on the trucks, the tiles needing most heat being placed at the highest level. Cooling begins soon after the tiles have passed the heat zone and continues until the tiles are delivered at the far end of the tunnel.

## SPECIFICATIONS

### No. 5.3 GLAZED TILES

**Composition**

1. Glazed tiles shall be manufactured from ball clay, china clay, china stone and flint fired to not less than 1200° C.

**Quality**

2. The tiles shall be fully glazed on the face, uniform in colour, free from cracks and other defects; the arises to be sharp and true.

**Shape**

3. Tiles shall be true and even on face and of even thickness throughout. The backs shall be with bond under cut key sufficient to ensure a good grip of the fixing medium. For wall tiling, the tiles shall have holes formed in the edges to take galvanized or copper clamps.

**Throating, Mortises, etc**

4. All throatings, mortises and stooling shall conform to the requirements of tiles.

**Measurement**

5. The measurements of tiles shall be in numbers. The unit of measurement shall be one hundred.

**Rate**

6. The unit rate shall include the cost of tiles conforming to above specifications, sorting, packing delivery and stacking at Site of Work, to be defined in the Conditions of Contract.

# Slate Roof Tiles

## INTRODUCTION

The use of slate tiles for roofing has many disadvantages. The tiles are expensive because of their high cost of carriage from the quarry to the site. These require a stronger roof construction capable of bearing their heavier weight and higher wind resistance as compared to other roofing material. The ease with which slate tiles get broken or deranged by the action of wind and frost make them a very inconvenient roofing material. Slate tiles for roofs are, therefore, not to be used unless architectural considerations admit of no other type of materials more suitable.

### TYPES

The slate roof tiles are of two types, i. e. rectangular slate tiles and eternit slate tiles.

### SIZE

The sizes of rectangular slate tiles are 24″ × 12″; 20″ × 10″; 16″ × 8″. The size of eternite tile is given in fig. I, (5.4).

## SPECIFICATIONS

### No. 5.4 SLATE ROOF TILES

**Source**

1. The slates shall be obtained from an approved source.

**Size**

2. The size of slate tiles shall be as specified.

**Quality**

3. Slate tiles shall be flat, properly squared to the specified size, shall be tough, hard, sonorous on being struck, rough to touch, free from flaws or cracks, non-absorbent and of uniform thickness. Tiles shall have holes formed as specified.

**Grain**

4. The grains of the tiles shall run longitudinally and not transversely.

**Colour**

5. The colour of the tile shall be as specified.

**Thickness**

6. Tiles shall not be less than 3/8″ nor more than 5/8″ thick.

**Nails**

7. Nails shall be of copper or of non rusting composition.

**Nailing Battens**

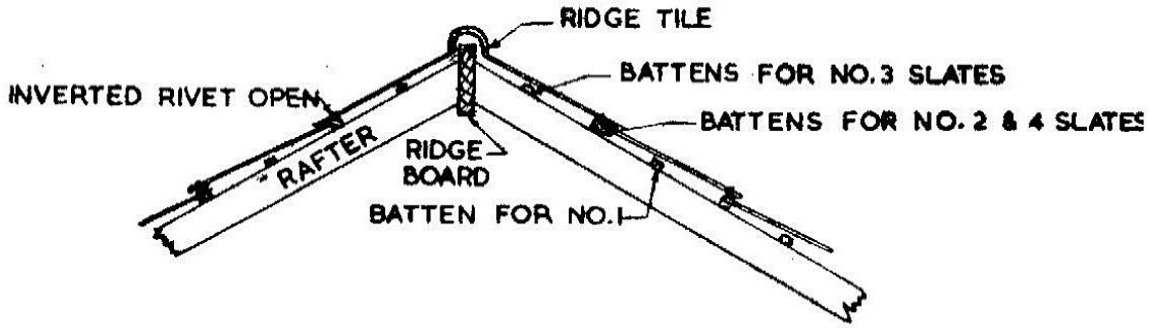
8. Nailing battens shall be of deodar wood complying with Specifications for timber and shall not be of a section less than $1\frac{1}{2}" \times 1\frac{1}{2}"$

**Measurement**

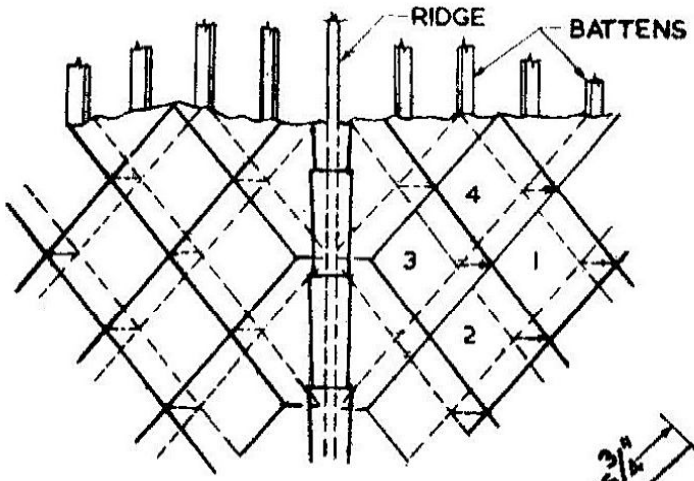
9. The measurement of tiles shall be in numbers and the unit of measurement shall be one hundred.

**Rate**

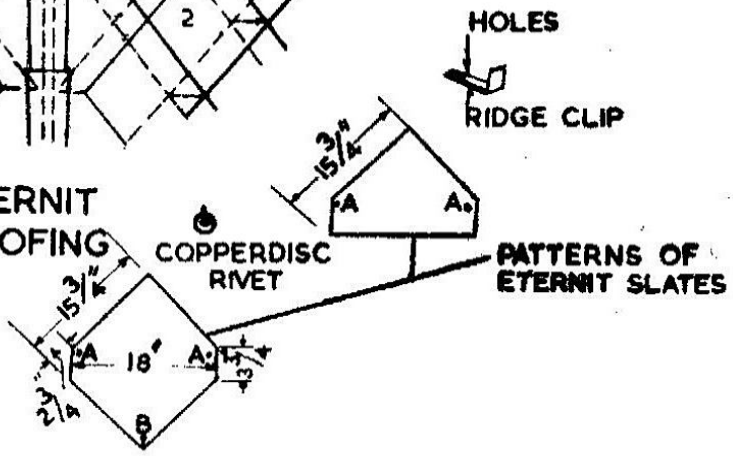
10. The unit rate shall include the cost of tile nails for fixing, the tile, sorting, stacking and delivery of tiles at site of Work, to be defined in the Conditions of Contract.




SECTION OF ETERNIT SLATE ROOFING




PLAN OF ETERNIT SLATE ROOFING




## REFERENCES

A. NAIL HOLES
B. COPPER RIVET HOLES

FIG: I (5.4)

# CHAPTER VI

## AGGREGATE AND INERT MATERIALS

### AGGREGATES

### SURKHI

### CINDER

# Aggregates

## INTRODUCTION

### DEFINITION

Aggregates are inert materials mixed with cementing materials and water to produce concrete and mortar.

### CLASSIFICATION

Aggregates are classified into fine and coarse. The term fine aggregate or sand is used to designate aggregates in which the maximum size of particles is 3/16". All aggregates above this size are designated as coarse aggregates.

### SOURCE

All aggregates can be divided according to their source into three groups:—

(i) **Natural Source.** Natural sources are river beds, pits deposits, dunes, seabeds and beaches. Aggregates obtained from natural sources are, Gravel, Bajri, Shingle and Sand, etc.

(ii) **Products obtained by crushing stones or bricks.** Granite Trap Rock (a name that has been applied to any dark coloured fine grained igneous rock), lime stone and hard sand stone are the most common rocks from which aggregates are manufactured; aggregates are also manufactured by breaking good 1st class bricks. These means of manufacture are employed only when the product is found to be more economical than naturally available materials.

(iii) **Industrial Products.** Aggregates obtained from industrial process are blast furnace slag, cinder and light weight aggregates manufactured from Shale. These products are used in areas where they are readily available and are economical or where special structural requirements dictate their use.

### REQUIREMENTS

Aggregates have to conform to the following requirements:—

(i) **Cleanliness.** The aggregates should be free from injurious amounts of clay, salt, alkali, organic matter, shale, loam, soft flaky particles and other deleterious substances. Aggregates when not obtained in clean state are invariably washed before use. All deleterious substances shall not exceed 5% in fine aggregates and shall not exceed 3% in coarse aggregates. The extent of these impurities are determined by various field and laboratory tests.

(ii) **Shape.** Manufactured aggregate should be sharp, angular and of hard grains, approximately cubical in size and those obtained from natural sources should be rounded, well shaped and of hard grains.

(iii) **Size.** To obtain high crushing strength of concrete the maximum size of aggregate should be as large as conveniently possible, but it should not be normally greater than one-fourth in plain concrete and one-fifth in reinforced concrete of the smallest dimension in the structure. The maximum size of aggregate may be up to 6 ins. for mass concrete, but a size of up to 9 ins. has also been used in dams. Aggregate of this size requires carefully

designed mixes to avoid segregation and it is probably wise to limit the maximum size to 3 ins. Large stones which are embedded in mass concrete works are called "plums" Plums should be sound and hard. The spacing between two plums or a plum and the outer surface should not be less than six inches. For heavily reinforced members the nominal maximum size of aggregate should be 1/4 in. less than the minimum distance between the reinforcement bars or the minimum cover of concrete over the reinforcement whichever is less, provided that the concrete can be placed without difficulty so as to surround all reinforcement thoroughly and to fill corners of the form work.

Maximum size of aggregate recommended for various types of construction are tabulated below:—

| Type of Section | Size of Section | | | |
|---|---|---|---|---|
| | 2½" to 6" | 6" to 12" | 12" to 30" | 30" or over |
| Reinforced Walls, beams and columns | ½" to ¾" | ¾" to 1½" | 1½" to 3" | 3" to 6" |
| Unreinforced walls or mass concretes | ¾" to 1" | 1½" to 3" | 3" to 6" | 6" |
| Heavily reinforced slabs | 3/4" to 1" | 1½" | 1½" to 3" | 3" to 6" |
| Lightly reinforced or unreinforced slabs | 3/4" to 1½" | 1½" to 2½" | 2½" to 3" | 3" to 6" |

(iv) **Grading.** Aggregates are required to be graded into different sizes and mixed in desired proportions for producing mortar and concrete of specified quality and strength. The graded aggregate is one that contains all sizes of particles between extremes of limits proportioned to produce a dense and economical mixture which will use minimum of cement per unit volume to give required strength. The aggregates are graded into nominal sizes by sieving and their fineness Modulus determined. The fineness Modulus is calculated by dividing by 100, the sum of the total, percentages retained on designated sieves in the standard sieve Analysis. A smaller value of the fineness modulus indicates the presence of large proportions of fine particles.

(v) **Durability.** Aggregates should be hard to resist grinding action; tough to withstand impact and sound to remain whole during changes in weather conditions. The resistance to grinding action is determined by Los Angles Abrasion Test. The soundness test is carried out by means of Sodium Sulphate Test. Crushing strength test is carried out to determine the strength. The specific gravity test is required to determine the density.

(vi) **Storage.** Storing on dusty, muddy or grassy spots should be avoided. Dumps must be protected from exposure to dust. Old steel sheets or wooden planks may be used as platforms for storage. On large works storage bins are usually used.

(vii) Miscellaneous Information

**A. Weight in lbs/cft.**

| | |
|---|---|
| Fine and dry river sand (loose) | 90 |
| Medium | 95 |
| Coarse | 100 |

| | |
|---|---|
| Burnt Clay ballast | 70 |
| Beach or river shingle 3/4" to 1/4" | 100 |
| Gravel Coarse, loose, unscreened | 115 |
| Broken brick 2" to 1/4" gauge | 80 |
| Broken stone | 100 |
| Stone screening 3/4" to 1/2" | 90 |
| Broken granite 2" to 3/4" | 105 |
| Granite chipping 1/4" down | 95 |
| Coke Breeze 1" down | 45 |
| Clinker hard furnace 1" to 1/4" | 70 |
| Pumice stone | 40 |
| Blast furnace slag 1½" to 3/4" | 90 |
| Honey comb slag | 40 |

**B. Percentage Voids**

| | |
|---|---|
| Sand (moist and fine) | 43 |
| Sand (coarse) | 35 |
| Sand (mixed moist) | 38 |
| Sand (mixed dry) | 30 |
| Stone screenings | 58 |
| Broken stone 1" and under | 46 |
| Broken stone 2" and under | 45 |
| Broken stone 2½" and under | 41 |

**C. Specific Gravity**

| | |
|---|---|
| Trap | 2.9 |
| Granite | 2.7 |
| Slate | 2.7 |
| Gravel | 2.66 |
| Sand | 2.65 |
| Limestone | 2.60 |
| Sandstone | 2.40 |

**D. Bulking of Sand**

The volumetric expansion of sand due to moisture content is called Bulking. Finer sands bulk more than coarser varieties. As the moisture increases and the sand becomes fully saturated it occupies the same volume as dry sand.

| % Moisture by Weight | % Bulking by Volume | | |
|---|---|---|---|
| | Fine | Medium | Coarse |
| 5 | 38 | 29 | 18 |
| 10 | 32 | 22 | 12 |
| 15 | 22 | 12 | 2 |
| 20 | 10 | — | — |
| 27 | — | — | — |

A list containing various types of aggregates available in West Pakistan is given below:

## QUARRIES AND MATERIALS QUARRIED IN WEST PAKISTAN.

| S. No. | Name of Quarry and Location | Material Quarried |
|---|---|---|
| 1. | Kisor range of hills near Chashma | Stone |
| 2. | Faqirwal range of hills near Bilot | Stone. |
| 3. | Fazirwal range of hills near Kotla | Stone. |
| 4. | Marwat range of hills near Chanda | Stone. |
| 5. | Dabra near Manzai | Aggregate sand, Bajree and Shingle. |
| 6. | Chunda Dera Ismail Khan | Aggregate sand, Bajree and Shingle. |
| 7. | Marble quarry Mullagori, Mile 24 Mullagori Road | Marble stone. |
| 8. | Jamrud quarry mile 27 Peshawar-Landi-Kotal Road | Limestone. |
| 9. | Baisai quarry, Mile 14 Frontier Road | Limestone. |
| 10. | Bara River quarry Mile 3 Peshawar-Kohat Road | Aggregate and sand. |
| 11. | Islamia College Khawar Mile 5 Peshawar-Jamrud Road | Aggregate and sand. |
| 12. | Pir Bala Khawar Mile 5 Peshawar-Michri Road | Aggregate and sand. |
| 13. | Ganjai near Takht-i-bai | Hard stone. |
| 14. | Rustam Cheena Nallah No . 1, 2, 3, 4, 5 and 6 | Stone and Bajree. |
| 15. | Toopi Nallah | Stone and Bajree. |
| 16. | Baran Nallah Boulder M/4 N.J.K. Road | Stone. |
| 17. | Bannu Nallah Boulder M/4 N.J.K. Road | Stone. |
| 18. | Toochi Nallah Boulder M/10 B.J.K. Road Nos. 1, 2, 3 and 4 | Stone and Bajree. |
| 19. | Kurram Nallah Boulder M/77 K.B. Road Nos. 1, 2, 3 and 4 | Stone and Bajree. |
| 20. | Compain Nallah Quarry Nos. 1, 2, 3 and 4 | Stone. |
| 21. | Toochi Nallah Boulder M/19. B.I. Road | Stone and Bajree. |
| 22. | Chona Rob Quarry M/26-27 Bannu Isha Road | Stone. |
| 23. | Isa Khel Quarry M/36 Bannu Isha Road Nos. 1 and 2 | Stone. |
| 24. | Miran Shah Quarry M/40 M.B. Road Nos. 1 and 2 | Stone. |
| 25. | Pai Khel | Stone and Bajree. |
| 26. | Musa Khel No. 1 and 2 S.W.W.M. | Stone and Bajree. |
| 27. | Kala Bagh | Stone and Bajree. |
| 28. | Loekhaver N.-W.F.P. | Stone. |
| 29. | Dak Quarry | Stone. |
| 30. | Samghakai N.-W.F.P. | Stone. |
| 31. | Panda Lalma | Stone. |
| 32. | Tangi near Tangi Village | Hardstone. |
| 33. | Nowshera near Kabul river R/Station | Limestone and Bajree. |
| 34. | Gohati at M/23-24 M. S. Road | Limestone. |
| 35. | Tarrako Ghundai at R. D. 232,000 Machai Branch | Marble quarry (leased out by Government). |
| 36. | Jamal Garhi never Jamal Garhi Village | Limestone. |
| 37. | Malakand | Granite and sand Stone. |
| 38. | Harno N llah M/12 Abbottabad-Murree Road | Sand, Bajree and Boulders. |
| 39. | Daur River M/7 Haripur, Tarbela and M/52 Hazara Trunk Road | Sand, Bajree and Boulders. |
| 40. | Harro River M/16 Haripur-Khanpur Taxila Road | Sand, Bajree and Boulders. |
| 41. | Ichar N llah M/16 Mansehra-Baffa Icharian Road | Sand, Bajree and Boulders. |
| 42. | Salhad Mile 70 Hazara Trunk Road | Stone. |
| 43. | Kehal and Shukhul-Bandi (Abbottabad Link Road) | Stone. |
| 44. | Kakul and Nawan Shehr (Nawan Shehr, Mirpur Link Road) | Stone. |
| 45. | Sherwan (Abbottabad-Sherwan Road M/23) | Stone. |
| 46. | Soriji Gali (M/12 Haripur-Khanpur-Taxila Road) | Stone. |
| 47. | Ustar Zai N llah (M/13 Kohat-Thal Road) | Stone. |
| 48. | Raisan Nallah M/17 Kohat Thal Road | Stone. |
| 49. | Kahi Nallah M/38 Kohat-Thal Road | Stone. |
| 50. | Darsamand Nallah M/51 Kohat-Thal Road | Stone. |
| 51. | Sangroha Nallah M/61 Kohat-Thal Road | Stone and Bajree. |
| 52. | Babri Banda Quarry M/22 Kohat-Thal Road | Stone. |

QUARRIES AND MATERIALS QUARRIED IN WEST PAKISTAN—(*Contd.*)

| S. No. | Name of quarry and Location | Material Quarried |
|---|---|---|
| 53. | Khandi Nallah M/61 Kohat-Thal Road | Stone. |
| 54. | Kirman Toi Mile 48/6 Thal-Parachinar Road | Stone. |
| 55. | Zehar Toi M/3 Kirman Road | Stone. |
| 56. | Risalpur Quarry near Risalpur | Marble stone. |
| 57. | Pirsabak Quarry near Pirsabak | Marble stone. |
| 58. | Maneri Quarry near Maneri village | Marble stone. |
| 59. | Sheikh Jana Quarry near Sheikh Jana | Marble stone. |
| 60. | Tarakai Quarry near Tarakai Hill | Soling stone and Metal stone. |
| 61. | Pezo Quarry M/50-52 Bannu D. I. Khan Road | Boulder and Bajree. |
| 62. | Kaur Nallah M/52 Tank-Kaur Road | Boulder Stone and Coarse aggregate. |
| 63. | Tank Zam Nallah M/5 Tank Zam Road | Boulder Stone and Coarse aggregate. |
| 64. | Local Nallah within 10 miles radius from Wana Camp | Boulder Stone and Coarse aggregate. |
| 65. | Kolachi Nos. 1—4 | Bajree. |
| 66. | Dara Band Nos. 1—2 | Bajree. |
| 67. | Hangu Sub-Division M/16, M/13, M/19 K. P. Road | Bajree. |
| 68. | Sheikhan Road M/1 (A) (B) | Bajree. |
| 69. | Thal Nallah T. I. (A) K.T.M./39 and M/4 Doaba-Nariab Road | Bajree. |
| 70. | Bara River Kohat Road M/3 (1) | Bajree. |
| 71. | Busai Khevar Jamrud Road M/5 | Bajree. |
| 72. | Pir Bala Peshawar Road M/5 | Bajree. |
| 73. | Subhan Khewat Peshwar Road M/22 | Bajree. |
| 74. | Pehlwan Khewat-Nowshera 25 G. T. Road | Bajree. |
| 75. | Kotla Chushma Canal Dera Ismail Khan | Bajree. |
| 76. | Bara Nallah-Peshawar | Bajree. |
| 77. | Islamia College-Peshawar | Bajree. |
| 78. | Kot Chana | Bajree. |
| 79. | Khandali Babri | Bajree. |
| 80. | Rahi Nallah | Bajree. |
| 81. | Jamrud | Bajree. |
| 82. | Swan (Mianwali) | Bajree. |
| 83. | Mari Indus | Bajree. |
| 84. | Katha | Bajree. |
| 85. | Gember (Mianwali) | Bajree. |
| 86. | Sangiani | Bajree. |
| 87. | Dara Tang | Bajree. |
| 88. | Baghanwala Quarry at Gharibwal R/S Distt. Jhelum | Stone Ballast of all sizes, Pitching stone, Boulder stone, Ashdar stone, Building stone, Spawl stone, Distance marks of all sizes, Boundary stone of all sizes, stone ballast machine, stone slabs and stone cubes. |
| 89. | Sikhanwala quarry, half mile from Sikhanwala Railway Station | Stone ballast of all sizes Pitching stone, Spawl stone Stone ballast machine crushed, Bajree of all sizes. |
| 90. | Wah stone, Shah Mot Nallah Nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12 | Stone and Bajree. |
| 91. | K. K. Road M/22, M/33/4, M/41/3 and M/5½. | Stone. |
| 92. | K. C. Road Kalur Khandwar Range G. I | Stone. |
| 93. | Katas Range Group III | Stone. |
| 94. | Rawalpindi Nos. 1, 2 and 3 | Stone. |
| 95. | Hub River Shingle | Stone. |
| 96. | Tarnah Shingle | Stone and Bajree. |
| 97. | Kaura Burj Charter Bank Lyallpur | Stone. |

QUARRIES AND MATERIALS QUARRIED IN WEST PAKISTAN—(*Concld.*)

| S. No. | Name of quarry and Location | Material Quarried |
|---|---|---|
| 98. | Chuhnar Jamali Crushed stone Nos. 1, 2, 3 and 4 | Stone. |
| 99. | Swan Boulder | Stone. |
| 100. | Bhimber Nallah Gujrat | Bajree. |
| 101. | Chablat | Bajree |
| 102. | Hassan Abdal | Bajree. |
| 103. | Usman Khathar | Bajree and Stone. |
| 104. | Jhelum Bed | Bajree. |
| 105. | Kahuta M/3 and M/22 R. K. A. Road | Bajree. |
| 106. | Khewra | Bajree |
| 107. | Sehala R. K. A. Road | Bajree. |
| 108. | Kaurang R. M. K. Road | Bajree |
| 109. | Sangla Hill | Stone. |
| 110. | Bulland Hill Quarry (Sargodha). | Sand, Aggregate, Revetment Material, Revetment stone (40—80 Lbs) Rock Spawls Road Metal (Min. 3"). |
| 111. | Chak Daulat 6 Miles U/S Jhelum City on Right bank of River Jhelum | Sand Aggregate, Road Metal. |
| 112. | Burabada | Stone. |
| 113. | Hundewali | Stone. |
| 114. | Jhallar | Stone. |
| 115. | Taxila | Stone. |
| 116. | Pehro | Stone. |
| 117. | Nari | Stone. |
| 118. | Bahawalpur | Bajree and Stone. |
| 119. | Fatehpur | Bajree. |
| 120. | Sutlej Quarry at Rohri | Pitching Stone, Spawls and Stone ballast. |
| 121. | Hab River C. K. Road, Kulachi ZA. I. A. $A_2$ $B_2$ | Bajree. |
| 122. | Guddu Barrage | Stone. |
| 123. | Bollary 12 miles from Hyderabad | Stone, Bajree and Sand. |
| 124. | Jacobabad Quarry | Stone. |
| 125. | Larkana Quarry | Stone. |
| 126. | Dadu Laki Quarry | Stone. |
| 127. | Chilran Nallah W. Z. H. Kh. Road M/12 | Bajree. |
| 128 | Burn Nallah, Karachi | Bajree. |
| 129. | Mipur Ballow Nos. 1 and 2 | Bajree. |
| 130. | Sukkur Stone Quarry 2 miles away from R/S | Stone. |
| 131. | Kashmore stone Quarry 19 miles from Guddu Barrage | Stone. |
| 132. | Stone quarry 2 miles from Rohri R/Station | Stone. |
| 133. | Boradabad 48 miles from Hyderabad | Stone. |
| 134. | Jungshahi 58 miles from Hyderabad | Sand and Bajree. |
| 135. | Gharo, 84 miles from Hyderabad | Stone and Bajree. |
| 136. | Luky shah, Saddar 80 miles from Hyderabad | Stone and Bajree. |
| 137. | Abban Shah 90 miles from Hyderabad | Stone. |
| 138. | Ganj Takkar 7 miles from Hyderabad | Stone and Bajree. |
| 139. | Matli 34 miles from Hyderabad | Sand. |
| 140. | Shah Nihal quarry 110 miles from Hyderabad | Stone and Bajree. |
| 141. | Petaro 20 miles from Hyderabad | Gypsum. |
| 142. | Khirtar 12 miles from Hyderabad | Stone and Bajree. |
| 143. | Hirrock | Stone and Bajree. |
| 144. | Stone Boulder Quetta-Sibbi Road | Stone. |
| 145. | Khesar Nala 1½ miles from Nushki | Stone. |
| 146. | Bulan River M/31 and M/41 Quetta side | Stone. |
| 147. | Ziarat Bajree M/35 | Bajree. |
| 148. | Qilla Sufaid 65 miles from Nushki | Bajree. |
| 149. | Khissar Nallah between Koshanzi 12 miles | Bajree. |
| 150. | Sadiqabad-Abe-i-Gum | Bajree. |
| 151. | Chaman T. I. B. Nallah M/39 K. T. Road | Bajree. |
| 152. | Murghai M/12, 1" to 1/8" | Bajree. |

## SPECIFICATIONS

## No. 6.1. (A) FINE AGGREGATE

**Source**

1. Fine Aggregate shall be obtained from an approved source.

**Grading**

2. Fine Aggregate shall consist of well graded sand, stone screening or other inert material of similar characteristics, or a combination of these. The whole of it shall pass through 3/16 inch sieve and 2 to 10 per cent through sieve No. 100.

**Cleanliness**

3. Fine aggregate shall be clean and free from clay lumps, soft and flaky particles shale, alkali, organic matter, loam, mica and injurious amounts of deleterious substances. The sum of percentages of all deleterious substances shall not exceed 5 per cent by weight.

**Quality**

4. Fine aggregate shall be sharp, cubical, hard dense and durable.

**Storage**

5. Fine aggregate shall be stacked on a brick, wooden or other suitable platform so as to adequately protect it from dust and other admixtures.

**Measurement**

6. Fine aggregate shall be measured in bulk. The unit of the measurement shall be one hundred cubic feet.

**Rate**

7. The unit rate shall include furnishing fine aggregate in well graded and clean state as per above specifications delivery and stacking at Site of Work to be defined in the Conditions of Contract.

## SPECIFICATIONS

## No. 6.1 (B) COARSE AGGREGATE

**Source**

1. Coarse aggregate shall be obtained from an approved source.

**Grading**

2. Coarse aggregate shall be well graded within the range of 3/16 in. to 3 ins. of any size or range of sizes within such limits as actually specified for any particular work. It shall consist of quarried or crushed stone or other inert material or combination of these as specified.

**Cleanliness**

3. Coarse aggregate shall be clean and free from soft, friable, thin or elongated pieces, alkali, organic matter, or injurious amounts of deleterious substances. The sum of the percentage of all deleterious substances in any size shall not exceed 3 per cent by weight.

**Quality**

4. Coarse aggregate shall consist of well shaped, hard, dense, durable, uncoated rock fragments or brick bats.

**Storage**

5. Coarse aggregate shall be stacked on a brick, wooden or other suitable platform so as to adequately protect it from dust and other admixtures. Each type and size of aggregate shall be stacked separately.

**Measurement**

6. Coarse aggregate shall be measured in bulk. The unit of the measurement shall be one hundred cubic feet.

**Rate**

7. The unit rate shall include furnishing coarse aggregate in well graded and clean state as per above specifications and delivery and stacking at Site of Work to be defined in the Conditions of Contract.

## SURKHI

### INTRODUCTION

Surkhi is used as a substitute for sand in concrete, etc. and mortar, and has almost the same function as sand. It also imparts some strength and hydraulicity. Surkhi is made by grinding burnt bricks, brick bats or burnt clay to powder.

### SPECIFICATIONS

### No. 6.2 SURKHI

**Source**

1. Surkhi shall be first class, that is made by pounding or grinding fully burnt first class bricks or bats. Surkhi shall, on no consideration, be ground from over-burnt or under-burnt bricks and bats or from clay burnt by unapproved methods or obtained from kiln linings.

**Quality and Storage**

2. Surkhi shall be free from any admixture of clay, dust or foreign matter and shall be stacked on a brick, wooden or other suitable platform so as to be adequately protected from such admixtures.

**Fineness**

3. Surkhi shall be of such fineness that it passes through a screen of $12 \times 12$ meshes to the square inch, but does not pass one of $50 \times 50$ meshes to the square inch. For work that is to remain permanently under water after construction the $12 \times 12$ mesh screen shall be replaced by one of $8 \times 8$ meshes to the square inch.

**Measurement**

4. Surkhi shall be measured in bulk. The unit of measurement shall be one hundred cubic feet.

**Rate**

5. The unit rate shall include furnishing, grinding and screening Surkhi as per above specification and delivery and stacking at Site of Work to be defined in the Conditions of Contract.

## CINDER

### INTRODUCTION

**CINDERS**

Cinders are produced as waste materials from steam boilers using bituminous coal. They are hard, vitreous, granular, porous and light in weight. Cinders weigh about 45 lbs. per cubic foot. They are used in buildings for floor and roof construction where there is no wetting and drying or freezing and thawing. They are commonly used in making a light weight concrete building block. The cost is low since they are a waste material and may usually be had for the hauling.

## SPECIFICATIONS

### No 6.3 CINDER

**Source**

1. Cinder shall be obtained from an approved source. Only clean furnace clinker of coal, i. e. residue from furnaces of steam boilers, etc., using coal fuel only shall be used and any admixture of wood ash shall cause the whole of the cinder to be rejected. Cinder produced from coal containing an excessive amount of sulphur or other injurious chemicals shall not be used at all.

**Quality and Storage**

2. Cinder shall be free from any admixture of clay, dust, vegetation, or any foreign matter and shall be stacked on brick, wooden or other suitable platform so as to be adequately protected from such admixtures.

**Fineness**

3. Cinders shall be ground in mill and screened so that the whole of it shall pass through a screen of 12 × 12 meshes to the square inch but does not pass one of 50 × 50 meshes to the square inch.

**Use**

4. Cinder shall be used as a substitute for sand or surkhi only when it is specified or allowed by the Engineer-in-charge.

**Measurement**

5. Cinder shall be measured in bulk. The unit of measurement shall be one hundred cubic feet.

**Rate**

6. The unit rate shall include furnishing, grinding and screening cinder as per above specifications and delivery and stacking at Site of Work, to be defined in the Conditions of Contract.

# CHAPTER VII

## STONE

# Stone

## INTRODUCTION

### STONE AS A BUILDING MATERIAL

Stone is a high class building material, and where permanency of structure is required, it continues to enjoy superiority over bricks and all other rival materials. It has satisfactorily stood the test of time. When properly selected, it weathers well and does not involve heavy maintenance costs. These qualities have always been the deciding factors in its favour for use in permanent engineering work.

### GEOLOGICAL CLASSIFICATION

Rocks are classified according to their geological formation in the following three groups:—

(a) **Igneous Rocks.** Igneous rocks are formed by the rapid cooling of the molten material from inside the earth and are volcanic in their origin. These rocks are generally strong and durable. Granite and Traps belong to this group.

(b) **Sedimentary Rocks.** Sedimentary rocks or aqueous rocks are formed by the consolidation of particles of decayed rocks which have been deposited by streams of water. Limestone and sandstone are typical examples of such rocks.

(c) **Metamorphic Rocks.** Metamorphic rocks are either igneous or sedimentary rocks which have undergone structural changes in the form and colour due to intense pressure or heat, or both. These rocks are hard and durable. Slates, marbles and schists are examples of metamorphic rocks.

### SCIENTIFIC CLASSIFICATION OF STONE

Building stones are classified under the following categories, depending upon their composition:—

(a) **Silicious Stone.** Its base or principal constituent is silica, e. g. sandstone, trap, granite, etc.
(b) **Argillaceous Stone.** Its base is clay, e. g. laterite, slate, etc.
(c) **Calcareous Stone.** Its base is lime or carbonate of calcium, i.e., limestone, marble, etc.

### SOURCE

Stone is obtained from rock by means of quarrying. The term quarrying is generally applied to the art of extracting stone of various types for general building works, etc. The area where the extraction takes place is termed as quarry.

### LOCATION OF A QUARRY

The exact location of quarry is done after carrying out some exploratory work to have an idea of the underlying rock and the over burden to be removed to reach it.

The following factors usually determine the location of the quarry.

(i) Availability of the desired building stone at or near the surface of the ground.
(ii) Proximity of the quarry to the existing communication lines.
(iii) The possibility of arranging the drainage for quarry pit at a very low cost.
(iv) Availability of suitable sites for the location of power station, stone crusher and stone dressing and cutting machinery, etc.

## METHODS OF QUARRYING

The method of quarrying depends on the structure and nature of the rock and the purposes for which the stone is intended to be used. There are two principal methods of quarrying in use; namely, quarrying by hard tools and quarrying by blasting.

(i) **Quarrying by hard tools,** such as crow-bars, jumper, pick-axes, feathers and wedges is generally employed for quarrying in soft rocks, stratified and cleavable types and in beds of shingle deposits.

(ii) **Quarrying by blasting** with the aid of explosives is carried out when the tools cannot be directly used or their use is not economical. Quarrying is carried out either by manual labour or with the aid of machinery, or by both.

## QUARRYING BY MACHINE

When the quarrying is carried out on a large scale the following mechanical means are employed:—

(a) **Channelling.** Channelling machines consist essentially of reciprocating saws or drills so operated as to cut grooves of any desired depth, and up to a maximum of 40 feet length. The machine is capable of moving on the rock surface. For softer stone, saws are used to cut large blocks from the rock mass.

(b) **Cutting.** The cutting of stone is done with the aid of either circular saws or reciprocating saws and the stone block is mounted on trolley which brings the stone before the saw machine. The use of abrasives is very important in cutting a stone. Machinery is also used for plaining and polishing the finished surface of stone blocks and paving sets.

(c) **Breaking.** Breaking the cut pieces and quarry spoils into road metal, concrete aggregate or railway ballasts is done by means of a jaw crusher, a gyratory crusher or impact crushing machine. To have effective crushing some form of automatic feed device is also installed. Some times two stage crushing gives better results. Subsequent to crushing, materials are screened and sorted out according to grades or sizes. Screen can be fixed, movable or rotary type.

(d) **Lifting.** For lifting large blocks, for handling and cutting and transportation of the material from the quarry, crane and derrick pool used are conveniently mounted on trollies or wagon.

(e) **Drilling.** Holes are drilled in rock by rotary type or percussion type power drills. Deep holes require impact drilling machines.

## QUARRYING WITH BLASTING

The quarrying of hard and compact stone is carried out with the use of explosives in a systematic manner. The aim of blasting is to loosen and to separate as much rock as possible out of the rock mass and not to shatter the rock into pieces. Blasting is also adopted to reduce the larger boulders into smaller ones which are more convenient and handy sized. This is usually termed as secondary blasting. The various stages involved in the method of quarrying by blasting are given below:—

(a) **Boring holes into the rock.** Great skill and experience is required for the location of the exact spots in the rock mass where the intended explosion should take place to produce the desired effects. Such spots having been located, holes are bored by hand tools consisting of hammer and a short iron rod with a chiselled edge. The size of the holes usually varies from $\frac{7}{8}$ in. to $1\frac{1}{4}$ ins. diameter. When stones are required in large quantities hand drilling may be replaced by machine drilling. Use of water is made to facilitate drilling operations. The rock powder and mud created during drilling are removed by a scraper or a spoon or by a blast of compressed air.

(b) **Charging with explosives.** The next operation is to charge the hole with an explosive. Before filling the explosives it is quite essential that the hole should be thoroughly dry.

There are several varieties of explosives used for the purpose, like blasting powder or gunpowder dynamite or nitro-glycerine, gun cotton or nitrocellulose, cordite.

**Blasting powder or gunpowder.** It consists of 70 to 75 parts by weight of saltpetre ($KNO_3$) and 15 parts of charcoal with 10 to 15 parts of sulphur, and generates the desired explosives force. This is considered to be a weak explosive and loosens fairly large blocks in soft stones.

**Dynamite or Nitro-glycerine.** It has a high explosive value and is available in the form of cartridges. Its cartridge form, makes it specially suitable for use under wet conditions and heavy work.

**Gun Cotton or Nitrocellulose.** It is much more powerful than dynamite and great care has to be taken in storing and using it.

**Cordite.** It is the most commonly employed form of explosive. It is readily available in the form of cartridges and sticks. It is slow burning but stronger and more economical than dynamite or blasting powder. It is also suitable for use under water. In modern practice, however, liquid oxygen is preferred to all other explosives.

(c) **Tamping.** Tamping is necessary to prevent the reaction of the explosives along the blasting hole itself. When the explosive is being put into the hole and before the tamping is done, a fuse of sufficient length is inserted. Tamping consists of filling up the hole with a specially prepared stiff sandy clay which is tamped each time a little quantity is put into a small depth in the hole. A brass rod called the tamping bar is used for the purpose of tamping. Tamping has to be done very carefully and at the same time very skillfully to render the explosive very effective. Sometimes a priming needle of about 1/16 in. diameter is inserted in the tamping material which is removed after the tamping is over. The fuse is then introduced to admit of the explosive being fired. Sometimes a small quantity of gunpowder is poured into the hole to connect the explosive to the end of the fuse at the top.

(d) **Firing.** The fuse is kept of a sufficient length to allow the person firing it enough time to retreat to a safe distance before the explosion of the charge takes place. Two or more holes or groups of holes may be connected with a common fuse for firing simultaneously. The number of holes fired each time should be recorded to make sure later if any charge has failed to explode. A dull sound of a muffled character indicates the liberation of a large mass of stone from the parent rock.

Electrically operated firing devices are also adopted to create the spark needed for the explosion. This is a safe method and a number of explosions can be controlled from one place in a series. Detonators are commonly used for this purpose.

(e) **Secondary Blasting.** When large blocks of stones are liberated from the initial blasting operation, they are again broken to smaller pieces by a secondary blasting operation.

**DIRECTIONS FOR BLASTING**

The following directions for blasting with dynamite and high explosives should be followed:—

(i) Blasting operations must be carried out under the supervisions of a competent person during fixed hour of the day, preferably during the mid-day luncheon hour or at the close of the working day.

(ii) Danger flags should be prominently displayed and all the people, except those who have actually to light the fuses must be removed to a safe distance of not less than 200 yards.

(iii) All fuses must be cut to the lengths required before being inserted into the holes.

(iv) The number of charges to be fired and the actual number of shots heard must be compared and the quarryman incharge must satisfy himself by examination that all charges have exploded before quarrymen are permitted to approach the scene. Under no circumstances is the withdrawal of an unexploded charge to be permitted; the tamping and charge should be flooded with water and the hole marked in a distinguishing manner. Another hole should be jumped at a distances of about 18 inches from the old hole and fired in the usual way. The results should be carefully examined by the quarryman incharge and the operation continued until the original charge is exploded.

(v) **For making the hole** in an explosive cartridge to take detonator, only hardwood should be used and only wooden tempers should be used for tampering explosive charge. On no account should any metal implements be used.

(vi) **After firing** an explosive charge sufficient time must be allowed to elapse before men are allowed to return to work within the danger zone otherwise asphyxiation from carbon monoxide fumes may occur.

(vii) **Some explosives are very dangerous** in frosty weather. If work cannot be suspended during frosty weather special precautions must be taken to keep the explosive cartridges at a safe temperature.

(viii) **When cartridges sweat** these should not be handled with bare hands.

**MIS-FIRES**

Mis-fires are sources of great danger. If it is suspected that a part of the blast has failed to fire or is delayed allow sufficient time to pass before entering the danger zone. When fuse and blasting caps are used, a safe time (at least an hour) should be allowed. The quarryman-in-charge should at once report to his next superior all cases of mis-fire, the cause of the same and the step taken by him in connection therewith.

**PRECAUTION AGAINST MIS-FIRES**

The following precaution should be taken against mis-fires.

(i) The safety fuse (lighting end) should be cut obliquely with a knife.

(ii) All sawdust must be cleaned out of the detonator; this can be done by blowing down the detonator and tapping the open end. No instrument must be inserted into the detonator for this purpose.

(iii) After inserting the fuse in the detonator, it should be fixed by means of the nippers.

(iv) If there is water present, or if the borehole is damp, the junction of the fuse and the detonator must be made watertight by means of tough grease, white lead or tar.

(v) The detonator should be inserted into the cartridge so that about one-third of the copper tube is left exposed outside the explosive. The safety fuse outside the detonator should be securely tied in position in the cartridge. Waterproof fuse only should be used in damp boreholes or when water is present in the borehole.

(vi) If a mis-fire has been found due to the defective fuse, detonator or dynamite, the whole quantity or box from which the defective article was taken must be returned to the office for inspection.

**STORAGE OF EXPLOSIVES**

A special magazine for the storage of explosives should be constructed and the following rules observed there:—

(i) The magazine should at all times be kept scrupulously clean. High explosives, like dynamite, should be stored in a dry, clean, well-ventilated bullet proof and fireproof building on an isolated site, at least 150 ft. away from any other building or thoroughfare and a quarter of a mile away from any working kiln or furnace.

(ii) No unauthorized person is at any time to be admitted into the magazine.

(iii) The person incharge of the magazine is to take care that the magazine is well and securely locked.

(iv) The magazine is on no account to be opened during, or on the approach of, a thunderstorm, and no person should remain in the vicinity of the magazine during such a storm.

(v) Magazine shoes without nails should be kept at all times in the magazine, and a wooden tub or cement trough about one foot high and 18" in diameter, filled with water should be fixed near the door of the magazine.

(vi) Persons entering the magazine must put on the magazine shoes provided for the purpose and be careful :

(a) not to put their foot on the clean floor unless they have the magazine shoes on;
(b) not to allow the magazine shoes to touch the ground outside the clean floor; and
(c) not to allow any dirt or grit to fall on the clean floor.

(vii) Persons with bare feet will, before entering the magazine dip their feet in water and then step directly from the tub over the barrier (if there is one) onto the clean floor.

(viii) A brush or broom should be kept in the lobby of the magazine for clearing out the magazine on each occasion it is opened, for the receipt, delivery or inspection of explosives.

(ix) No matches or inflammable materials should be allowed inside the magazine. Light should be obtained from an electric storage battery lantern.

(x) No person having articles of steel or iron on him is to be allowed to enter the magazine.

(xi) Oily cotton rags, waste, and articles liable to spontaneous ignition should not be taken into the magazine.

(xii) Workmen or menials should be examined before they enter the magazine to see that they have none of the articles mentioned in rules (ix), (x) and (xi) on their person. All other persons shall have no such articles on their person.

(xiii) No tools or implements other than those of copper, brass, gunmetal or wood should be allowed inside the magazine. Tools should be used only with great gentleness and care.

(xiv) Boxes of explosives should not be thrown down or dragged along the floor and should be stacked on wooden trestles. Where there are white ants, the legs of the trestles should rest in shallow copper, lead or brass bowls containing water. In hot countries open boxes of dynamite should never be exposed to the direct rays of the sun.

(xv) Empty boxes should not be kept in the magazine, nor should any loose packing materials be about.

(xvi) If the magazine has a lightning conductor, it should be tested at least once a year.

(xvii) Blasting caps and electric blasting caps should never be stored in the same box, magazine or building with other explosives.

(xviii) Should there be any difficulty in keeping the magazine free from damp, fresh burnt quick lime, exposed in wooden trays is recommended.

(xix) The following should be hung up in the lobby of the magazine:—

(a) A copy of these rules.
(b) A statement showing the stock in the magazine.
(c) Certificate showing the last date of testing of the lightning conductor.

## CHARACTERISTICS OF GOOD STONES

In selecting a stone for an engineering work, the following characteristics should be looked into though the choice is in most cases further limited by the cost.

1. **General structure.** Stones are liable to be disintegrated if the particles are non-crystalline or amorphous.

2. **Fineness of grain.** Fine grained stones are more suitable for carved and moulding works.

3. **Compactness.** Compact stones are generally durable. Good stones are thus of older formation, found at a depth where they remain subjected to the pressure of earth above. Sometimes these stones are brought to the surface by earthquakes or volcanic eruptions.

4. **Porosity and absorption.** All stones are porous but some stones are so porous that they are most unsuitable for exposed situations; porous stones decompose and dis-integrate. Stones are tested by soaking specimens in water and noting the amount of water absorbed.

5. **Durability.** The durability of stone depends upon its chemical composition and physical structure and also upon its position in the building. Stones, which are crystalline in structure, homogeneous and close grained with good cementing materials, have a power to resist wear and tear under atmospheric and other stresses.

6. **Strength.** The resistance to crushing of stones ranges from 150 to 1,000 tons per sq. ft. but in ordinary building work it is immaterial as the pressure seldom exceeds 10 tons per sq. ft.

7. **Hardness.** Hardness is to be taken into consideration when the stone is to be subjected to a considerable amount of wear and friction as in the case of floors and pavements or hydraulic structure.

8. **Weight.** Heavy stones are required for dams, retaining walls, slope protections and aprons, etc., to add to their stability, while for arches, vaulting, etc., light stones are preferred.

9. **Appearance.** This is important when stone is used for the face work of buildings. Stones with uniform colour are generally found to be durable. Red and brown shades and mottled colour indicate the presence of injurious materials.

10. **Facility in working.** The ease with which stone can be cut or dressed into different shapes and sizes is an important consideration.

11. **Seasoning.** Just after quarrying, stones contain moisture, called quarry sap, which makes them soft and easier to cut. Stone should, therefore, be dressed soon after quarrying. It is essential that the sap should be expelled before they are used otherwise they may disintegrate. After quarrying, they are seasoned in open air, for about six to twelve months. These are often covered on the top to protect them from rain.

12. **Natural beds.** Natural beds in stones are planes of stratification formed by successive layers of deposits which have reduced cohesion. They are not always horizontal; the strata being often inclined due to the disturbance of volcanic or other agencies. All stratified stones should be placed on their natural bed, i. e. in the same position in which they were originally deposited. The natural bed of stone should be at right angle to the pressure for strength to resist crushing. Stones are placed with layers at a right angle to the face of the wall so as to offer greatest resistance to disintegration by frost or other sources. A good mason can find out easily the natural bed of stone by the 'feel' of the grain working the surface.

13. **Weathering.** It is the power to resist the action of weather, i.e., wear and tear due to atmospheric stresses. Well-weathered stones should be selected for face work.

## TEST AND EXAMINATION OF STONE

Generally in ordinary atmosphere the least porous, dense and strong stone will be durable. The following tests may be applied to find out the suitability of stones for building purposes:

(i) **Smith's Test.** A few small chips from a freshly quarried stone are put in a glass one-third full of water and then stirred briskly for half an hour. Stone will not be durable if the water becomes dirty.

(ii) **Brad's Test.** A few stone chips are weighed when damp and then immersed in a concentrated boiling solution of sulphate of soda. The stone is suspended for a few days and re-weighed. The loss in weight shows the probable effect of frost.

(iii) **Acid Test.** Stone chips are soaked for some days in a dilute solution of nitric and sulphuric acid to see whether these will withstand the foul atmospheric action in industrial area or not. This test is not applicable to limestone.

(iv) **Resistance to crushing.** It can be tested in a compression testing machine, though usually it is not necessary.

(v) **Weathering qualities.** Faces of newly quarried stone and old buildings made of that stone can be compared and the difference noted.

(vi) **Absorption of water.** A sample of stone is weighed when dry and reweighed after immersion in water for 24 hours. The difference in weight will give the weight of water absorbed. The stone which absorbs less water is more durable. A good building stone should not absorb more than 5% of its weight in this way.

(vii) **Microscopic examination.** The fractured surface of a durable stone should be bright, clean and sharp, with grains well cementing together. Stone likely to decay shows a dull earthy appearance.

Characteristics and uses of the important varieties of building stone are given in the following table:

| Name of stones. | Origin, Composition and characteristics | Uses |
|---|---|---|
| Granite | Igneous in origin and consists of quartz, felspar and mica. It is crystalline in nature and has a texture varying from coarse grained to fine grained. It is very hard and heavy and retains fine polish. | Used in bridge piers, marine works and ornamental columns. |
| Trap | Igneous in origin and consists of felspar, hornblende, augite and iron. It is very hard, tough and compact and therefore expensive to work. | Used for paving, road metal and aggregate. |
| Limestone | Sedimentary in origin and consists mainly of carbonate of lime (Calcium Carbonate). Its properties like colour, texture, hardness and durability are variable. | Used for paving and road metal under light traffic, blast furnace, bleaching tapping and manufacture of lime. It is not, however, suitable for industrial towns. |
| Marble | It is a metamorphic variety of limestone. It is crystalline in nature and retains fine polish. It is hard and compact. | Used in columns, pilasters, table slabs, steps, floors, and other ornamental purposes. |
| Sand stone | It is sedimentary in origin and consists of quartz cemented with lime, magnesia, alumina and oxide of iron. | Hardest ones for ashlar work, paving and road metal; fine grained ones for carving and coarse grained one for rubble work; road metal with tough materials will be muddy in wet and dirty in dry weather. |
| Quartzite | It is metamorphic variety of Silicious sand stone. It is compact, hard and brittle. | Used as road metal and concrete aggregate. |
| Slates | It is metamorphic in origin and chiefly consists of silica and alumina. It is fine grained, hard, durable and gives metallic sound when struck. It can be spilt into thin sheets along planes of cleavage. | Thin ones for roof covering but thick ones for floor, step, landing, shelve, sill, bath cistern, etc., used also as damp proof course. |
| Laterite | Sandy clay stone containing high percentage of iron oxide. | Used as building stone and road metal. |

DATA FOR BUILDING STONES OF GOOD QUALITY

| Kind of Stone | Weight pounds per cu. ft. | Compressive strength p.s.i. | Shearing strength p.s.i. | Modulus of Rupture p.s.i. | Modulus of elasticity p.s.i. ..x(10)$^6$ | Coeff. of. expansion per deg. F. ..x(10)$^6$ | Absorption of water percent of weight of stone |
|---|---|---|---|---|---|---|---|
| Granite, range | 160 to 170 | 15000—26000 | 1800—2800 | 1200— 2200 | 5.9 — 9.8 | — | — |
| Average | 165 | 20200 | 2300 | 1600 | 7.5 | .40 | 0.5 |
| Sandstone, range | 135—150 | 6700—19000 | 1200—2500 | 500— 2200 | 1.00— 7.70 | | |
| Average | 140 | 12500 | 1700 | 1500 | 3.30 | .55 | 5.0 |
| Limestone, range | 140—180 | 3200—20000 | 1000—2200 | 250— 2700 | 4.00—14.70 | | |
| Average | 160 | 9000 | 1400 | 1200 | 8.40 | .45 | 7.7 |
| Marble, range | 160—180 | 10300—16100 | 1000—1600 | 850— 2300 | 4.00—12.60 | | |
| Average | 170 | 12600 | 1300 | 1500 | 8.20 | .45 | 0.4 |
| Slate range | 170—180 | 14000—30000 | — | 7000—11000 | 13.90—16.20 | | 0.5 |
| Average | 175 | 15000 | — | 8500 | 14.00 | .58 | |
| Trap, average | 185 | 20000 | — | — | — | — | — |

## METHODS OF PRESERVING STONE

Stone must be protected against deterioration to prolong the life of the structure and to stop the face work from becoming unsightly. The most common methods are:—

(i) painting, and

(ii) plastering.

Various paints, oil and chemical solutions can be applied to protect stone from deterioration. These treatments have to be renewed periodically, say after every 5 to 10 years. The more successful of such methods of treatment have been the application of boiled linseed oil, paraffin, soap and alum solutions, silicate of lime or Ransome's process. Before the application of any of these treatments, the surface must be brushed, cleaned and made completely dry.

Boiled linseed oil is brushed on in one or two coats followed by a coat of dilute ammonia in warm water. The latter application unifies the discolouration produced by the oil.

Melted paraffin may be applied by brush and then forced into the pores of the stone by heating the surface to a temperature of about 60°C. Sometimes paraffin is mixed with a solution of creosote and naptha to prevent organic growth on the stone.

Ransome's process consists of filling potassium or sodium chloride into the pores of the stone by repeated applications of the solution by brush. After completely drying the surface, a coat of calcium chloride is applied, which produces a strong lime silicate cement which is not soluble in water.

The use of paint is not recommended as it never gives the desired shade of the stone and has to be renewed quite frequently, which makes it a costly treatment.

In spite of the high preservative qualities of coal tar or bitumen, their black colour does not permit of their use on face work. In atmospheres charged with sulphurous or carbonic acids, the use of a solution of barium hydrate $B_a\ Ch_2$ known as "Baryta" is helpful when applied in three coats on stones where the cause of decay is the formation of crystals of calcium sulphates. The formation of barium sulphate on the surface due to the application of "Baryta" give an insoluble surface to the stone, which is not affected by the atmoshphere.

"Szerelmeys" Stone Liquid" consists of silicate of sodium or potassium in combination with chloride of clacium and barium and is applied in two or three coats. Before applying the liquid, generally a preliminary coat of some bituminous liquid is given.

None of these methods is cheap enough to make the use of the preservatives possible in ordinary buildings. Also under the normal climatical conditions prevailing in West Pakistan, preservation of stone is generally not required.

## SPECIFICATIONS

### No. 7.1 STONE

**Source**

1. Stone shall be procured from an approved quarry using an approved method.

**Quality**

2. For use in masonry work, pitching or dumping and as road metal or aggregate the stone shall be hard, tough, compact and durable, free from faults and cleavage.

**Weight**

3. Pitching and Dumping stone shall weigh between 50 lbs to 80 lbs apiece and shall have at least one side cut.

**Stone for pavements**

4. For use in pavements and ornamental work the stone shall be hard, heavy, durable and fine-grained, capable of retaining fine polish.

**Dimensions**

5. Blocks required for dimensioned work must be square and true and shall be in accordance with the specifications given under stone masonry.

**Bedding**

6. Rubble stone shall be evenly bedded and shall be quarried in as large blocks as will permit of being handled. No stone shall measure less than one-third of a cubic foot.

**Stacking**

7. Stacking stone should be done on even ground. The length and breadth of the stack shall be in multiples of 10 and the height may vary from 2 ft. to 5 ft.

**Measurements**

8. Stone shall be measured in bulk, the unit of measurement shall be one hundred cubic feet. Actual stone contents shall be obtained by multiplying the stack measurement with a factor of 0.75.

**Rate**

9. The unit rate shall include furnishing stone conforming to the above specifications and stacking at Site of Work to be defined in the Conditions of the Contract.

## SPECIFICATIONS

### No. 7.2 STONE METAL FOR ROAD WORK

**Source**

1. Stone metal shall be procured from an approved source.

**Quality**

2. Stone metal shall be broken from hard durable tough stone of uniform texture. Only best stone available at the quarry shall be used. Where metal has been broken from water-borne boulders, no individual boulder shall weigh less than 8 lbs.

**Gauge**

3. Stone shall be broken to the gauge specified. The broken metal shall have sharp edges and clean fractured faces.

**2½" Gauge**

4. Stone metal of 2½ inches gauge shall pass a 2½" internal diameter ring in one direction and on dimension of any stone shall be greater than 3".

**2" Gauge**

5. Stone of 2 inches gauge shall pass through a ring of 2" internal diameter in one direction and no dimension of any stone shall be greater than 2½".

**1½" Gauge**

6. Stone metal of 1½ inches gauge shall all pass through a ring of 1½" internal diameter in one direction and no dimension of any stone shall exceed 2" in length.

**Sifting**

7. Stone metal, when sifted through a screen made of 1/4" diameter bar spaced 3/4" centre to centre, shall yield not less than 5% and not more than 10% by volume of fine material or "bajri". Where required, the contractor shall so sift the stone, stacking the fine material and the metal separately.

**Supply included in rate but not screening**

8. Unless otherwise specified the cost of this sifting or screening is not included in the rate for supply of stone metal and shall be paid for separately as screening. The supply of fine material is, however, included in the rate and this material will not be paid for in addition to the metal.

**Stackings**

9. Metal shall be stacked at roadside clear of formation width in continuous stacks leaving only such gaps for drainage as are ordered by the Engineer-in-charge. The stacks shall be made on even ground and shall be to the template supplied by the Engineer-in-charge. Where metal has not been stacked to such template, the Engineer-in-charge shall have the option of selecting one length of 10 feet in each furlong and getting it restacked in his presence and basing his measurements, for the entire mile, on the average of the results obtained from such restacking. Stacking shall be commenced at the end farthest from the source of supply and shall proceed continuously. Stacks shall be normally about 30 feet from the centre line of the road and parallel to it.

**Measurement**

10. The measurement stone metal shall be by volume. The unit of measurement shall be one hundred cubic feet.

**Rate**

11. The unit rate shall include the cost of stone metal conforming to the above specifications, delivery and stacking at Site of Work to be defined in the Conditions of the Contract.

# CHAPTER VIII

## TIMBER

# Timber

## INTRODUCTION

### DEFINITION

The word "Timber" is derived from a Saxon word "Timberian" meaning to build. It signifies wood of sufficient size, suitable for Engineering purposes and is applied to trees measuring not less than 2 feet in girth. When wood forms part of a living tree it is called standing timber; when the tree is felled it is called rough timber; when the bark is removed and the tree is hewn roughly it is called log; and when it is sawn into various marketable sizes such as planks, sleepers, battens, beams, posts, etc., the wood is called converted timber.

### AGE OF A TREE

A tree contains in section a number of rings consisting of cellular tissue and woody fibre arranged in distinct concentric circles or rings round the pith generally formed at the rate of one in every year. These are formed by the deposition of sap below the bark. Thus the number of annual rings indicates the age of the tree.

### TIME FOR FELLING

The best time for felling trees is mid-summer or mid-winter when the sap is at its minimum in quantity. The timber is liable to decay if felled in spring or autumn when the trees contain their maximum quality of sap due to its vigorous growth. There is too much sap wood in young trees and therefore they are not felled till full growth is attained. However, if full grown trees are allowed to stand longer valuable heart wood is spoiled and later the timber becomes brittle and loses elasticity. Good timber trees generally attain maturity in anywhere between 40 to 100 years.

### DEFECTS IN TIMBER

Several natural defects occur in all kinds of timber caused by the nature of the soil upon which the trees grow as well as by the changes to which it is subjected while growing or after felling. These defects should be avoided or removed as far as possible during conversion for use. The following are the most common defects in timber:—

1. **Star shakes.** They radiate from the centre of the tree and widen out at the edges. They are caused by defective shrinkage of timber.
2. **Heart shakes.** They are cracks or pits which run through the core of the tree.
3. **Upsets.** These appear as defects of the grain and result from violent shocks during felling and handling.
4. **Twisted Timber.** Certain parts of a tree sometimes get twisted up during its growth. Timber from such trees cannot be used in any work.
5. **Knots.** Knots are either alive or dead. When small in number alive knots are not as harmful as dead knots.
6. **Rot in Timber.** It is decomposition or putrefaction of timber generally occasioned by dampness and it is preceded by the emission of gases chiefly carbonic acid and hydrogen.

There are two kinds of rot, namely, dry rot and wet rot.

**Dry-rot** is the decomposition of the substance of felled or dead timber by the action of various fungi. Favourable conditions for generation are a moist, warm and confined atmosphere.

**Wet-rot** occurs when the gases evolved cannot escape and the tissue of the wood, especially the sappy portions, are decomposed. Wet rot may occur while the tree is standing, whereas dry rot takes place only when the wood is dead.

## CHARACTERISTICS OF GOOD TIMBER

The quality of timber depends upon (a) the treatment the tree has received (b) the timber and age of felling, and (c) the nature of the soil in which it has grown. The following are some principal features which are characteristics of good, strong and durable timber:—

(i) Firm adhesion of fibre, hard and compact modullary rays.

(ii) Narrow annular rings. They indicate slow growth; wide annular rings generally indicate weak and soft timber.

(iii) Uniform texture; straight in fibres and dark in colour.

(iv) Heavy weight.

(v) Sweet smell, hard and shining appearance at a freshly cut surface. Bad smell or a dull chalky appearace is a sign of bad timber.

(vi) Sonorous ring. Dull, heavy sound indicates decay.

(vii) Absence of woolliness at a freshly cut surface. It will not clog the teeth of saw with loose fibres.

(viii) Freedom from sap wood, alive or dead knots, flaws, shakes or blemishes of any kind.

## PRESERVATION AND STORAGE OF TIMBER

The most important methods of preserving timber are (1) Seasoning (2) Free circulation of air (3) Painting with protective materials. If these three methods are employed properly, the timber is likely to be protected and preserved for a very long time.

**Seasoning.** A freshly felled tree always contains sap both in sap wood and heart wood. Seasoning of timber consists in excluding all the sap and moisture so that it will not decay by fermentation of the sap, or warp or bend owing to uneven expansion or contraction of the moist timber with a rise or fall in temperature. Seasoned timber works easily under the saw and retains its size and shape even after it leaves the hands of carpenters and joiners. The strength of timber is about doubled by proper seasoning. Timber becomes less in bulk and weight due to seasoning. Timber fit for carpentry is seasoned when it loses 1/5th of its weight and fit for joinery when about 1/3rd of its weight has been lost after felling.

Seasoning is carried out either by natural process or by artificial means.

(a) **Natural Air Seasoning.** It is carried out by stacking timber with spaces in between so that there is free circulation of air, but at the same time protecting it from the sun and rain. It should be kept clear of the ground by a foot or two, supported on damproof bearers. The timber should be turned frequently. Irregular drying will cause splitting. This is the best but a slow method of seasoning. It takes 2 to 4 years before the timber is suitable for carpenters' or joiners' work.

(b) **Natural Water Seasoning.** It consists in totally immersing timber in water, preferably in a running stream for 2 to 3 weeks soon after felling. It is then taken out and carefully dried and seasoned in the aforesaid manner with free access of air. Partial immersion in water is very harmful. It is a

quick process and renders timber less liable to warp and crack but, on the other hand, weakens the timber. Salt water makes timber hard and durable but the timber will have a tendency to absorb moisture.

(c) **Seasoning by Boiling in Water.** This is a very quick method of seasoning but it is pretty expensive. It causes less shrinkage but reduces the strength and elasticity of timber. Seasoning by steaming has more or less the same effect as boiling and, in addition, it prevents dry rot.

(d) **Hot Air Seasoning or Dessication.** It consists in stacking timber in chambers and exposing it for about 3 days to a current of hot air which dries up the sap. It makes timber brittle and bleaches highly coloured timber.

(e) **McNeills' Process.** This is the best method of artificial seasoning as it has no injurious effect upon the appearance and strength of timber. It consists in exposing the timber to a moderate heat in a moist chamber charged with various gases produced by the combustion of fuel. Timber is rendered harder and denser. The process is costly but it prevents dry rot entirely.

(f) **Smoke Drying.** This consists in drying timber over a fire of straw or twig. Heat is applied gradually to prevent splitting. It renders timber harder, more durable and worm-proof. This process is generally adopted for bending planks in boat building.

## 2. STORAGE

Timber should be stacked in crosswise layers under a temporary roof to protect it from the sun and rain. There should be enough space between different layers of the timber for free circulation of air. For this purpose small blocks are sometimes placed to separate one layer from the other. The ground should be dry and preferably paved to avoid the growth of weeds or fungus. The stacks should be raised on sleepers which may be of wood or iron and carefully levelled.

## 3. PAINTING WITH PROJECTIVE MATERIALS

Protection against moisture is afforded by oil paints provided the timber is perfectly dry. In case the wood is not dry, painting up of the outer surface confines the moisture within the body of the timber which ultimately causes rot. The paint must be renewed from time to time. In cases where wooden sleepers have to be buried in earth or a certain part of the wooden structure is sunk in ground, it is generally coated with pitch or tar which protects it against dry rot and attack by termite and other wood boring insects. One of the good methods of preservation is creosoting. That is to say, dipping the wood in a solution of creosote at a very high pressure. The creosote enters the body of the wood and protects it from dry rot, fungus and such other defects. Wooden sleepers used on railway lines is one of the examples of creosoted timber used in engineering works. In addition to creosote, there are a number of other preservatives such as Celenite, Celprif, Mycomort, Antiselbar, Colron, Flutol, Solignum, etc., to suit every type of job.

## TYPES AND USAGES

Various timbers available in Pakistan and their uses are described below:—

| Species | Brief Description | Uses |
|---|---|---|
| Chirpinus Long folia (CHIR, CHILL) | A large tree of Lower Himalayas from Kashmir eastwards, which grows at a height of between 1,500 to 5,000 feet above sea level. Its sapwood is creamy white, heartwood light red when fresh, ageing to light reddish buff, with darker reddish lines of resin channels. It is a soft wood, rather coarse, uneven in texture, not durable in exposed positions, but can be fairly readily treated with a preservative. It is available in West Pakistan in the form of logs and sleepers. It is easy to work but it is liable to surface and end cracks unless protected against too rapid drying. | Constructional works, cheap furniture, planking and packing cases, ballies and electric poles, etc. |

| Species | Brief Description | Uses |
|---|---|---|
| DEODAR | It is the most important soft wood of West Pakistan, Found, in the Himalayan ranges between 4000 to 7000 elevation. It is yellowish brown in colour. Its heartwood is strong and durable due to natural preservatives in it. It is easy to season and work and retains its shape well. | Being light and moderately strong, it is used for structural work, railway sleepers, railway carriage wagons, planking, shingles, pattern making and cheap furniture, etc. |
| Fir & Spruce abils. Findrow Picea. Morinds (PARTAL) | It is a very large evergeeen tree of the higher Himalayas which is found at an elevation of between 7000 to 11000 ft. in Northern West Pakistan. Its wood is almost white with a reddish or yellowish tinge, ageing to a pale reddish buff. Its heartwood is not distinct. The wood is lustrous, straight-grained with medium fine and even texture, but only moderately durable under cover. It is liable to be attacked by white ants and fungus and is not easy to treat with a preservative even under pressure. It is easy to season and work. | It is used for fruit cases, packing cases, shingles, foot rules, picture frame, mouldings and sleepers. Selected material is suitable tor aeroplane work if quick conversion and seasoning is carried out to avoid fungus attack. |
| Sisso-Dalbergia (SHISHAM) | It is a large tree of plain areas as well as the sub-Himalayas forests growing at an altitude of about 3000 ft. or less. It is largely planted along the canals and roadsides in West Pakistan. Its sapwood is pale brownish-white and heartwood is golden brown to dark brown with deeper brown streaks. The wood is dull with interlocked grain and medium coarse texture. It is easy to season but hard to work. It keeps its shape well if properly seasoned and takes on a fine finish. | It is chiefly used for flooring, panelling, furniture sports goods, turnery and wheelwork; when peeled it can be made into beautifully grained plywood panels. |
| Mulberry-Moras Alba (TOOT TUTI) | It is moderately sized tree of the irrigated plantations of Northern Pakistan. Its supply is limited. Its sapwood is yellowish white. Its heartwood golden brown when freshly cut becoming much darker on exposure. The wood is lustrous, straight grained, medium coarse and of uneven texture. It is porous and durable under cover and strong, tough and elastic. If seasoned well, it works easily to a clean finish and turns and curves well. | It is used for tennis and badminton rackets, hockey sticks and other sports goods and furniture. It is a good substitute for imported ash. |
| Babul-Acacia Arabica. (KIKAR). | It is moderately sized evergeen tree thriving in hot dry weather which attains a large size in Southern Pakistan. Its sapwood is whitish and heartwood pinkish when fresh, ageing to reddish brown. It is straight-grained and has a coarse texture. It is very durable both in exposed positions and in contact with water. Its heartwood is not attacked by white ant or other insects. If seasoned well it is hard to work but takes a smooth finish. | It is suitable for posts, wheelworks, agricultural implements, tent pegs, cane crushers, railway keys (excellent for char-coal and firewood) |

| Species | Brief Description | Uses |
|---|---|---|
| Teak (SAGWANS) | It is a large-deciduous tree grown in East Pakistan, its size varying with the locality. It is also imported from Burma and India. Large teak plantations have been started in the hill tracts for Chittagong Division in East Pakistan. The trees are, however, at present young and immature and not fit for high class work. Its sapwood is narrow, pale yellowish brown and its heartwood dark golden yellow, turning dark brown with age; the colour and markings of the heartwood vary considerably with locality. The wood gives a rough oily feel and a characteristic odour. It is straight-grained, coarse and of uneven texture with clear annular rings and one of the most durable woods in the world. It is extremely sturdy under the most trying conditions and superior to every other wood in the world for keeping its shape. | It is used for doors, windows and other structural work, ship building, furniture, planing, railway carriages and wagons, carving, flooring, electric casing etc., and is suitable for veneering and ornamental work. |
| Shorea Tobusta (SAL) | It is a large and common tree of the sub-Himalayan forests of East Pakistan and its supplies are abundantly available. Its sapwood is pale brownish-white and heartwood dark reddish brown. The wood is dull, heavily interlocked and of medium texture. Its heartwood is extremely durable. A naturally durable wood, not usually attacked by white ants, it requires very slow and careful seasoning and is difficult to work though very durable. | It is used extensively for house constructions, structural work and sleepers. |
| Dandrocalamus Strict (BAMBOO). | A strong and flexible tree found in East Pakistan | It is used for scaffolding, rafts, roofings and furniture, etc. |
| Mangifers Indica (MANGO) | A fruit bearing tree and is found almost all over Pakistan; having grey hard wood. | It is used for planks, boats, well curbs, door panels. |
| Pinus Exceles (KAIL) | An evergreen tree, moderately hard, durable and close-grained. It is found in the Himalayas. | It is used for furniture, house building and Railway sleepers, etc. |

TABLE T—8.10

SAFE WORKING STRESSES FOR DIFFERENT KINDS OF TIMBER IN LBS. PER SQ. INCH AND COEFFICIENTS FOR DESIGN OF BEAMS

| Trade Name | Weight lbs. per Cft | Tensile stress in Bending | Shear | | Compression | | Moduls of Elasticity in 1000 lbs/sq. in | Design for | | Explanation |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Hori-zontal | Along Grains | Parallel to Grain | Perpendi-cular to Grain | | Strength with WL $BD^2 = \frac{}{x}$ value of x = | Deflection with $WL^2$ $BD^3 = \frac{}{y}$ value f Y = | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| Fir, Partal .. | 29 | 1100 | 85 | 120 | 850 | 230 | 1340 | 120 | 160 | Col. 3. Is max. fibre stress for design of beams and other tension members. |
| Babul, Kikar | 52 | 2600 | 220 | 315 | 1600 | 930 | 1540 | 290 | 190 | 4. For design of beams. |
| Deodar .. | 35 | 1450 | 100 | 145 | 1100 | 380 | 1350 | 160 | 160 | 5. For design of fastening bolts and bevelled joints. |
| Kail Blue Pine | 32 | 950 | 80 | 115 | 750 | 240 | 970 | 105 | 120 | 6. For design of short columns. |
| Chir .. | 36 | 1200 | 90 | 130 | 900 | 320 | 1390 | 130 | 170 | Bending moment values have been taken for simply supported beams with $\frac{WL}{8}$ |
| Sal (M. P.) .. | 50 | 2400 | 135 | 190 | 1500 | 650 | 1800 | 260 | 220 | Where W is in lbs. L is in ft., b and d are in inches. Deflection is taken L/360. For round beams multiply the strength and deflection equations by 1.7 which will give the values for $d^3$ and $d^4$. |
| Teak | 42 | 2300 | 140 | 200 | 1500 | 630 | 1600 | 260 | 200 | |
| Shisham | 49 | 2140 | 150 | 815 | 1310 | 640 | 1231 | 240 | 180 | Where beams are subject to continuous heavy loading the Modulus of Elasticity should be reduced by 75 to 50 p.c. of the tabulated values or the beams should be calculated for lesser deflection than L/360. |

Note. 1. The strength of the timbers given in the table provide for ordinary good class timbers having only minor defects. Where the timber is of exceptionally good quality/bad quality, the strength should be increased/decreased by multiplying it with 1.2/.84.

2. The recommended safe working stresses are for inside locations, where the timbers will remain continuously dry or protected from weather. For works built in outside locations or where timbers are occasionally subjected to wetting and quick drying, the safe tensile stresses (Col. 3) should be multiplied by 5/6 and safe compression (Col. 6 ) by 8/9. Where the timbers are in continuously wet position, the stresses should be multiplied by 2/3 and 8/11, respectively.

## SPECIFICATIONS

### No. 8.1 Timber (General)

**Source**

1. Timber shall be procured from an approved source.

**Quality**

2. (i) Timber shall be of good quality, felled not less than two years before use for carpentry and four years for joinery and shall be properly seasoned.

(ii). Timber shall be uniform in texture, straight in fibre, free from open shakes, bore holes, fungus attack rots, dots, decay, warp, twist, spring or crook and all other defects and blemishes.

**Sapwood**

(iii) Sapwood shall not be permissible in hard wood thresholds and projecting window sills.

(iv) Sapwood shall not be permissible in hard wood joinery unless properly treated with a suitable preservative.

(v) In soft wood joinery which is ordered as 'selected for staining' discoloured sap wood shall not be permissible in surfaces which are intended to receive the final decoration.

(vi) In all other uses sap wood including discoloured sap wood if sound shall be permitted.

**Knots**

(vii) Exposed surfaces of hard wood sills shall be free from knots other than isolated sound tight knots not exceeding $\frac{3}{4}$" in diameter.

(viii) In joinery which is ordered as 'Selected for staining' all surfaces intended to receive final decoration shall be free from knots.

(ix) Glazing bars shall be free from all knots other than sound knots appearing on one surface only and not exceeding $\frac{1}{4}$" diameter in the web and $\frac{1}{2}$" diameter elsewhere.

(x) Loose or decayed dead knots shall not be permissible in any joinery and shall be cut out and plugged properly.

(xi) In all other cases sound and tight knots including knot clusters which appear on any surface shall be permitted subject to a maximum of:—

(a) One live knot measuring $1\frac{1}{2}$" to 2" across the major diameter per 2 feet length, i.e. a max of four 2" knots per 8 feet length and five such knots in 10 feet length. (Smaller live knots shall be tolerated provided they are not so numerous or so ground as to affect unduly the strength of the sawn out turn therefrom).

(b) One dead knot measuring $\frac{1}{4}$" to 1" across the major diameter per 3 feet length, i.e. three such knots per nine feet length and four such knots in twelve feet length (Dead knots below $\frac{1}{2}$" diameter shall, however, be considered as negligible).

**Shakes**

(xii) Straight splits or shakes shall be permissible in the ends up to a total for both ends of $\frac{1}{8}$" per foot of length at the time of passing.

(xiii) Timber shall not be spongy or in brittle condition.

**Storage**

3. Timber shall be stacked on a raised wooden or paved platform to eliminate chances of white ant attack. It shall be stacked under a proper shelter where maximum aeration is possible without subjecting it to the direct sun, rain or other weathering agents.

**Measurements**

4. The timber shall be measured in bulk. The unit of measurement shall be one cubic feet.

**Rate**

5. The unit rate shall include procurement of wood (Timber) conforming to above specifications, delivery and stacking at Site of Work, to be defined in the Conditions of Contract.

## SPECIFICATIONS

### No. 8.2 Logs and Squares

**Source**

1. Logs or squares shall be obtained from an approved source.

**Size**

2. (i) Round logs shall not be of size less than 10′ in length and 60″ in girth.

(ii) Logs shall not be longer than 35 feet in length. Tapered logs shall not be less than 54 inches in girth at the small end.

(iii) Squares shall be of the size not less than 10′ in length and 15″ × 15″ in cross section.

**Quality**

3. Logs or squares shall conform to the specifications No. 8. 1. for Timber (General).

**Measurement**

4. The timber in logs shall be measured in bulk. The unit of measurement shall be one cubic foot. The procedure for taking measurements shall be as follows:—

(i) Bark must be removed at the middle of the logs where the girth measurements will normally be taken.

(ii) Girth measurements shall exclude bark, knots and projections at the middle of the logs.

(iii) Length measurements shall be reduced for cut, split, star-shakes, tapered or burnt ends. The ends shall be preferably sawn square. Rough hewn squares shall not be accepted.

(iv) The girth shall be taken in the middle of the accepted length of the log. In the case of tapered logs or logs having a bulge, large knots or projections at the middle, the mean shall be taken of measurement at the big end, small end and the centre of the log. The requisite girth shall, however, be obtained by reducing the length of the log not below the minimum permissible. For example, if a log is 20 feet long and the girth is 55 inches at the centre, i. e. 10 feet from the butt end, this log would be to specification if the centre girth was 60 inches at 7 feet from the butt. In cases like this the log would be accepted as 14 feet long and 60 inches girth.

(v) The cubical contents will be calculated by multiplying length by $\left(\frac{G^2}{4}\right)$. Where G is the girth at the middle of the log or the mean girth. In measuring the girth of round logs, $\frac{1}{2}$″

and below in actual size will be ignored; above ½" and below 1" will read to the next inch, e. g. 5 feet 6⅝" in actual girth will be taken as 5 feet 6 ins. and 5 feet 6⅝ ins. in actual girth will be as 5 ft. 7 ins. In measuring the length of logs, fraction of a foot must be in multiples of 3 ins. length measurements should read, for example, 20 feet 0 ins, 20 feet 3 ins. 20 feet 6 ins. 20 feet 9 ins. and 21 feet 00 ins. Lengths between 3 inches to be taken to the lowest 1/4 foot, e.g. a log 20 feet 5 ins. will be accepted as 20 feet 3 ins. Logs must be put out on skids or supports in order that they can be freely rolled for inspection.

## SPECIFICATIONS

### No. 8.3 First Class Sleepers

**Source**

1. (i) Sleepers shall be obtained from logs cut from sound mature trees duly approved by the Engineer-in-charge

(ii) Wood in sleepers shall conform to the specifications for Timber (General).

**Quality**

2. (i) Sleepers shall be straight and out of winding with faces square to one another. A max of ⅛" winding shall be permitted.

(ii) The wood in sleepers shall be free from sapwood, heart shakes, serious cracks. 3" end splits shall however be permitted for B.G. only in case when the sleepers are full 9' or over in length.

(iii) Sleepers shall be properly seasoned and free from insect attack, fungus attack, rot, etc. Max spring allowed is 2" for B.G. and 1¼" for M.G. and N.G. sleepers.

(iv) Sleepers shall be free from any defect near the rail seat which might interfere with the driving or screwing of spikes.

(v) Sleepers shall not have large, unsound or starred heart. Tight boxed heart shall be permitted under the following conditions:—

(a) For broad-gauge timber up to and including 7" depth, at one end only, provided the centre-heart is not more than 1½" within that section.

(b) For narrow-gauge timbers above 7" depth (i) At both ends (irrespective of the position of the centre-heart in the timber), provided the heart line is not visible on more than one broad face of a sleeper and if both ends are clamped.

(c) At one end only (irrespective of the position of the centre-heart in the timber provided the end with the centre heart is clamped.)

**Wane**

1" wane shall be permitted in standard sections only, i.e. 10" × 5", 8" × 4½", and 7" × 4½" in case of B.G. M.G. and N.G. sleepers respectively.

**Knots**

A max of 2 tight knots 2" in diameter (away from the spike holes of Rails) shall be permitted within 6" from the centre of rails. Away from the rail seat a tight knot measuring upto 3" shall be permitted for broad-gauge sleepers and upto 2" for meter and narrow-gauge sleepers.

**Twisted fibre**

(For chir only). Percentage of fibre that shall run through the whole of sleeper:—

(a) On either breadth face—20% (To be within this limit the fibre starting from the top corner at one end of the sleeper shall finish at above 2″ from the bottom corner at the other end).

(b) On either depth face 20% (To be within this limit the fibre starting from the top corner at one end of the sleeper shall finish at above 1″ from the bottom corner at the other end).

**Dimensions**

3. (a) Dimensions of broad-gauge sleepers shall be 9′ × 10″ × 5″ at the time of presentation. 30% of the supply may be accepted in sizes upto 8′-9″ × 9″ × 4¾″.

(b) Dimensions of meter gauge sleepers shall be 6′ × 8″ × 4½″ at the time of presentation. 30% of the supply may be accepted in sizes upto 5′-9″ × 7″ × 4″.

(c) Dimensions of narrow-gauge sleepers shall be 5′ × 7″ × 4½″ at the time of presentation. 30% of the supply may be accepted in sizes upto 4′—9″ × 6″ × 4″.

**Tolerance in measurements**

4. (a) A tolerance of ±¼″ shall be permissible in width and thickness, i.e. 4¾″ will count as 5″ and 9¾″ will be counted as 10″ and 5¼″ shall count as 5″ and 10¼″ as 10″.

(b) The length shall be measured in multiple of 3″, i.e. to the lowest 1/4 foot. A sleeper 9′-5″ shall be accepted as 9′-3″ and a sleeper 10′-11″ shall be accepted as 10′-9″.

Discretion may be used by the passing officer in passing a sleeper in cases where points arise which are not mentioned in the above items.

## SPECIFICATIONS

### No. 8.4 Second and Third Class Sleepers

Second class sleepers shall be serviceable for the main line, but is one which contains 25% more defects than the first class sleepers.

Third class sleepers shall be those in which the defects are so pronounced that they cannot be used on main lines but can be used only in sidings or in buildings in case of deodar sleepers.

# CHAPTER IX

## PAINTS, DISTEMPERS AND VARNISHES

# Paints

## INTRODUCTION

### USE

Paints are used to preserve materials from decay due to the actions of weather, i.e., heat, gases, moisture, etc., and also to improve their appearance.

### COMPOSITION

Paints essentially consist of: (i) Base, (ii) Vehicle, (iii) Pigment, (iv) Drier and (v) Thinner.

(i) **Base.** The base of a paint is the principal constituent forming its body. It also possesses binding properties. Zinc white, white lead, and red lead are the common materials used as base. Sometimes iron-oxide and graphite are also used. The base forms an opaque layer to obscure the surface of the material to be painted. A lead paint is affected by atmospheric action and is, therefore, not suitable for final coats of paints. But it is quite suitable for painting iron and steel work as it sticks quite well and acts as a good protective. White Zinc is unaffected by weathering, but is costly. It is an oxide of Zinc. For interior work Lithophone is largely used as white paint.

(ii) **Vehicle.** The function of a vehicle is to contain all the materials of a paint and to allow them to be applied on the surface to be painted. It is also responsible for the protective qualities and durability of the paint. The vehicle usually contains both volatile and non-volatile constituents. The volatile or solvent portion facilitates application and contributes through its evaporation, to drying of the paint, but it has no permanent part in the paint film. The non-volatile portion is frequently referred to as the binder since it remains as an integral part of the paint film to bind the pigment particles together.

(a) Linseed oil obtained from flaxseed is the most widely used vehicle in making paints. Wood oil, cotton seed oil and soyabean oil are also used in some places. Linseed oil contains acids which react readily with oxygen and harden by forming a thin film. Raw linseed oil does not dry quickly and is not fit for external work. Pale boiled linseed oil is better than raw linseed oil. But to have best results and to dry the paint quickly and successfully in the form of a thin and a uniform homogeneous film, refined and double boiled linseed oil only is used. It is quite suitable for external work. Boiling makes the oil thicker and get darker in colour. Raw oil is thin and when mixed with a suitable drier it is used for making delicate thin paints for interior woodwork. Besides linseed oil some of most commonly used vehicles are mentioned below:–

(b) Synthetic resin formulations such as vinyle resin, chlorinated rubber, and phenolic resin vehicle are frequently used where paint films are subjected to chemical solutions or to prolonged immersion under water.

(c) Nitrocellulose lacquer is often used as vehicle where very rapid drying is needed.

(d) Resins and drying oils are emulsified with water to form the vehicle in some decorative paints.

(e) At times Portland cement and lime have also been used to form the vehicles for cement paints and white wash respectively.

(iii) **Pigments.** These form the colouring matter used for giving the required tint or shade to the paints. They are solids in a very fine state of division and usually of the colloidal dimensions. These fine particles have a reinforcing effect on the thin film of the paint. The dried film of linseed oil cracks on hardening and the pigments lessen these cracks. It is, therefore, necessary that the particles of the pigment should be in a completely wetted condition and fully dispersed in the vehicle. The best pigments are those that do not change their colour when exposed to heat, sun's rays or acid-laden atmosphere. Most pigments fail to satisfy this requirement. The common pigments are basic carbonate white lead, zinc oxide for white colour, titanium dioxide, lithophone for lamp black, soot and charcoal black for black colour; Venetian red, red lead iron oxide, chrome orange and Indian red for red colour; burned amber, raw and burned sienna for brown colour; chrome green for green colour; prussian blue and ultramarine for blue colour; ochre and chrome yellow, zinc yellow, iron oxide, for yellow colour. Powdered metals like aluminium, copper, bronze, etc., are also used as metallic pigments. Factors entering into the selection of a pigment are colour, opacity, particle size, compatibility with other ingradients, resistence to light, heat, alkali, acid and the cost.

(iv) **Driers.** The function of a drier is to absorb oxygen from the air and to supply it to linseed oil which hardens, as explained above. Driers are usually compounds of metals like lead, manganese, cobalt, etc., dissolved in a volatile liquid. Driers have a tendency to destroy the elasticity of the paint and, therefore, should not be used in excess, as this would cause the paint to peel off in scales. Driers are also termed as plasticizers.

(v) **Thinners.** This acts as a solvent for the purpose of thinning the paints and thus imparts better covering power to them, so that the paint could be spread uniformly on a surface. It also gives proper consistency to paint. The common thinning agents used are petroleum spirit, turpentine and naptha. The thinner evaporates and dries the oil consequently.

**TESTS**

(i) **Drying time.** The paint, after complete removal of any surface skin, is well mixed by shaking and/or stirring, as may be necessary. The mixed paint is then brushed out on a clean non-absorbent surface, say a piece of glass 6 inches by 6 inches, and exposed in a vertical position in a well-ventilated room at 95° F to 105°F. The painted surface is illuminated by diffused daylight for at least six hours during the drying period. In order to avoid interference through excessive humidity, care is taken that, throughout the drying process the temperature of the room is above the dew-point. The paint when tested in the above manner should not become "surface dry" in less than 8 hours and should become "hard-dry" in not more than 24 hours. Paint is "surface-dry" when clean, dry silver (graded to pass a No. 44. B.S. Sieve, but retained on a No. 100 B. S. Sieve) sprinkled on to the surface of the paint and allowed to remain for about one minute, can be removed with a camel-hair brush without injury to the paint film. Paint is "hard-dry" when a second coat of paint could be satisfactorily applied over it.

(ii) **Colour, opacity, finish and consistency.** The paint film, prepared in the manner described at (i) above should, after drying for 48 hours, match in colour, opacity and finish (i.e. gloss, smoothness of surface, freedom from runs, specks, etc.,) a film prepared in the same way at the same time from an agreed sample.

(iii) **Fastness of colour to exposure.** Direct exposure (i. e. glass not intervening) to bright summer sunlight for 100 hours is usually a sufficiently good test for fastness of colour to exposure. In the absence of such sunlight the paint film may be exposed to the standard lamp for 80 hours.

The change of colour of the direct paint film, when tested in the manner, described above should not be greater than that of a film of an agreed sample tested in the same way and at the same time.

(iv) **Water contents.** The paint should not contain more than 0.5 per cent of water.

(v) **Flash point.** The flash point (Abel closed test) should not be below 90° F or 32.3°C.

## MISCELLANEOUS PROPERTIES

(i) **Keeping properties.** The paint when stored in the original sealed containers should retain its properties for a period of not less than 12 months.

(ii) **Consistency.** Consistency is a term applied to correct working with the brush. A paint which is too thick will drag or streak, while too thin a paint will tear. A suitable consistency may be obtained by using a paste paint and a thinner in equal volumes.

(iii) **Spreading powers.** The spreading power of a paint is the area which can be covered with one gallon of material. It varies very much with the material, with the surface to be painted and the number of the coats. The first coat on wood has a considerably smaller spreading power than the second, and for a given paint the spreading power is greater on plaster than on wood and greater on metal than on plaster. In fact, as a rough guide, the spreading power of paint may be taken as twice as great on metal as on wood. Spreading power of some of the paints in given in the following table:

| Type of Paint | Spreading power |
|---|---|
| Zinc oxide. mixed into paint | 700 to 1,000 sq. yds/cwt |
| White lead, mixed into paint | 500 to 550 ,, |
| Red Oxide, mixed into paint | 900 to 1,200 ,, |
| Red lead, mixed into paint | 560 to 590 ,, |
| Washable distemper, two coats inside | 250 to 260 ,, |
| Washable distemper, two coats outside | 150 to 160 ,, |
| Ceiling white, one coat | 350 to 400 ,, |
| Water paint one coat | 480 to 550 ,, |
| **Ready-mixed paints in oil** | |
| First coat on wood or plaster | 50 to 55 Sq. yds/gallon |
| Second coat | 60 to 65 ,, |
| Finishing coat | 75 to 85 ,, |
| **Ready-mixed paint in turpentine** | |
| When used on an oil coat | 85 to 90 ,, |
| **Undercoating, ready for use** | |
| The ordinary flattening type | 85 to 90 ,, |
| **Varnishes** | |
| Easy bodied type | 90 to 100 ,, |
| Full-bodied type | 85 to 90 ,, |
| **Enamel** | |
| Easy-bodied type | 75 to 80 ,, |
| Full-bodied type | 85 to 90 ,, |
| Aluminium paint | 130 to 140 ,, |
| Emulsion paint, on bare plaster | 60 to 80 ,, |

(iv) **Durability.** The chief cause of disintegration of paint is the oxidation of the vehicle. Oxidation is essential for drying but it does not stop when paint is hard dry and an elastic resinous film is formed. Oxidation goes on slowly until the film becomes hard and brittle when disintegration sets in.

## SPECIAL VARIETIES OF PAINTS

In recent years besides ordinary oil borne paints, described above, certain special paints have been developed. They are (i) Rubber Paints, (ii) Alkali resisting primers, (iii) Plastic emulsion or Latex paints, (iv) Imitation stone paints.

(i) **Rubber Paints.** They are of three kinds:—

(a) **Oxidized Rubber Paints.** These are available as undercoats and finishes for internal work and as stoving paint. The first of these consists of a solution of oxidized rubber to which oil and pigments are added to form a paste for grinding, after which white spirit is added to produce final consistency. Application is by brush, roller or spray, and the paint can be obtained in either matt or gloss finish. The second type is stoved at temperatures of up to 220° C for use on chimneys, radiators, retorts, stack-pipes and similar sites. It is resistant to heat, acids, alkalis, solvents, water and corrosive atmospheres. Pale colours in these paints are not recommended.

(b) **Cyclized Rubber Paints.** They are based on cyclized or isomerized rubber; the rubber is plasticized and dissolved in white spirit or produced as small chips which are quickly and easily dissolved in turpentine, pigments (non-metallic or metallic) being added as required. These paints resist chemical attack, especially that of organic or concentrated mineral acids. They have a hard high gloss and can be applied by spraying methods; they withstand heat up to 200° C; but acquire a yellowish tinge at temperatures above 120° C. They can be used on wood and on metals and adhere well to concrete or wood floors; it is even possible to use them as abrasive-resistant materials.

(c) **Chlorinated Rubber Paints.** They are made from the solution of raw rubber in carbon tetrachloride, chlorine gas being passed through the solution; the chlorinated rubber is dissolved in a solvent and the addition of plasticizers and pigments produce the paint. A paint of this kind cannot be thinned with white spirit, special solvents being necessary. They become touch dry in 16 minutes and finally dry in 24 hours. They are flexible, hard and durable. These paints are resistant to acid, alkali, chlorine, corrosion, salts and water vapour. They are used in factories, docks, coastal areas and in ships, but are not suitable for use on external wood work since they entrap moisture in the wood.

(ii) **Alkali-resisting Primers.** These primers are designed for use with alkaline materials such as hydrated or semi-hydraulic limes, anhydrous plasters, concrete renderings and asbestos-cement products where damp conditions obtain. These circumstances lead to attack of the alkyde present in linseed oil and produce its saponification, and pigments, such as prussian blue, brunswick green and some yellow, are also attacked. Primers based on tung oil containing phenolic coumarin resins or chlorinated rubber will resist this attack. If the wall has not dried out, a porous type of primer should be used to permit escape of water vapour and the finishing coat should also be porous. If drying out is complete an impervious primer should be used. The liability of a wall to cause alkali attack can be tested by scraping off a small amount of plaster and putting it in a saucer, mixing it with B. D. H. Universl Indicator and leaving it for 15 minutes to stand. If the indicator turns to a blue or green colour the wall is alkaline, if pink or orange, the plaster is acid. It is not recommended that priming should be carried out following the trowel.

(iii) **Plastic Emulsion or Latex Paints.** They consist of polymer latex, a plasticizer and a stabilizer and thickening agent, together with colouring pigments. Paints of this kind are used internally for

decorating non-absorbent surfaces such as tone-plaster, or cement-absetos sheeting. Occasionally they are used on wood but not on metal. They are easily applied by brush or roller but are not suitable for external use. The most commonly used plastic emulsion paints are polyvinyl acetate (PVA) based; PVA being a synthetic resin. They range from matt to oil-gloss finish; the flat and egg-shell gloss types being best for damp walls since the glossier types are apt to blister if used in this way. All PVA based paints will resist alkali attack; they are, however, acid in the liquid state and may, therefore, foster the corrosion of iron and steel. For this reason, these paints should not be used in steel paint kettles. They work easily, are free from persistent smell while drying and dry rapidly. They are not suitable for situation where maximum protective action is required. The paint in the can will not withstand frost and in this respect resembles distemper. They can be washed from 3 to 7 days after application. The best surfaces on which to apply them are brick, retarded semi-hydrate plaster or renderings, softer surfaces such as ungauged lime plaster or smooth hard surfaces such as highly-trowelled Keene's cement are likely to cause trouble and special primers should be used in such cases. Further notes on emulsion paints are given below:—

(a) Paints of this kind should not be applied to soft or friable surfaces such as old lime plasters or lime washes; even more care is needed in the preparation of such surfaces than is necessary with oil-gloss paints. Emulsion paints are not recommended for use in situations where condensation may occur such as in kitchens and bathrooms nor on highly trowelled smooth plasters.

(b) Emulsion paints will not adhere to oily or greasy surfaces.

(c) The use of such paints on difficult surfaces may be facilitated by the use of a suitable oily primer.

(d) Some emulsion paints are not suitable for external use on brickwork or renderings although polyvinyleacetate (PVA) emulsion paints can sometimes be so used in off-white or fawn colours showing some sheen; they should only be applied in very dry weather.

(e) Certain emulsion paints can be applied to notoriously difficult surfaces such as asbestos cement sheetings and some of the PVA variety can even be applied over old hard bituminous coatings.

(f) The probable life of these paints on exterior surfaces is intermediate between that of oil-bound distempers (shortest) and oil-gloss paints (longest); used internally, the life of emulsion paints should equal that of normal oil paints.

(iv) **Imitation Stone Paint.** It is a mixture of granular stone and/or pigment in a drying oil or emulsion medium, preferably an alkali-resistant.

## PAINT FOR IRON WORK

The iron work to be painted may be either above water or under water. The materials to be used and the specifications to be followed are different for each and are given below:—

### (A) Painting of iron work above water

(i) **Material to be used.** Grey Graphite paint has been found to be the most suitable and should invariably be used. Green or Red Graphite paints should not be permitted and as far as po sible darker shades of the Grey should be adopted in preference to the very light shades, as they afford greater protection. Graphite itself being black, the further the shade removed from black the further is the composition of the paint removed from that of a graphite paint. Very dark shades, however, are not pleasing to the eye and a suitable mean should be carefully selected between light grey and dark grey. In cases where special colour scheme is in vogue, suitable paints may be applied.

(ii) **Quantity required.** With careful work on smooth iron about 1¼ lbs. of paint should do for 100 sq. ft. per coat; when the work is rough or broken into a number of small surfaces, somewhat larger quantities would be required.

(iii) **Number of coats.** On new work three coats should be applied but on old work it is sufficient to give two coats only. It is advisable, though not essential, that coats should vary slightly in shade so that the number of coats actually applied can be easily counted.

**(B) Paints for iron work which remains under water**

(i) **Materials to be used.** For this kind of work the following mixture known as khanki Mixture has been found to be useful:—

| | |
|---|---|
| Coaltar | 84 lbs. |
| Mineral pitch | 10 lbs. |
| Slaked white lime | 9 lbs. |
| Kerosine oil | 9 lbs. |
| | 112 lbs.=1 cwt. |

The mixture should be prepared by heating Pitch and Coaltar separately, before mixing them together over a fire, stirring well and adding the slaked lime gradually while stirring. Kerosine should be added stirring well into the mixture after it has been removed away from the fire. Care should be taken to see that the mixture is not overheated; 350 °to 450° is the correct temperature for mixing. The pitch scales off if the mixture is burnt.

(ii) **Quality required.** The average covering capacity of the mixture is about 2,500 sq. ft. per cwt.

(iii) **Number of coats to be applied.** Two or three coats are sufficient.

## SUPPLY OF PAINT AND STORAGE

Ready made paints are available from approved makers, packed in sealed tins, bearing the batch number of production and its date of manufacture. Only such quantities should be stored as can be utilized within one year of manufacture.

## SPECIFICATIONS

### No. 9. 1 PAINTS

**Source**

1. Paints shall be procured from an approved source, packed in sealed tins, bearing the batch number of production and its date of manufacture. No paint shall be used after one year of its manufacture.

**Quality**

2. The paint shall be thoroughly ground to a condition that stirring readily produces a smooth uniform mixture of such a consistency that it works well under the brush and satisfies the following requirements:

2.1. Paint shall become surface dry in not less than 8 hours and hard dry in not more than 24 hours when tested in the manner explained in the introduction.

2.2. The paint after complete removal or any surface skin, shall be well mixed by shaking and/or srirring as may be necessary. Two coats of the mixed paint shall then be applied by brushing on to a smooth, clean, non-absorbent surface. The first coat shall be allowed to dry thoroughly before the application of the second one. The agreed sample shall

be treated in the same same way and at the same time, and the two surfaces after drying for 48 hours shall match in colour, opacity and finish (i.e. gloss, brightness, smoothness of surface, freedom from runs and specks).

2.3. The change of the colour of the paint film, when exposed to the direct exposure of bright summer sunlight for 100 hours shall not be greater than that of a film of an agreed sample tested in the same manner and at the same time.

2.4. The paint shall not contain more than 0.5 per cent of water.

2.5. The flash point shall not be below 90°F or 32.3°C.

**Measurement**

3. Paints shall be measured in bulk. The unit of measurement shall be one gallon.

**Rate**

4. The unit rate shall include supply of paint conforming to above specifications at the Site of Work, to be defined in Conditions of Contract.

# Distemper or Water Paint

## INTRODUCTION

Every distemper contains:—

(i) A base, which is casein, glue or starch,
(ii) A thinning agent, which is water or water and oil emulsion, and
(iii) A pigment, as described in the section on Paints.

Casein is mixed with hydrated lime to form a paint in combination with desired pigment. Casein requires a preservative to be mixed with. Water emulsion in oil and synthetic resin are also used in making these paints. They are suitable only for interior decorative work, as they cannot stand exposure to weather. They should be used only in dry climates as they yield poor results in a wet locality. To get the full advantage out of them, it is necessary to have a priming coat as recommended by makers.

The oil bound water paint or distemper is usually available in the form of a soft mass or paste which can be thinned with water at the time of using it. Oil free distemper are, however, available in the form of powder which has to be mixed with water to form a colouring liquid of required consistency. Both those varieties are washable i.e., once they are applied and they get hardened, the surface can be washed by gentle rubbing. Inferior types of distemper are also manufactured by mixing a pigment in glue or a mixture of starch and glue. These distempers are not washable.

## TYPES OF DISTEMPERS

(1) **Oil-free washable distemper** is a mixture of casein with borax, lime or similar material to render it soluble during application, with alkali-resistant pigments and extenders; this material is sold as paste or powder and is mixed with water at site.

(2) **Oil-bound distempers for external use.** They are similar to (1) above but have a more durable binding medium.

(3) **Soft distempes (non-washable).** These distempers have pigmented powdered chalk with glue size as a binding agent.

## SPECIFICATIONS

### No. 9.3 DISTEMPER

**Source**

(i) Distemper shall be obtained from an approved source.

**Quality**

(ii) When thoroughly mixed and applied it shall give a uniform colour free from runs and specks.

**Storage**

(iii) Distemper shall be stored in sealed tins and only in such quantities as shall be consumed within one year of its manufacture.

**Measurements**

(iv) Distemper shall be measured by volume when in liquid form and by weight when in solid form. The unit of measurement shall be one gallon and one lb. respectively.

**Rate**

(v) The unit rate shall include furnishing distemper conforming to above specifications at Site of Work, to be defined in the Conditions of Contract.

# Varnishes

## INTRODUCTION

### DEFINITION

Varnish is a more or less viscid liquid (usually a solution of resinous matter in an oil or volatile liquid) which when spread upon a surface, dries either by evaporation or chemical action, forming a hard lustrous coating capable of resisting to an appreciable extent the action of air and moisture.

### USE

Varnishes are used to brighten the appearances of the grains in wood, to render painted surfaces more brilliant to protect them from atmospheric action.

### PREPARATION OF VARNISHES

(i) **Varnish for iron work and outdoor works.** In about 2 lbs. of tar oil ½ lb. of asphaltum is dissolved with an equal quantity of pounded resin. This is heated in an iron kettle and mixed thoroughly. Care is taken to prevent contact with flame. It is used when cold.

(ii) **Varnish for common work** 3 lbs of lump resin is powdered and placed in a tin can; 2½ pints of spirit of turpentine is then added and the mixture shaken well occasionally for a day or two. Five quarts of boiled linseed oil, or Tung oil is then added and the mixture shaken well together and allowed to stand in a warm room till it is clear. The clear portion is decanted and used or reduced with spirits of turpentine until of the proper consistency. This varnish is intended for protecting surfaces exposed to weather.

The following are good recipes for Varnishes:—

| | |
|---|---|
| Resin | 2 parts |
| Europe linseed oil | 2 parts for common works |
| Spirit of turpentine | 1 part |
| Copal | 3 parts |
| Oil of turpentine | 5 parts |
| Linseed oil | 2 parts |
| Amine resin | 2 lbs |
| Litharge | 1 oz. |
| Sugar of lead | 1 oz. |
| Spirit of Turpentine | 5½ quarts |
| Linseed oil | 7 quarts |
| Pale shellac | 7½ parts |
| Mastic | 6½ parts |
| Spirit of Wine | 10 parts |

## FRENCH POLISH

A good French Polish suitable for Pakistani climate can be made with the following ingredients:—

| | |
|---|---|
| Methylated spirit (12 bottles) | 3 gallons |
| Shellac Black (chapati kali lakh) | 3 lbs. |
| Oil banum (isesa) | ½ lb. |
| Gamboge (Revanching shiro) | ½ lb. |
| Copal or Sandarach (chaurusa) | ½ lb. |
| Gum benzoin (lobana) | ½ lb. |

The gums are pounded fine and added to the spirit. The mixture is agitated until the gums are dissolved. A warm bath aids the operation.

The following is an excellent wood or furniture polish:—

16 qts. linseed oil
2 qts. spirit of wine
1 pint muriatic acid.
The oil to be heated and the whole mixed up.

1 qt. of vinegar
1 qt. turpentine
1 qt. copal varnish

## BRASS LACQUER

| | |
|---|---|
| Pale shellac | 1 lb. |
| Gamboge | 1 oz. |
| Cape altes | 3 ozs. |
| Alcohol | 2 gallons. |

## GOLD LACQUER

| | |
|---|---|
| Pale shellac | 3/4 lb. |
| Sandarach (copal) | 3½ lb. |
| Turmeric | 1 lb. |
| Gamboge | 2½ ozs. |
| Alcohol | 2 gallons |

## WAX POLISH

Where a dull polish which will not destroy the natural colour and grain of teak or shisham is required, wax polishing should be done. Wax Polish can be prepared in the following way:—to bees-wax add 2 parts of boiled linseed oil and heat over a slow fire. When dissolved and still warm add one part of turpentine.

## STOPPING OUT WAX

Woodwork which has to be painted, varnished or polished must have all holes, inequalities and defects filled with stopping-out wax.

Stopping-out wax should be prepared as follows:—Put a cupful of common shellac in an iron pot and a teaspoon of powdered resin, a piece of bees-wax (the size of half a walnut) and a teaspoonful of powdered lemon chrome or other colouring matter to match the finished work; the wax will not take a stain afterwards. Heat until the whole is melted and stir with a stick till thoroughly mixed. The mixture can be made into sticks by rolling between boards whilst still plastic.

## SPECIFICATIONS

## No. 9.4 VARNISH

**Source**

(i) Varnishes shall be procured from an approved source.

**Quality**

(ii) Varnish shall be clear and transparent suitable for use on interior or exterior work as specified and shall give a uniform and glossy coating free from runs and specks.

(iii) Varnish shall become surface dry in not more than 6 hours for interior and 8 hours for exterior work and hard dry in not more than 18 hrs.

(iv) The loss in weight on heating in a suitable oven after placing on a metal dish, at a temperature of 105° to 110 °C. for 3 hrs. shall not exceed 50%.

**Composition**

(v) Unless otherwise specified, it shall be the best English Copal.

**Colour**

(vi) It shall be extra pale, pale, or ordinary as specified in the Conditions of Contract.

**Supply and Storage**

(vii) The ready-made varnish shall be packed in sealed tins and shall bear the batch number of production and the date of manufacture. No varnish shall be used after one year of its manufacture.

**Measurement**

(viii) It shall be measured by volume when in liquid form and by weight when in solid form. The unit of measurement shall be one gallon and one lb. respectively.

**Rates**

(ix) The unit rate shall include supply of varnish conforming to above specifications at Site of Work, to be defined in Conditions of Contract.

# CHAPTER X

## METALS AND ALLOYS

(Ferros and Non-Ferrous)

# Ferrous Metals

## INTRODUCTION

### IRON

The chief ores used for producing iron are red or brown haematite (ferric oxide), brown haematite in the form of ferric hydroxide, magetite (ferric tetraoxide) and sidrite (ferrous carbonate), or other ores rich in iron. The various forms of iron are, Pig iron, Cast iron, Wrought iron and Steel.

### PIG IRON

Pig iron is the name given to the crude metal resulting from the smelting of iron ores and is so called because it is cast into ingots called pigs. Smelting takes place in blast furnaces which are charged with a mixture of iron ore and coal; the burning fuel reduces the ore to molten metallic iron which trickles down to the base of the furnace; molten impurities in the form of slag float on the metallic iron and are tapped off at a point high up in the iron chamber, the molten form being drawn off at the bottom of the furnace and run into moulds to form pig iron on cooling. Carbon monoxide and carbon dioxide gases are released during the smelting process.

Pig iron is the raw material used for the manufacture of ferrous metals such as cast iron, wrought iron and steel.

### CAST IRON

Cast iron is made from pig iron in a blast furnace known as a cupola. It may contain about 3.5 per cent of carbon in addition to small amounts of manganese, sulphur and phosphorous, the silicon content can be between 0.35 and 4.25 per cent. Cast iron has a fibrous crystalline structure and is much stronger in compression than wrought iron and steel. It is, however, weaker in tension and is markedly brittle and does not absorb shocks. It does not possess the properties of ductility and malleability and cannot be forged or rolled like steel. The specific gravity of cast iron varies from 7. 0 to 7.5. It is used for all types of castings.

**Mouldings.** In the process of moulding a core of hollow space is formed. Special foundry sand usually green, sand, dry sand or loam possessing the necessary properties of adhesion and refractory nature, isused for the purpose. Pure silica sand with very small quantities of alumina, magnesium and lime gives best results. The pattern is placed in the moulding box and filled around with the foundry sand. To facilitate the removal of the pattern, the mould is made up of two or more parts called core boxes or flasks. The pattern is then taken out leaving behind a hollow core for the metal to be poured in. Feeding openings are provided in the mould to connect the core for pouring in the metal. Sand moulds can be used once only and for the next casting another has to be made. Where a number of articles of identical shape are to be cast, metal moulds are made and can be used repeatedly, but they have the disadvantages such as sudden cooling, difficulty in allowing air bubbles to escape, etc.

**Castings.** After the core is ready in the mould, the molten metal, specially prepared to suit the requirements, is poured in, with the aid of ladles, until every part of it is filled. Pipes are cast in a vertical position and are then spun with a centrifugal motion. This gives a uniform density of texture to the material.

**Injection Moulding.** In this case the molten metal is forced under great pressure into the mould. This is also called Die Casting.

After the casting is cooled and has solidified it is taken out from the mould. It is then cleaned with a wire brush or a sand blast, and water. The irregularities on the surface of the casting are removed by filing and sometimes by chipping. A defective casting is detected by a dull and deadening sound when gently struck with a small hammer. This indicates blow holes and air bubbles in the body of the casting. A good casting should not have any cracks or rough surfaces.

**Pattern Making.** Patterns of the articles to be prepared by the moulding process have to be made first. These are made slightly oversize so that after the shrinkage of the moulded article on soldifying exact dimensions are obtained. The pattern is made either of well-seasoned wood, metal or Plaster of Paris. Sharp corners and angles are avoided generally in the castings.

## WROUGHT IRON.

It is made from the refining of pig iron by submitting the latter to the action of slags rich in iron oxide at a temperature above the melting point of pig iron but below that of pure iron. During manufacturing operations much of the included slag is squeezed out of the metal, but some remains and it is this that gives the metal its characteristic fibrous structure. The final product is practically pure iron with fibres of slag running through it. Wrought iron is the purest form of iron available on the commercial market. A good variety of wrought iron contains the following percent ages of its constituents: 99.5 of iron, less than 0.1 of carbon, 0.1 of silicon, 0.01 of sulphur, 0.07 of phosphorus and 0.03 of manganese. The remaining is slag in small quantities. Wrought iron is tough and can resist shocks and strain. It forges easily in either the cold or the hot condition and is not hardened by quenchi g like steel. As it can be very easily welded it is used very widely in ornamental ironwork. It is very malleable and ductile. Its ultimate tensile strength ranges between 19 to 24 tons per sq. incl an elastic limit between 12 to 14 tons per sq. inch. Its yield point is 14 tons per sq. inch. Izod impact value 44 feet – lb and Brinell's hardness number 105. It melts at about 2800 F° but it cannot be cast in moulds. Wrought iron is used for making pipes, chains, boiler plates, sheets, grills, nails and wires, etc.

## STEEL

Pig iron is the raw material used in the manufacture of steel. The process consists of refining pig iron by oxidation so that only the requisite quantity of carbon remains. Steel contains carbon from anything below 0.25 per cent to 1.5 per cent. Carbon occurs in the form of iron carbide, $Fe_3C$, compound of iron and carbon. The chief types of steel used in building and structural engineering are (1) Mild Steel (2) High tensile structural steel, (3) High tensile structural steel, (fusion welding quality), (4) Prestressed steel, and (5) Steel alloys.

**ALLOY STEELS.** Alloy steels may be defined as carbon steels to which a definite percentage of some special element has been added in order to produce particular characteristics. The more important alloy steels are nickel steel, chrome steel, nickel-chrome steel, chrome-vanadium steel, manganese steel, silicon steel, tungsten and the high-speed tool steels. The characteristics of these alloy steels are as follows:—

**NICKEL STEEL.** Nickel steel for constructional work contains from 2 to 4 per cent. of nickel and from 0.20 to 0.50 per cent. of carbon. The additio of nickel increases the ultimate tensile strength and gives a higher ratio of yield point to ultimate strength without reducing the ductility. Thus a 3 per cent nickel steel with 0.3 per cent carbon, in the normalized condition, will have an ultimate tensile strength of about 40 tons per square inch, a yield point of over 22 tons per square inch, and an elongation of about 25 per cent. Nickel steel withstands shop treatment better than hard carbon steel of equal strength, cracks develop more slowly and its resistance to fatigue is greater. It is less liable to corrosion. The melting point of nickel steel is lower than that of ordinary carbon steel and castings

made from it are freer from blow holes. It can be forged but not welded. A 0.35 per cent carbon, 0.55 per cent Manganese, 3½ per cent Nickel, steel oil-hardened at 860 °C and tempered at 600 °C. will have an ultimate tensile strength of about 50 tons per square inch, a yield point of 40 tons per square nch and an elongation of 25 per cent. Such steel is suitable for engine parts. High nickel alloys with 20 to 30 per cent. Ni. resist corrosion to a marked degree, and INVAR—a low carbon steel with 36 per cent. Ni.—is almost unaffacted in length by temperature changes. It is used in precise surveying and levelling instruments and for clock pendulums, etc.

**CHROMIUM STEELS.** Chromium steels containing 0.5 to 2 per cent. of chromium and 0.3 to 1.5 per cent of carbon, are very hard and have a high tensile strength combined with a considerable degree of toughness and resistance to wear and abrasion. They also resist corrosion particularly when the percentage of chromium is high. The material can be used in the form of castings or forgings. High carbon steels (0.8 to 1.10 per cent. carbon) containing 1.0 to 1.6 per cent. of chromium are used for the balls, rollers and races in ball and roller bearings. Chromium steel containing 1.3 to 1.5 per cent. carbon and about 0.5 per cent. chromium is used for files.

**STAINLESS STEEL.** Stainless steel contains from 12 to 14 per cent. of chromium, the other constituents being more or less normal. When the steel is in a hardened condition, after suitable heat treatment, it will resist atmospheric and other corrosion. It is an air hardening steel but may also be successfully hardened by quenching in oil. A steel containing 0.4 per cent. of carbon and about 13 per cent of chromium, air hardened from about 900 °C. will have an utimate tensile strength of about 100 tons per square inch, but a very small elongation. Tempered from 600 °C. the ultimate tensile strength will be about 60 tons per square inch with an elongation of about 15 per cent.

Stainless steel may be forged or hot rolled at temperatures above 1000 °C. It can only be machined or worked cold in a softened condition, produced by annealing at about 800 °C. A stainless steel containing 0.10 per cent. or less of carbon is sometimes termed as restless iron. This material has a considerably less tensile strength than the stainless steels with higher carbon percentages, is softer and more malleable. It is easier to machine and can be stamped and pressed. Stainless steel is used for cutlery, pump rams, valves and other parts where resistance to corrosion is necessary. The softer varieties are used for turbine blades, tubes, drop forgings, etc. A corrosion resisting alloy steel, called Staybrite Steel containing about 18 per cent. chromium and 8 per cent. Ni. remains practically unaffected by acids which attack ordinary stainless steel.

**NICKEL-CHROMIUM STEEL.** The addition of nickel and chromium, in combination to carbon steels produces Nickel Chromium Steel, an alloy steel of great tensile strength, a high yield ratio, ductile yet hard and wear resisting. Ordinary nickel-chrome steel may contain from 1½ to 3½ per cent. of Nickel and from 0.5 to 1.25 per cent of Chromium. Air-hardening Nickel-Chrome Steels, used where very high tensile strength is required in large masses, may contain from 3½ to 4½ per cent nickel and from 1.1 to 1.75 per cent. Chromium. A Nickel-Chromium Steel containing about 0.3 per cent. carbon, 1½ per cent of nickel and 1 per cent chromium, oil-hardened from 850°C. and tempered at 600°C. will have an ultimate strength of 45 to 50 tons per square inch, and an elongation of about 20 per cent; whilst an air-hardening steel, containing about 0.3 per cent. carbon, 4 per cent nickel and 1.3 per cent. chromium, air-hardened from 820°C. will have an ultimate tensile strength of about 110 tons per square inch and an elongation of over 10 per cent. Tempered at 600 °C. the ultimate strength would be over 60 tons per square inch, with an elongation of about 20 per cent. Nickel-Chromium steels are difficult to machine; this must be done with the steel in a softened condition and the material heat tested afterwards. They can only be forged at temperatures above the hardening temperature. They are used in motorcar construction, for transmissions gears where great strength combined with hardness is required, and for armour-plates and projectiles.

**CHROME-VANADIUM STEEL.** The addition of vanadium to chrome steels improves their strength and toughness and increases their resistance to shock and fatigue. The amount of vanadium usually added is from 0.10 to 0.30 per cent. A chrome-vanadium steel with 0.4 per cent carbon, 1 per cent. chromium and 0.15 per cent. vanadiun oil-quenched from 870°C. and tempered at 650°C. will have an ultimate tensile strength of about 65 tons per square inch, and an elongation of over 18 per cent. Vanadium steels have excellent mechanical properties. They are easy to heat-treat, weld readily and can be forged without difficulty. They are used for crankshafts, gears, etc.

**MANGANESE STEEL.** These steels contain from 11 to 14 per cent. of Manganese and from 1 to 1½ per cent. of carbon. They can be cast easily, filling the mould well. After casting and cooling slowly, the material is exceedingly brittle but when reheated to over 1000 °C. and quenched in water, it becomes very ductile and tenacious. Its properties are improved by hot working followed by quenching when an ultimate strength of over 60 tons per square inch, with an elongation of 50 per cent. in 8 inches can be obtained; the yield ratio, however, is low. Owing to low yield point the material tends to flow under certain conditions, particularly in compression. Annealing makes it brittle. The effect of heat treatment is the reverse of that obtained in the case of carbon steels. It is, therefore, impossible to soften it; that is why it cannot be machined. It is difficult to roll or forge into any but simple shapes. It is specifically useful where great strength and hardness combined with ductility are required. It offers great resistance to wear and abrasion and the resistance increases with the severity of the service. It, therefore, forms an excellent material for rails and railway crossings and the jaws of stone and ore crushers.

**SILICON STEEL.** A valuable alloy steel can be obtained by increasing the percentage of Silicon normally present in carbon steel. The material thus obtained may be divided into two classes, 1 per cent Silicon Steel, and 4 per cent Silicon Steel. The 1 per cent Silicon Steel is used for high tensile ship plates. The addition of the Silicon raises the ultimate strength and still more the yield ratio, without diminishing the ductility. A 0.27 C Steel containing 1.122 per cent Silicon would have an ultimate tensile strength of about 44 tons per square inch, a yield point of about 29 to square inch, and an elongation of about 27 per cent in 8 inches.

The 4 per cent Silicon Steels, containing from 3.5 to 4.0 per cent of silicon, 95-96 per cent of pure iron, and less than 0.25 per cent of impurities, form valuable materials for magnetic work, the eddy current and hysteresis losses being less than one half of the best charcoal iron. So it is widely used in electrical transformers.

A product termed Silico manganese steel, 0.4—0.5 per cent C; 1.5—2.0 per cent Silicon; 0.7—0.9 per cent Mn. is chiefly used for motorcar springs.

**COPPER STEEL.** The addition of a small percentage of copper to mild steel is found to increase its resistance to corrosion to a marked degree. To resist atmospheric corrosion the best percentage of copper appears to be from 0.2 to 0.3; to resist acids the percentage should be increased to 0.5-0.7. These percentages have no deleterious effect on the mechancial properties of the material. Several "high-grade" mild copper steels, suitable for structural purposes, have been introduced recently. A properties include typical example contains 0.15 per cent C; 0.5 to 0.8 per cent Cu; 0.4 per cent Cr. Its mechanical tenacity of 33 to 39 tons per square inch, the lower yield point at 22.8 tons per square inch, minimum elongation of 20 per cent and reduction in area of 45 to 68 per cent. The finished product is very uniform, readily weldable and highly resistant to corrosion.

**HIGH-SPEED TOOL STEELS.** The tip of modern high-speed tools usually runs at or near red heat. The cutting edge nevertheless retains its hardness and sharpness; this property is called red-hardness. There are a number of brands of steel which possess this quality. These alloys contain tungsten, chromium, cobalt, molybdenum a ndvanadium in different proportions. To produce their characteristic property these steels must be hardened by heating to a temperature approaching the melting point (1200—1300°C.) and cooled fairly rapidly in a blast of air or by quenching in oil. A more certain heat treatment is to heat the tool in a salt-bath furnace kept at constant temperature by an electric current. When removed from the bath a thin film of fused salt adheres to the tool which prevents oxidisation; this film dissolves off during quenching. After quenching the tool is reheated to 580—600 °C., held for about five minutes and then cooled in air. This treatment increases both the hardness and the toughness of the steel. The initial high temperature is necessary to bring about the solution of the tungsten and other elements which then form hard carbides. After the first quenching the steel has a certain amount of austenite which changes to martensite, a very hard constituent, during the second heat treatment. The cause of the red-hardness is not definitely known, but is probably due to the structural stability conferred on the martensite by particles of complex carbides of tungsten, chromium, and vanadium. These steels may be forged at a temperature of about 1100°C, and if annealed at 800°C. and cooled very slowly, they are then soft enough to be machined. Two interesting alloys used for cutting tools, which possess the property of red-hardness are Stellite and Tungsten Carbide Alloy. Stellite has 60 per cent. Co; 22 per cent Mo; 11 per cent Cr; 2 per cent Mn; 3. per cent Fe. Tungsten Carbide Alloy has either 4 per cent Carbon and 96 per cent W, or 6 per cent Carbon, 87 per cent W and 6 per cent Co. The latter is one of the hardest metals available; such alloys may replace high-speed tool steel just as the latter has replaced plain carbon tool steels.

## MILLING OPERATIONS

To give steel products the required shape following operations are carried out:

(a) **Ingot Mould Casting.** Prepared steel in the molten condition is poured into metal moulds called ingot moulds. The molten metal can also be used directly to obtain steel casting. The solidified metal from an ingot mould is termed an ingot. The ingots are stored for further use.

(b) **Rolling.** Before the ingot is used for milling operations, it has to be uniformly heated to working temperatures. After heating it is passed through chilled rollers to reduce its size. As a result of this the crystals formed in the ingots during cooling are drawn out into threads and the steel gets a fibrous texture. The ingot is made to pass through the rollers many times and each time it gets reduced in section. Rounds, flats, angles, squares, tees, channels and I-sections are all obtained by this method of rolling. Sheets are also similarly rolled.

(c) **Drawing.** The round sections of rolled metal can be further drawn into wire by passing them through holes of successively smaller diameters.

(d) **Forging and Dressing.** Forging consists of shaping a hot piece of steel with the aid of a die, or a series of successive dies, under a power hammer. The metal is kept in the die of the required shape of the article and is pressed into it under a hammer.

The milling operations improve the quality of steel also; above all the steel becomes ductile.

## HEAT TREATMENT

By the term "Heat Treatment" is to be understood those processes in which the steel is first heated to a definite temperature and then cooled in some particular way with the object of obtaining material with certain definite physical characteristics. The four processes included under this heading are (i) normalising (ii) annealing, (iii) case hardening, and (iv) tempering.

The properties of steel, particularly of those steels containing a high percentage of carbon can, be profoundly modified by heat treatment. The heating should be done slowly and thoroughly, great care being taken to attain a uniform degree of heat throughout the mass. The duration of the heating depends chiefly on the time necessary to attain this uniform temperature; the larger the charge the longer the time. The rate and manner of cooling depends on the quality of steel it is desired to produce. For rapid cooling, the steel would be quenched in a bath of water, for less rapid cooling in a bath of oil. Air cooling is still less rapid, slow cooling is effected by allowing the charge to remain in the furnace while the temperature of the latter gradually diminishes. Thin objects must be cooled not so rapidly as thick ones, and high carbon steels require slower cooling than low carbon steels. Unless otherwise stated, the temperature mentioned in the following paragraphs have reference to plain carbon steels. Alloy steels are similarly heat treated but the critical temperatures depend on the chemical compositions of the material.

(i) **Normalising.** In this process the steel is heated to a temperature which exceeds its upper critical range, but not more than 50°C. It is maintained at this temperature for about 15 minutes and then allowed to cool freely in air the object of normalising is to re-establish the normal condition of the material after the vicissitudes of manufacture. During the various processes to which the steel must be subjected, it is heated to a high temperature and often allowed to cool as it may, which may well result in large coarse grain, yielding weak material. In a casting there are internal stresses due to shrinkage while cooling and in forging the internal structure gets badly distorted, the material being in a state of strain due to mechanical causes. The effect of normalising is to refine the grain, i.e. to produce small crystals and to remove the internal strains, leaving the steel in its best condition.

(ii) **Annealing.** The purposes of annealing are firstly to remove internal stresses, secondly to soften the material and thirdly to refine the grain. To anneal, the material is heated to an apppropriate temperature (depending on the effect desired) and kept at this temperature for some hours or even days, then allowed to cool slowly, usually in the furanace. The material thus annealed has a lower tenacity but greater ductility than un-annealed material and usually, a much reduced resistance to shock. Too rapid a cooling after annealing diminishes ductility and too slow a cooling produces a weak and brittle material. To remove internal stresses, steel castings are usually annealed at about the normalising temperature: strain-hardened material can be softened by annealing at temperatures below the lower critical range. In order to refine the grain the material can be heated to a temperature exceeding the upper critical range (50°C above) as in normalising, and not cooled too slowly. If kept long at such high temperatures and then cooled slowly, there is a tendency for the grains to grow in size, with a consequent weakening of the material.

(iii) **Case Hardening.** To harden steel it is heated to a temperature exceeding the lower critical range by about 50°C., say to about 750°C., and then cooled rapidly by immersing it in a suitable medium (water, oil or air), depending on the rate of cooling required.

(iv) **Tempering.** For ordinary engineering purposes quenched steel is much too hard and brittle and requires to be tempered. To temper steel it is reheated after hardening to a temperature below the lower critical range (i.e. to a temperature not exceeding say 700°C) and then allowed to cool. This diminishes the hardness and increases the toughness of the material. The degree of softening required is regulated by the temperature to which the steel is reheated, the rate of cooling does not matter. Regarding the relative advantages of normalised and hardened and tempered steels, it is established that for given ultimate strength and ductility (as shown by the elongation and reduction in area in a tension test) a properly hardened and tempered steel will be much tougher than a normalised steel: that is to say, the resistance to shock of the hardened and tempered steel will be much greater than that of the normalised steel.

## CORROSION OF IRON AND STEEL

Corrosion of metals is primarily electrochemical in nature. The ideal conditions for its propagation are the presence of moisture, oxygen and acid or saline conditions. Thus very pure water attacks iron and steel only in the presence of oxygen and the action proceeds very slowly; and it tends to choke itself owing to the low water solubility of the oxides which are formed. In saline conditions, the rate of corrosion is very much faster.

The electrolytic theory of corrosion is now universally accepted as explaining the mechanism of the process. This theory postulates that when a salt, such as zinc sulphate, is dissolved in water the molecules split up or dissociate to some extent; some of the salt takes the form of zinc ions carrying positive electric charges and accompanying each zinc ion is a sulphate ion carrying negative charges thus:

$$ZnSo_4 = Zn^{++} + So_4^{--}$$

These ions are thought to be atoms, or groups of atoms, carrying electric charges as indicated.

**The attack on iron by acid.** A good example of this action is that of an imperfectly copper coated piece of iron immersed in a dilute sulphuric acid. The iron, copper and acid system act like a small electrolytic cell or battery and electric current is generated. The iron (which is attacked) is the anode and the copper (which is not attacked) is the cathode. If the hydrogen liberated is deposited on the cathode it slows down the process of attack and the system is said to be polarized; if the hydrogen is given off as bubbles and escapes through the acid which is usually the case, the corrosion is continuous and the action proceeds until the iron is totally destroyed.

**Attack by natural water.** Most natural waters are slightly acidic in character and sometimes contain minute quantities of saline matter. They also contain dissolved oxygen which is necessary for corrosion to proceed. Their action is thus very similar to that described above for sulphuric acid solutions though it is, naturally, slower.

**Atmospheric attack.** Sulphurous acids present in the air of large towns together with the carbonic acid which is always present, to some extent, in the atmosphere and atmospheric moisture combine to make corrosion possible. The critical humidity for iron corrosion is 65 per cent; above it the process continues at a rapid rate. Places situated at or near the coast are especially susceptible to iron corrosion on account of the appreciable amounts of salt contained in the coastal atmospheres.

## PROTECTIVE MEASURES

In order to prevent the metallic products from corrosion, surface treatment is essential. Surface treatment consists of (i) Metallic coating and (ii) Metallic coating and painting.

Before any surface treatment is applied iron as well as steel should be scraped and wire-brushed to remove mill scale and rust. But where the metal is pitted and rust lies inside the pockets the only safe method of cleaning is by spraying the metal with steel grit; if the grit fails to clear the pits, sand should then be shot. The initial cost is high but for a long term point of view it is economical. It is essential that all rust is removed and as soon as the surface is ready for treatment it should be applied without delay.

### (i) Metallic coating

(a) **Electro-plating.** This term generally describes the deposits of any metal or metal alloy on another metal or alloy by means of electric current. The coatings thus obtained vary in their protective power, durability and decorative value from metal to metal and on the general conditions (atmosphere, wear, etc.) in which they are used. The more important metals deposited electrolytically as coatings for decorative or protective purposes are silver, gold, nickel, chromium, copper, tin, zinc and cadmium. Zinc and cadmium are used particularly for the protection of iron and steel against corrosion.

(b) **Chromium-plating.** Before chromium-plating any material it should be highly polished and free from scratches or other surface blemishes. A thick coat of copper should be applied first, then one of nickel and finally the chromium.

(c) **Galvanizing.** In this treatment for rust prevention the material is dipped in a bath of molten zinc; the superfluous zinc is allowed to drip off and the residue forms a protective coating. Where it is inadvisable to heat the thing that has to be treated because of the danger of warping or loss of temper, the zinc may be electrically deposited.

(d) **Sheraridizing.** This process consists essentially in the formation of a zinc-iron alloy directly with the surface of the metal being treated. There is practically no alteration in the size of the metal after treatment. It is, therefore, possible to sherardize screw threads and moving parts after machining.

The case with hot galvanising is, however, different. The surface produced by it has a matt texture, grey in colour and it is eminently suited as a base for paint. It can be lacquered to prevent the grey matt surface from showing finger and grease marks and can be buffed and polished.

Flaking of the zinc alloy surface is impossible provided the work is properly carried out. It will also stand considerable rough handling.

(ii) **Metallic coating and painting**

For all types of protection the priming coat should be red lead, except aluminium or sprayed zinc coatings which require a zinc chromate paint. Red or white-lead based paints are not suitable for use on sprayed zinc coating. Bitumen, or tar-based paints may contain phenolic constituents and should, therefore, be avoided for such use. The best paint in this case being a resin (alkyd or pheno formaldehyde) vehicle paint.

Red oxide of iron, zinc chromate, zinc oxide or titanium dioxide paints are all suitable not only for use on sprayed zinc coatings but also on other protective coatings.

For structures remaining continuously under water Khanki mixture has been used with appreciably satisfactory results.

# Non-Ferrous Metals

The principal non-ferrous metals are copper, zinc, lead, nickel, tin, aluminium and chromium. Other non-ferrous metals are tungsten, manganese, cobalt, molybdenum, titanium vanadium, etc., they are principally used as alloying metals.

## COPPER

Next in importance to steel is copper. It weights 550 lbs. per cu. ft. and has a redish colour. It is malleable and ductile and can be rolled and drawn. It melts at about 1950°F. Copper does not corrode in dry air. It has a high thermal and electrical conductivity. It is very widely used for making electrical wire, cables, etc.

## ALLOYS OF COPPER

(a) **Brass.** This is an alloy of copper and zinc in proportions varying from 70% of copper and 30% zinc to 85% copper and 15% zinc. Brass resists corrosion quite well. It can be rolled into sheets, turned into tubes, drawn into wires and cast into moulds.

(b) **Bronze.** This is an alloy of copper, zinc and tin. All bronzes cotain about 80 per cent copper. The addition of tin—up to 20 per cent imparts hardness and strength to copper. Phosphorous—bronze contains about 1 per cent of phosphorous.

## ZINC

It is a very soft metal. It resists oxidation on exposure to weather. It is principally used for galvanizing and for alloying. It weights about 430 lbs. per cu. ft. and melts at 480°F. Zinc oxide is extensively used for painting.

## LEAD

It is a very soft and non-corrodible metal having a very low strength. It is malleable and ductile and can be drawn into wires. Lead is widely used in making alloys, in plumbing work paints, roof covering, etc. It is widely used in the making of type metals in printing presses. Lead melts at 625°F. and has a weight of 700 lbs. per cu. ft.

## TIN

It is a white lustrous metal occurring in a nature as an oxide ore. It is extracted by melting and refining. Tin is highly resistant to corrosion. It is a very soft and weak metal, extensively used for tinplating and for making alloys. It has a melting point of about 450°F. and weights about 450 lbs. per cu. ft.

## ALLOYS OF TIN AND LEAD

(a) **Solders.** A very common process of joining lead pipes, tin plates, galvanized iron and copper is by soldering. A solder is an alloy with a melting point lower than that of the metals to be jointed. A solder has an important property of wetting the two surfaces to be joined. A flux is generally added to clean the surfaces to be jointed to develop adhesion. Zinc chloride, ammonium chloride and resin are the common fluxes used. The metals to be soldered should be heated to a temperature near about the melting point of the solder to enable tin to adhere and flow. The common types of solders used are (i) soft solder containing equal proportions of lead and tin (ii) fine solders containing 60% tin and 40% lead and (iii) the wiping solders used by plumbers which contains 40% tin and 60% lead, and (iv) a 20—80 tin and lead alloy which gives a solder for jointing metals where strength is required. (In all the above solders 2 to 3 per cent of antimony is also used).

(b) **Whitemetal.** In the case of metals required for bearings of moving parts it is necessary that one of them should be of a softer metal. The white metal is an alloy of tin, lead and antimony with copper, all in varying proportions. The bearing metals accommodate themselves for any defect in the alignment of bearings. After wearing away, the bearing could be replaced by suitable white metal.

(c) **Fusible alloy.** Fusible alloys of lead and tin could be made to melt at a temperature of about 350°F. The addition of **bismuth** reduces this temperature to about 200°F and that of bismuth and cadmium brings it down to even 150°F. Fusible alloys are largely used as safety measures in controlling the rise of temperatures.

## ALUMINIUM

Aluminium occurs very widely as an oxide $Al_2O_3$ on the surface of the earth. Clays contain more than 25 to 30 per cent of alumina. The oxide ore which yeilds aluminium on a commercial scale is Bauxite. After the ore is purified, the metal is extracted by an electrolytic process.

Aluminium weights 165 lbs. per cu. ft. and melts at about 1150°F. It is very soft and ductile. Aluminium is largely used for electrical works. It can be powdered to a great fineness which helps it to act as a pigment in paints. Commercial aluminium is hard and tough and is used for making sheets, plates, bars, wires and various structural parts.

## ALUMINIUM ALLOYS

Aluminium forms alloys well with silica, zinc, copper nickel, tin and chromium. Aluminium steel

gives a very good type of a light structural material. Commercial aluminium contains silicon and manganese which impart their hardening properties to the alloy.

The most important alloy of aluminium is "**Duralumin**" or "**Dural**". It contains 4 per cent copper, less than 1 per cent of manganese and magnesium and the balance is aluminium; generally iron and silicon are also present to the extent of about 0.5 per cent. It is as strong as mild steel and can receive heat treatment quite well.

## SPECIFICATIONS

### No. 11.1 MILD STEEL

**Composition**

1. Mild steel shall contain copper between 0.2% to 0.5% and shall not contain more than 0.06% of Sulphur or Phosphorous.

**Quality**

2. All finished mild steel shall be well and cleanly rolled. It shall be free from cracks, surface flaws, laminations, rough, jagged and imperfect edges and all other defects and shall be finished in a workman-like manner.

**Tensile and Elongation Tests**

3. The tensile breaking strength of all plates sections and flat bars shall range between 28 to 33 tons per square inch. Elongation shall not be less than 20 % for steel of 3/8 inch thickness and upwards and not less than 16 per cent for steel of smaller thickness. For plates, sections and bars under 0.25 inch thick, cold bend tests only shall be necessary. For round and square bars other than rivet bars, the requirements shall be as above, except that for bars under 3/8 inch thick, cold bend tests shall only be required. Elongation shall not be less than 20 to 24 per cent, according to the form of test piece used. For rivet bars the tensile breaking strength shall lie between the limits of 25 to 30 tons per square inch with an elongation of not less than 26 to 30 per cent cent according to the form of test piece used.

**Yield Point**

4. The yield point of Mild Steel shall be at least 14.75 tons per square inch for plates, sections and bars over 1½" thick. For thinne test pieces it shall range between 15 to 16 tons per square inch.

**Cold Bend Tests**

5. For bend tests, except in the case of round bars 1 inch in diameter and under, the test piece when cold shall withstand, without fracture, being doubled either by pressure or by blows from hammer until the internal radius is not greater than 1½ times the thickness of the test piece and the sides are parallel. In the case of round bars 1 inch in diameter and under, the internal radius of the bend shall not be greater than the diameter of the bar. For sections having flanges less than 2 inches wide these bend tests may be made on the flattened section.

**Rivets**

6. Manufactured rivets, selected from bulk, shall conform to the following requirements:—

(a) the rivet shanks shall be bent cold and hammered until the two parts of the shank touch without fracture on the outside of the bend;

(b) the rivet heads shall be flattened while hot without cracking at the edges; the head shall be flattened until its diameter is 2½ times the diameter of the shank.

**Young's Modulus (E)**

7. The value of E for Steels used in structural works shall be of the order of $30 \times 10^6$ lbs. per square inch.

**Measurement**

8. The mild steet products shall unless otherwise specified be measured by weight. The unit of measurement shall be one Ton.

**Rate**

9. The unit rate shall include furnishing mild steel products conforming to above specifications at site of work to be cleaned in the conditions of contract.

## SPECIFICATIONS

## No. 11.2 HIGH TENSILE STRUCTURAL STEEL

**Composition**

1. High tensile steel shall contain not more than 0.3. per cent of carbon for material other than rivet bars and not more than 0.3. per cent of carbon for rivet bars; not more than 0.5 per cent of sulphur or phosphorous; copper may be present up to 0.6 per cent.

**Quality**

2. All finished steel shall be well and cleanly rolled. It shall be free from cracks, surface flaws, lamination, rough, jagged and imperfect edges and all other defects and shall be finished in a workman-like manner.

**Tensile and Elongation Tests**

3. For plates, sections and flat bars the tensile breaking strength shall range between 37 to 43 tons per square inch. Elongation shall not be less than 18 per cent, for steel of 3/8 inch thickness and upwards and not less than 14 per cent for steel of smaller thickness. For thickness of less than $\frac{3}{8}$ inch cold bend test only are required. For round and square bars tensile strength shall range between 37 to 43 tons per square inch. Elongation shall not be less than 18 to 22 per cent depending upon the form of test piece used. For rivet bars the breaking strength shall lie between 30 to 35 tons per square inch with an elongation of not less than 22 to 27 per cent depending upon the form of test piece used.

**Yield Point**

4. For plates, sections and flat bars yield point for different thicknes shall range between 23 tons per square inch for a thickness of 1/4 in. to 19 tons per square inch for a thickness of over $2\frac{1}{4}$ inches. For round and square bars yield points shall range between 23 tons per square inch for bars of diameter or side of square one inch or less to 19 tons per square inch for thickness of over $2\frac{1}{2}$ inches.

**Cold Bend Tests**

5. For bend tests, except in the case of round bars 1 inch in diameter and under the test piece when cold shall withstand, without fracture being doubled over either by pressure or by blows from a hammer, until the internal radius is not greater than $1\frac{1}{2}$ times the thickness of the test piece, and the sides are parallel. In the case of round bars, 1 inch in diameter and under, the internal radius of the bend shall be not greater than the diameter of the bar. For sections having flanges less than 2 inches wide these bend tests may be made on the flattened section.

**Rivet Bars**

6. The test piece shall withstand, without fracture, being doubled over either by pressure or by blows from a hammer and closed flat.

**All Other Respects**

7. In all other respect, High tensile structural steel products shall conform to specification No. 11.1 for mild steel.

## SPECIFICATIONS

### No. 11.3. HIGH TENSILE STRUCTURAL STEEL (FUSION WELDING QUALITY)

**Composition**

1. It shall not contain more than the following percentages of impurities:—

| | | |
|---|---|---|
| 1. | Carbon | 0.23 per cent |
| 2. | Silica | 0.35 „ |
| 3. | Manganese* | 1.8 „ |
| 4. | Chromium optional* | 1.0 „ |
| 5. | Nickel optional | 0.5 „ |
| 6. | Sulphur | 0.06 „ |
| 7. | Phosphorous | 0.06 „ |

*The combined percentages of manganese and chromium shall not exceed 2 per cent. Copper may also be present up to 0.8 per cent.

**Quality**

2. The finished material shall be sound and free from harmful segregation of impurities and from cracks, surface flaws and laminations. It shall also have a workmanlike finish and shall not have been hammer dressed.

**Tensile Stress and Elongation Tests**

3. For plates tensile breaking strength shall be between the limits of 37 to 43 tons per square inch for thickness of test piece up to ½" inch, between 35 to 41 tons per square inch up to 1 inch and between 33 to 39 tons per square inch for sections over one inch.

Elongation shall not be less than 14 per cent for sections below 3/8 inch thick and upwards. For sections, round and flat bars, the tensile breaking stress range shall be between 35 to 41 tons per square inch for section up to ⅜ in. thick; and between 33 and 39 tons per square inch for sections over ⅜ inch thick. The elongation shall not be less than 14 per cent for section less than 3/8 inch thick. For sections 3/8 inch thick and over it shall not be less than 18 to 22 per cent depending upon the type of test piece used.

**Yield Point**

4. For plates yield point shall range between 23 tons per square inch for section below 3/8 in. thick to 19 tons per square inch for section one inch thick and upwards. For section, round and flat bars yield point shall range between 21 tons per square inch for section up to 3/4 inch thick to 19 tons per square inch for section over 3/4 in. thick.

**Cold Bend Test**

5. For bend tests, except in the case of round bars 1 inch in diameter and under, the test piece when cold shall withstand, without fracture, being doubled over either by pressure or by blows from a hammer until the internal radius is not greater than 1½ times the thickness of the test piece and the sides are parallel.

In the case of round bars, 1 inch in diameter and under, the internal radius of the bend shall be not greater than the diameter of the bar. For sections having flanges less than 2 ins. wide these bend tests may be made on the flattened section

**In All Other Respects**

6. In all other respects it shall conform to specification No. 11.1 for mild products.

# CHAPTER XI

## COAL

# Coal

## INTRODUCTION

### ORIGIN

Coal is of organic origin, formed from the remains of vegetation such as trees, herbs, shrubs, vanes and other plant materials that flourished millions of years ago, during the periods of widespread uniformly mild moist climate. From this variety of vegetation and its complex carbon compounds come a great assortment of coals, from peat, brown coal and lignite to the hardest kind of anthracite. The character of coal depends upon the nature of the original plant debris, the extent and character of its decay and weathering before burial and upon the geological vicissitudes consequently undergone. Geological forces determine the density and heat value of the coal.

### CLASSIFICATION OF COAL.

Coals are classified according to rank i.e. according to their degrees of metamorphism or progressive alteration in the natural series from Lignite to Anthracite. The basic scheme of classification is according to fixed carbon and heat value calculated to the mineral-matter-free basis. The higher rank coals are classified according to carbon on dry basis and the lower rank coals according to the Btu. on the moist basis.

Classification of a few famous varieties of coals is given below (F.C. Fixed carbon. V.M. Volatile matter).

| Class | Group | Limit of fixed carbon (F. C.) or Btu. mineral-matter-free basis | Requisite physical properties |
|---|---|---|---|
| Lignite. | (1) Lignite<br>(2) Brown coal | Moist Btu. less then 8300<br>Moist Btu. less than 8300 | consolidated<br>unconsolidated |
| Sub-bituminous | (1) Sub-bituminous<br>(2) Sub-bituminous<br>(3) Sub-bituminous | (A) Moist Btu. 11000—13000<br>(B) Moist Btu. 9500—11000<br>(C) Moist Btu. 8300—9500 | |
| Bituminous | (1) Low volatile<br>(2) Medium volatile<br>(3) High volatile<br>(4) High volatile<br>(5) High volatile | Dry F. C. 78—86%<br>Dry VM 14—22%<br>Dry F.C. 69-78% Dry VM 31-32%<br>(A) Dry F.C. less than 69% Dry VM more than 31% and moist Btu 14000 or more<br>(B) Moist Btu. 13000—14000<br>(C) Moist Btu. 11000—13000 | |
| Anthracitic | (1) Meta-anthracite<br>(2) Anthracite<br>(3) Semi-Anthracite | Dry F. C. 98% or more<br>Dry V. M 2% or less<br>Dry F. C 92—98%<br>Dry V. M 2—8%<br>Dry F. C 86—92%<br>Dry V. M 8—14% | |

## VARIETIES OF COAL

1. **Peat.** It is a loose and light variety representing the first stage of decomposition. It is a dark brown or black residium, produced by the partial decomposition and disintegration of mosses, sedges trees and other plants. It is exceedingly friable and is variable in quality. Its colour is yellowish to brown and black, and the dry weight 7 to 60 lb./cft. Air dried peat is 8 to 18 times as bulkly as coal for the same evaporating effect, is easily kindled, burns freely, and gives quick intense heat. A typical percentage analysis of air dried manufactured peat is; moisture 25.61, ash 4.61, volatile matter 48.51, fixed carbon 21.3, sulphur 0.25, heat value 7040 Btu/lb. Illuminating gas, producer gas and a variety of valuable by-products can be made from peat.

2. **Lignite.** Lignite is a low-rank brown to black coal in which the original plant components are discernible. It shows a brown streak and disintegrates rapidly upon exposure. It burns with smoke and is largely soluble in alkalies. It contains 66 to 75 per cent of carbon.

3. **Sub Bituminous Coal.** It is a low-rank banded, black coal with commonly visible woody layers. It disintegrates when exposed to the air, but fairly slowly. It has a brownstreak and smokes when it burns. It is non-coking and insoluble in alkalies.

4. **Bituminous Coal.** It is a medium to high rank black, usually banded, coal with coking qualities poorly developed in highly volatile coals but well developed in coals of medium to low volatility. It weathers slightly or not at all. It is insoluble in alkalies and shows black streak when fresh. It smokes when it burns. Three of its common varieties are:—

(i) normal banded coal,

(ii) cannel coal, which is an unbanded coal with silky lustre, grossly conchoidal fracture an with large proportion of waxy components mainly in the form of spore exines, and

(iii) splint coal, a dull, faintly stricted coal opaque in thin sections and with somewhat metallic ring when sharply struck. Neither cannel nor splint coal usually posseases coking properties. The later contains 75 to 90 per cent of carbon.

5. **Anthracite** is a high-rank coal of dense rocklike texture, a glassy lustre and conchoidal fracture. Although faintly banded, banding does not determine breakage. It has a black streak, does not coke and burns with a nonluminous flame. It contains 90 to 93 per cent carbon and is produced by further action of heat and pressure upon bituminous coal.

## COAL RESOURCES OF PAKISTAN

Soft shales and clays belonging to the various divisions of the Eocene Age contain the main deposits of coal in Pakistan. Coal of no earlier times, except insignificant stringers in the Jurassics, has been reported so far. Peat lignite deposited under the mantle of Recent to sub-Recent alluvium has been lately reported from East Pakistan. The Tertiary coal measures of Western Pakistan are mainly confined to the Salt Range in Rawalpindi, Sargodha, Peshawar, Hyderabad and Quetta Divisions. Many of the Eocene Coals are lignites, often of the Cannel type, non-coking, sometimes banded and bright. Most of the coal seams are either shallow water marginal deposits in brackish water lagoons or accumulations of drifted vegetal matter deposited in estuaries and deltas. The tertiary coal seams are characterized by marked physical and chemical variation in different area.

In West Pakistan the coal out crops occur mainly in the abrupt scraps facing the plain of Jhelum in the eastern part of the Salt Range in the steep and high scraps immediately below the crest of the Trans-Indus ranges, overlooking the Indus plains in the Mianwali District.

Besides this, there are distinctly two workable seams, both occurring in the Ranikot stage of the lower Eocene. The seam in the Eastern Salt Range called the Dandot seam, is slightly younger than the one called the Makerwal seam in the Trans-Indus Range.

**DANDOT, RAWALPINDI DIVISION**

The Dandot seam underlies lime-stone which forms an extensive plateau covering over 200 sq. miles. The coal fields in this area have reserves to the tune of 75.46 million tons.

The seams are generally thin and lenticular and shale partings are common. Broadly they fall into lignitic to sub-bituminous rank, generally in the Cannel groups of non-coking variety. At places they are rich in, resinous matter.

**ANALYSIS OF COAL**

| Locality | Moisture | Ash | Volatile Matter less Moisture | Fixed Carbon | Fuel Ratio | Sulphur |
|---|---|---|---|---|---|---|
| Dandot seam | 5.87 | 12.44 | 48.65 | 38.04 | 0.87 | 2 |
| Dandot Pidh | 4.44 | 16.48 | 40.38 | 38.70 | 0.95 | 6 |

**MAKERWAL, SARGODHA DIVISION** (Trans-Indus Range)

The thickness of the seam varies from 4 ft. to 8 ft. and to a maximum of 12 ft.

Coal seams continue to crop out in the scrap slopes from Mallakhel to Kalabagh. Proved reserved available from the present mine workings are of the order of 1.7 million tons. Coals from these areas vary in quality, usually having high though variable contents of moisture, ash, sulphur and resin. Better quality selected coals from certain areas show coking properties on distillation.

**ANALYSIS OF COAL**

| | Moisture | Volatile Matter | Fixed Carbon | Ash | Total |
|---|---|---|---|---|---|
| Mine 1. | 2.80 | 42.34 | 36.96 | 17.92 | 100.00 |
| Mine 2. | 3.04 | 43.43 | 44.29 | 9.24 | 100.00 |

| | | |
|---|---|---|
| Sulphur percentage | 6.35 | (Mine 1) |
| | 5.90 | (Mine 2) |
| Sp. Gravity | 1.440 | (Mine 1) |
| | 1.338 | (Mine 2) |

**PESHAWAR DIVISION**

The productive coal bearing areas in Peshawar Division totals about 12 sq. miles along the strike. A thin seam rapidly varying from 1 to 2½ ft. has been worked. Assuming an average thickness of 1½ ft. extending over 12 sq. miles, the reserves would be approximately 2.6 million tons.

**QUETTA DIVISION.** Coal seams here are usually more than two in number, separated by strata of shales.

The seams are generally thin, intercalated with clay and limestone bands.

**Khost, Sharigh and Harnai Coal Fields.** The coal bearing strata runs from 25 to 30 miles. There are three seams one above the other of 1½ to 2 ft. 2 to 3 ft, and 1½ ft. thicknesses. All the three include thin shally intercalations.

**ANALYSIS OF COAL**

| | Moisture | Ash | Vol. Matter less Moisture | Fixed Carbon | Fuel Ratio |
|---|---|---|---|---|---|
| Khost | 2.29 | 9.68 | 41.45 | 46.52 | 1.12 |
| Sharigh | 6.80 | 4.80 | 40.80 | 47.60 | 1.17 |

The coal is of lignitic to sub-bituminous rank. In places it has been reported to be suitable for steam-raising purposes. Sharigh Coal is usually regarded as better grade lump coal. Coking variety has been reported from a few selected localities. The coal is usually liable to spontaneous combustion.

**Mach, Quetta Division.** There are a number of thin seams varying from a few inches to 3½ feet in different areas of Mach. The seams invariably contain shale and limestone bands. Sometimes a few inches thick. The coal is usually powdery and friable.

**ANALYSIS OF COAL**

| Description | Moisture | Volatile | Ash | F.C. | Total | Sp. Gr. | Sulphur |
|---|---|---|---|---|---|---|---|
| 3-3½ ft. seam | 11.58 | 40.96 | 8.96 | 38.50 | 100 | 1.373 | 5.48 |
| 1¾" ,, | 9.40 | 40.56 | 11.94 | 38.10 | 100 | 1.393 | 4.27 |
| 1½"-1¾" ,, | 7.86 | 36.96 | 16.38 | 38.80 | 100 | 1.460 | 5.00 |

**Sor Range Area, Quetta Division.** Two coal seams occur in this area separated by a variable thickness of strata. They include an upper seam, 2½ ft. to 2¾ ft. thick and a lower seam 4 to 5 ft thick.

The reserves would be nearly 5 million tons.

**ANALYSIS OF COAL**

| Moisture | Volatile | Ash | Fixed Carbon |
|---|---|---|---|
| 7.46 to 12.84 | 44.94 to 47.28 | 5.20 to 8.90 | 34.42 to 40.66 |

Sulphur usually varies up to 4%

B. Th. U.=9137.8

**Digari Coal Field, Quetta Division.** Of the three seams of Digari coal fields two have been worked; the lower seam is 5 ft. thick and the upper 2½ feet thick; the two are separated by 30 to 40 ft. of shale and sand stones. The coal of this area is of good quality, being of a highly volatile lignitic variety with varying sulphur contents of up to 4%. Lump and slack are equally mixed however, the ratio can be altered by improved mining.

## JHIMPIR AND METING SEAM IN HYDERABAD DIVISION

Soft brown lignite occurs near Jhimpir and Meting. The seam is very thin and lenticular in nature, varying from 9″ to 2½′ in thickness occurring at a depth of 50 to 70 ft. below the surface. The coal is generally soft in nature and lignitic with high moisture and sulphur contents.

## EAST PAKISTAN

Lignite, Brown coal has been found in fields extending from Sylhet to Tippera. The thickness of the seams varying from 2 feet to 8 feet and they are covered by about 12 feet of river silt.

### ANALYSIS OF COAL

| Moisture and Volatile Matter | Fixed Carbon | Ash | Calorific Value. (B. Th. U.) |
|---|---|---|---|
| 59.56% | 24.52% | 18.02% | 9600 |

It burns with a smell of peat and does not appear to be very sulphurous.

Note.—Twenty to Twenty-five tons of indigenous coal of 10,000 to 12,000 B. Th. U. is required in order to burn one lac. Bricks. of 9″×4½″×3″.

## MAIN USES OF COAL

(1) Steam raising.

(2) Coking.

(3) Gas making.

(4) Industrial manufacturing process.

1. **Coal for steam raising.** Since the development of forced draught, mechanical stokers and modern boiler plant, the range of coal for steam raising has been greatly widened and every type of coal from free burning to strongly coking is being used.

2. **Coking Coal.** The essential properties of coking coal are that it will produce strong hard coke suitable for metallurgical purposes; and this is best obtained from coals which combine a high coking power into a relatively low percentage of volatile matter. For metallurgical purpose, the coke must be low in sulphur and phosphorous and this restriction removes a number of otherwise suitable coals from consideration.

3. **Gas making coal.** For gas making it is desirable that coal used forms a good coke, and at the same time has a high volatile content to ensure a high yield of gas. With the advent of continuous vertical retorts and the steaming of the charge, however, the range of the coals which can be successfully carbonized has widened in the direction of lower coking power.

4. **Manufacturing coal.** There are many types of furnaces and kilns used in industry and the design of the installation usually determine the type of coal used. Generally, a coal of moderately high volatile matter is required for furnaces of reverberatory type, but where a high local temperature is required lower volatile coals are most suited; but these need more draughts. For producer gas manufacture, the best fuels are the non-coking or weakly coking coals. The fusion temperature of the ash should be reasonably high unless the producer is of the slagging type.

**SPECIFICATIONS.** It is not possible to lay exact specifications covering the qualitative requirements of various types of coals. Specifications of coal supplied from Indian collieries to Pakistan Railways are however reproduced below to serve only as a guide in drawing up specification for any variety of coal needed for a special purpose. These specifications therefore will not be obligatory.

**Quality**

1. All coal to be supplied to PWR shall conform to the specified grades.

**Size of coal**

2. The coal to be supplied shall be free from stone or other foreign matter. Steam coal shall be of large size screened over 2" mesh screen and consignments shall not contain more than 10% coal below 2" in size. Rubble coal shall be double screened between ¾" to 2" size.

**Grades of coal**

3. The grades of coal supplied shall be determined as follows:—

(a) **Coal from Raniganj seams.** If the ash and moisture contents thereof:—

| | |
|---|---|
| (i) Do not exceed 17.5% | Sel. Gr 'A' |
| (ii) Exceed 17.5% but do not exceed 19% | Sel Gr 'B' |
| (iii) Exceed 19% but do not exceed 24% | Grade I |
| (iv) Exceed 24% but do not exceed 28% | Grade II |

(b) **Coal from any other seams.** If the ash contents thereof

| | |
|---|---|
| (i) Do not exceed 15% | Sel Gr 'A' |
| (ii) Exceed 15% but do not exceed 17% | Sel Gr 'B' |
| (iii) Exceed 17% but do not exceed 20% | Grade I |
| (iv) Exceed 20% but do not exceed 24% | Grade II |
| (v) Exceed 24% but do not exceed 28% | Grade III |
| (vi) Exceed 28% but do not exceed 35% | Grade III B |

Minerals having an ash content in excess of 35% shall not be vendible as coal.

**Method of drawing sample**

4. The following procedure shall be adopted:—

(i) Sample shall be preferably taken direct from wagon.

(ii) Shovelfuls shall be taken from different points of the bulk, e.g. top, middle bottom ends and sides of the wagon. A total bulk of 1% may be taken initially.

(iii) Shovelful so extracted shall be dumped on a clean floor and large lumps broken down to the size of a man's fist and mixed well leaving a round heap.

(iv) This heap shall be divided into four equal portions, rejecting two opposite ones, which may be sent to the stock.

(v) Lumps in the remainder shall be broken to a maximum size corresponding to a large walnut, and heap divided into four equal portions, rejecting two opposite ones as before.

(vi) Remaining sample shall be broken up to pass $\frac{1}{4}$" mesh and process of mixing and dividing repeated.

(vii) The above operations of breaking, mixing and dividing shall be continued till approximately 2 lbs are left. This shall be packed in an airtight tin and despatched for analysis.

**Conditions under which chemical analysis is to be carried out**

5. All analysis of high moisture coal shall be carried out on 72 such samples after equilibrating under the conditions given below for 48 hours:—

(i) Atmospheric Temp—40°c±2°c.

(ii) Relative humidity 60%±2%.

(iii) The specific gravity of sulphuric acid shall be maintained at 1.27.

(iv) The ash contents shall be determined at a temperature between 775°C and 800°C.

# CHAPTER XII

## BITUMEN AND TAR

# Bitumen

## INTRODUCTION

Bitumens are mixtures of natural pyrogeneous hydrocarbons and non-metallic derivatives soluble in carbon disulphide which may be gaseous, liquid viscous or solid. Natural and naturally occurring bitumens or bitumen prepared from natural hydro-carbons or from derivatives of natural hydro-carbons by distillation, oxidation or cracking crude or viscous oil containing a low percentage of volatile products, possessing agglomerating properties and substantially soluble in carbon di-sulphide are known as asphaltic bitumens. They are of various types as described below.

(a) **Steam refined Asphaltic Bitumen.** It is made by straight distillation of suitable crude oils or residues from crude oil, the more volatile products having been distilled off leaving the required grade of asphaltic bitumen as an end product such as Mexphalte 80/100, Spramex 180/200.

(b) **Blown Asphaltic Bitumen.** It is also known as oxidised bitumen and is produced by blowing air through molten steam refined asphaltic bitumen with the result that the characteristics of bitumen gradually change as the blowing is continued. The effect of blowing is to raise the melting point for given penetration and to lower the ductility. Blown asphaltic bitumen has better weathering property than steam refined type and is more suitable for exposure to sun's rays for long period. The examples of blown grades are Mexphalte R 115/15, Mexphalte R 85/25, etc.

(c) **Pitch type asphaltic bitumen.** It is made by distillation of residues from cracking plants at a lower melting point for the same penetration as steam refined type. It is also characterised by rapid fall in viscosity with increase in temperature. That is to say, at high temperature it is more fluid than other grades and is more brittle at low temperatures. The combination of brittleness and low melting point makes it suitable as a substitute for coal and tar pitch and as a binder for the production of coal briquettes. Example is Mexphalt DH 70/75.

(d) **Cut Back.** It is a mixture of straight run asphaltic bitumen and a volatile solvent such as Kerosene or Creosote; it is Shelspra B. S., Shelmac R. C. 3. Cut back has the advantage over straight run asphaltic bitumen in that it can be brought to working consistency at a much lower temperature. When cut back is applied to stone aggregates the Kerosene evaporates in a few hours leaving the stone well coated with bitumen. Cut back is sufficiently fluid to coat every piece of aggregate and allows sufficient time for the coated material to spread to the required thickness and consolidation before the mixture sets up.

(e) **Emulsion.** It is a liquid in which a substantial amount of bitumen is suspended in water in a finely divided and stable state with small percentage of soap. The typical example of asphaltic bitumen emulsions is "Colas". This is used for surface dressing and grouting work only. As soon as it comes in contact with road surface the water evaporates rapidly and leaves a layer of asphaltic bitumen on the road. It is generally used in cold season when other bitumens cannot be maintained at temperatures of application or there is no heating arrangement.

## TESTS

The following tests are carried out to measure and assess the various properties associated with the use of bitumen.

(a) **Specific gravity.** It is usually expressed at 25°C or 77°F and is needed for (i) volume/weight conversions (ii) controlling uniformity of supply and identifying bituminous materials.

(b) **Penetration.** It determines the hardness or consistency of the bitumen and is measured with an instrument known as a penetrometer. The penetrometer measures the distance (in units of hundreds of a centimeter) to which a standard needle penetrates into the bitumen under specified conditions of loading, time and temperature, the usual combination being 100 grams, 5 seconds, and 25°C (77°F). The softer the bitumen the greater is the penetration value.

(c) **Penetration index.** It is a scale derived empirically from the relationship between the penetration at different temperatures. It gives an indication of the temperature susceptibility of a bitumen. High indices indicate bitumens having a low temperature susceptibility and little brittleness, whereas a very low figure (below 1.5) would indicate a temperature susceptible bitumen.

(d) **Softening point.** The temperatures at which the bitumen reaches a certain degree of softness is its softening point. When bitumen is heated it gradually gets softer and softer. So much so that it starts flowing readily, but at no stage of the heating process is there a point of critical temperature, at which it suddenly changes from a solid to a liquid; it has, therefore, no true melting point and any test of the melting or softening point is merely arbitrary.

(e) **Ductility.** It is a measure of the distance in cms. that a standard briquette of bitumen at a temperature of 25°C (77°F) can be drawn out without breaking when the ends are pulled apart at a rate of 5 cms. per minute. This test helps in indicating the adaptability of the bituminous material in connection with certain usages and differentiating blown petroleum asphalts from nature or residual asphalts etc.

(f) **Solubility.** It determines the amount of impurities present in the bitumen.

(g) **Ash content.** It is chiefly of value for detecting the presence of mineral matter in the bitumen and is carried out by igniting (or heating strongly) a known quantity of bitumen and recording the percentage of incombustible residue.

(h) **Volatility.** It determines the loss of weight of the bitumen when heated under standard conditions in an oven for five hours at 163 °C (325 °F). It usually follows the determination of the softening point, penetration and ductility of the residue to give an indication of the effects of heat on the bitumen and to show the presence of any volatile constituents in the original bitumen. Other things being equal. The lituminous substance showing the smallest percentage of volatile matter will prove most weather proof on exposure. The cut backs usually have a large percentage of volatile constituents.

The following tests are carried out specially for the cut-back bitumen:—

(a) **Viscosity.** It gives a relative indication of the consistency of the cut back and is primarily used for grade discrimination and production control.

(b) **Distillation.** It shows the volatility of the flux used in the manufacture of the cut back and will give some indication of type of cut back and the rate at which it will 'set' or 'cure'.

(c) **Flash point.** It shows the temperature at which the cutback will evolve vapours which ignite upon contact with flame under certain arbitrary test conditions. Flash point should be at least 50°F higher than the max. temperature to which the bituminous substance will be subjected in process of blending or utilization.

**Table No. 12.1**

**VARIOUS TYPES OF BITUMENS WITH THEIR CHARACTERISTICS AND USAGES**

| Bitumens with commercial names | Penetration at 25°C. | Solubility in carbon disulphide | Specific gravity | Melting point in centi-grade | Application Tempera-ture in Fahrenheit | Uses. |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **(A) STRAIGHT GRADES** | | | | | | |
| i. Mexphalte | 20/30 20/30 | Over 99% | 1.03/1.07 | 59/69 | 375 | This is used in Hot-Mix specifications or where use hard bitumen is indicated and expansion joints in cement concrete construc-tion. |
| ii. Mexphalte | 30/40 30/40 | Over 99% | 1.02/1.06 | 55/64 | 350—375 | This is used for grouting work in road construction. |
| iii. Mexphalte | 80/100 80/100 | Over 99% | 1.01/1.05 | 47/54 | 350—375 | This is used as binding and surface dressing material in road construction. The traffic resistance and adhesive properties are good. |
| iv. Spremex | 180/200 180/200 | Over 99% | 1.01/1.04 | 37/43 | 350—375 | It is generally used in tro-pics. It is also used for light surface dressing, in cold climates and for the manufacture of bituminous emulsions. |
| **(B) CUT BACK** | | | | | | |
| i. Shelmac B.S. | 120/150 | — | — | — | 275—300 | It is used as a binder in road construction work and as a water proofing material. |
| ii. Shelspra B.S. | — | — | — | — | 300 | It is used in the "pre-coated chiping carpet" type of road construction and re-surfacing work and as a water proofing material. |
| **(C) EMULSIONS** | | | | | | |
| i. Colas | — | — | — | — | Applied cold | It is used for surface dress-ing and grouting in road construction, (It is also used in cold season when other bitumens cannot be main-tained at their temperature of application or there is no arrangement of heating.) |
| ii. Colasmix | — | — | — | — | Applied cold | It is used for pre-coated stone carpet construction. It can be used with damp aggregate. |

## TAR

Tar is a black or dark-brown bituminous material obtained as a condensate in the destructive distillation of organic substances such as bituminous coal, petroleum and wood. It is principally bitumen of liquid to semi-solid consistency which yields pitch as residue when fractionally distilled, .

**COAL TAR.** It is produced by the destructive distillation of bituminous coal.

**COKE OVEN TAR.** It is a variety of Coal Tar obtained as a by-product from the destructive distillation of bituminous coal in the production of Coke.

**OIL GAS TAR.** It is a petroleum Tar produced by cracking oils at high temperature in the production of oil gas.

**WATER GAS TAR.** It is a petroleum tar produced by cracking oils at high temperature in the production of carbureted water gas.

**REFINED TAR.** It is produced from crude tar by distillation to remove water and to produce a residue of the desired consistency. Refined tar may also be produced by blending tar residue with a tar distillate. Tar refined in quality and consistency for use in paving is called a road tar.

**PITCHES.** They are black or dark brown solid cementitious residues which gradually liquify when heated and which are produced by distilling of the volatile constituents from tar.

**TESTS**

Test for road tars are in general very similar to those applied to asphaltic material. However, even though the same property is being measured in many a cases, the methods of testing differ in detail from those applied to asphalts.

The following tests apply to Tar :—

1. **Engler Specific Viscosity (ASTM Designation T 54).** The time in seconds for 50 milligrams of road tar to flow through the standard orifice of the Engler Viscosimeter at a specified temperature, when divided by the time in seconds for 50 milligrams of water to flow through the same orifice at 77° F. is termed as specific viscosity.

2. **Float Test (ASTM Designation D 139 T 50).** Float test is applied to measure the consistency of tar materials which are too soft for the penetration test and too viscous at the desired test temperature for viscosity test. It is also a useful consistency test in those cases where the quantity of material to be tested is small. This test has been used to indicate temperature susceptibility since the test results are somewhat dependent on this property in the normal case. This test is also used to measure the consistency of the heavier grade of road tar.

3. **Specific Gravity (ASTM Designation D 70).** The specific gravity of road tar is needed for billing and shipping purposes. It is also a property reflecting its make up indicating the amount of free carbon.

4. **Total Bitumen (ASTM Designation D 4).** The method of test for total bitumen is the same as that applied to asphalts for determination of solubility, except that for tars carbon disulphide is always used. The soluble portion is bitumal by definition, whereas insoluble portion is principally free carbon.

5. **Distillation Test (ASTM Designation D 20).** As in the case of Cut Backs and road oils, the distillation test on tars is performed to determine the nature and amount of both the distillate and the residue from distillation. However, the test applied to tar is carried out in a smaller glass flask than that used for asphaltic materials and the condenser is air cooled rather than water cooled. The temperature of the vapour rather than of the liquid in the flask is measured and the distillation results are expressed as a percentage by weight of the total material rather than as a percentage by volume of the total distillate.

6. **Softening Point Test (ASTM Designation D 872).** The softening point test applied as a measure of the consistency of residues from the distillation of tar is the same as that applied to asphalts. It should be noted that the residues from the distillation of road tars are rather hard materials, as indicated by their softening point values.

7. **Sulphonation Index (ASTM Designation D 872).** The sulphonation index test is applied to the total distillate from a road tar or to that fraction of distillate, distilling between 300° and 355° C. In this test $5 \pm 0.1$ gram of the distillate is reacted with sulphuric acid under conditions that will sulphonate the distillate to completion. The sulphonation index is obtained by dividing the milliliters of unsulphonated residue by the weight in grams of the sample and multiplying this quotient by the percentage by weight of the distillation in the tar. Thus the sulphonation index is the milliliters of unsulphonated residue per 100 grams of tar. It is a measure of the amount of saturated hydrocarbons present in the total distillate. Since hydrocarbons derived from tar are essentially unsaturated, the test is an identifying one with respect to these materials. Hydrocarbons from asphaltic sources, on the other hand, are largely saturated. Thus placing a limitation to sulphonation index limits, i. e., the amount of solvent or flux from petroleum which the tar refiner might use in blending operations is fixed.

8. **Water contents (ASTM Designation D 95 T. 55).** This method of test as applied to road tar is the same as that for asphaltic materials.

TABLE NO (12.2)

| Grades | Rt. 1 | Rt. 2 | Rt. 3 | Rt. 4 | Rt. 5 | Rt. 6 | Rt. 7 | Rt. 8 | Rt. 9 | Rt. 10 | Rt. 11 | Rt. 12 | RTCB-5 | RTCB-6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Consistance Engler S. P. VISC. at 40°C | 5—8 | 8—13 | 13—32 | 22—35 | — | — | — | — | — | — | — | — | — | — |
| do at 50°C. .. | — | — | — | — | 17—26 | 26—40 | — | — | — | — | — | — | 17—26 | 26—40 |
| Float test at 32°C. .. | — | — | — | — | — | — | 50—80 | 80—120 | 120—200 | — | — | — | — | — |
| do at 50°C. .. | 1.08+ | 1.08+ | 1.09+ | 1.09+ | 1.10+ | 1.10+ | 1.12+ | 1.14+ | 1.14+ | 1.15 | 1.16 | 1.16+ | 1.09+ | 1.09+ |
| Sp Gr. at 25°C/25° .. | 88+ | 88+ | 88+ | 88+ | 83+ | 78+ | 78+ | 78+ | 78+ | 75+ | 75+ | 75+ | 80+ | 80+ |
| Water, % by Vol. .. .. | 2.0— | 2.0— | 2.0— | 1.5— | 1.5— | 1.5— | 1.0— | 0 | 0 | 0 | 0 | 0 | 1.0— | 1.0— |
| Distillation, % by Wt. .. .. | 7.0— | 7.0— | 7.0— | 5.0— | 5.0— | 5.0— | 3.0— | 1.0— | 1.0— | 1.0— | 1.0— | 1.0— | 2.0—8.0 | 2.0—8.0 |
| to 170°C. .. | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| to 200°C. .. | — | — | — | — | — | — | — | — | — | — | — | — | 5.0+ | 5.0+ |
| to 235°C. .. | — | — | — | — | — | — | — | — | — | — | — | — | 8—18 | 8—18 |
| to 270°C. .. | 35.0— | 35.0— | 30.0— | 30.0— | 25.0— | 25.0— | 20.0— | 5.0— | 15.0— | 10.0— | 10.0— | 10.0— | | |
| to 300°C. .. | 45.0— | 45.0— | 40.0— | 40.0— | 35.0— | 35.0— | 30.0— | 5.0— | 25.0— | 20.0— | 20.0— | 20.0— | 25.0— | 25.0— |
| Softening point of distillation residue, C. | | | | | | | | | | | | | | |
| Sulfonation index (when specified) on distillate .. .. .. | 30—60 | 30—60 | 35—65 | 35—65 | 35—70 | 35—70 | 35—70 | 35—70 | 35—70 | 40—70 | 40—70 | 40—70 | 40—70 | 40—70 |
| to 300°C. .. | 8— | 7— | 6— | 6— | 5— | 5— | — | — | — | — | — | — | — | — |
| to 355°C. .. | 1 | 1.5— | 1.5— | 1.5— | 1.5— | 1.5 | — | — | — | — | — | — | — | — |
| Typical uses and suggested temperatures for application | Prime coat | | Prime coat & surface treatment | | Surface treatment & Road mix. | | Surface treatment Road mix, premix seal coat. | | Surface treatment premix, & seal coat penetration & track filler. | | | Surface treatment road mix & premix when low temperature & application and quick setting are desired. | | |

# CHAPTER XIII

## SANITARY APPLIANCES AND FITTINGS

# Sanitary Appliances and Fittings

## DEFINITION

Any appliance fitted to an appropriate system for the collection and discharge of foul and waste matter is termed a sanitary appliance or fitting. The materials used for the manufacture of sanitary appliances and fittings are to be durable, impervious, corrosion resistant with smooth surface that can easily be cleaned.

## WATER CLOSET

### INTRODUCTION

A water closet consists of a pan, a seat, a flushing cistern and a flush pipe. In a combination of installations where it is desirable to ensure rapid refilling of flushing cisterns, flushing troughs are used instead of independent flushing cisterns. Water closets are of the following types.

(a) **Pedestal type.** A water closet in which the contents of the pan are removed by a flush of water discharged into the pan is known as the pedestal type.

(b) **Pedestal type Siphonic water closet.** It is a water closet in which the contents of the pan are removed by siphonage and the flushing cistern is replaced in some cases by regulating valve.

(c) **Corbel type water closet.** This type of water closet is supported on brackets so that the floor below shall be left free for cleaning.

(d) **Squatting type water closet.** Its pan is fixed in the floor and the top of the pan is in level with the floor. It is also known as the Asiatic pattern water closet.

### PAN

It is made as ceramic ware in one piece of any material which is durable, impervious and corrosion resistant. The common colours of the pan are white, yellow, green, blue, pink and ivory. The materials commonly used for the manufacture of pans and their corresponding weights are given below:—

| MATERIAL | WEIGHT IN LBS. |
|---|---|
| Caneware No. 1 | 24 |
| Caneware No. 2 | 28 |
| Earthenware | 24 |
| Fireclay | 45 |
| Heavy earthenware | 32 |
| Stoneware | 45 |
| Vitreous china | 32 |

The pans are commonly of pedestal type, corbel type and squatting type for fixing to the floor, to the wall and in the floor respectively. In case of siphonic water closet the pan is of siphonic type, with large water area and deep seal. The bowl of the pan is kept sufficiently large so as to prevent soiling of the surrounding floors in reasonable use. It is provided with a flushing rim so designed as to discharge complete component of the flow at each flush and also scour effectively the inside of the bowl. Ordinarily the length of the pan is 16 inches and 20.5 inches for earthen ware type and 25 inches for

heavy fire clay type. For schools and nurseries 14 ins. 12 ins. and 10 ins. long size may be adopted. The important dimensions for pedestal type water closet pan are given below:—

| No. | Important Dimensions | "S" trap | "P" trap |
|---|---|---|---|
| 1 | Overall height | 16 ins. | 16 ins. |
| 2 | Distance from end of trap to floor | 3/4 in. | |
| 3 | Overall length | 20.5 ins. minimum<br>25 ins. max | 20.5 ins. min.<br>25 ins. max. |
| 4 | Angle of outlet | 180° | 104° |
| 5 | Floor fixing holes | 2 No—1/4 in. diameter. | 2 No—1/4 in. diameter. |

Each pan has one trap 'S' or 'P' as a separate fitting. The minimum water seal is kept as 2".

## SPECIFICATIONS

### No. 13.1 PAN

**Source**

1. The pan shall be of an approved manufacture.

**Composition**

2. The pan shall be made as ceramic ware in one piece of materials, as specified.

**Manufacture**

3. Each pan shall be fired at such a temperature as to produce a satisfactory fused clay.

**Quality**

4. Each pan shall show good workmanship without dents or faults. The surface and colour shall be uniform, non-corrigible, non-plumber ferrous, free from discolouration and imperfections.

**Colour**

5. The colour of the pan shall be as specified.

**Type**

6. The type of the pan shall be as specified.

**Size**

7. The size of the pan shall be as specified.

**Trap**

8. The trap shall be either S or P type as specified.

For manufacture and quality it shall conform to the above specifications for pan. Each trap shall have a circular opening of 2 inches i/d for connection of anti-siphonage pipe.

**Foot rest**

9. The foot rest shall be supplied alongwith the squatting type pan. For manufacture and quality, the foot rests shall conform to the above specifications of pan. For 'Orisa' pattern squatting type pan, the foot rest shall be an integral part of the pan.

**Measurement**

10. The measurement of the pan shall be in numbers, the unit of measurement shall be unity.

**Rate**

11. The unit rate shall include the cost of pan, trap and foot rests for squatting type; the sorting packing and delivery at site of work, to be defined in the Conditions of Contract.

## SPECIFICATIONS

### No. 13.2 SEAT

**Source**

1. Seat shall be of an approved manufacture.

**Composition**

2. Seat shall be manufactured from "Phenal" or "Amino" plastic.

**Quality**

3. Seat shall be made in one piece. It shall be thoroughly cured, free from blisters. The surface shall be highly polished, impervious and hygienic.

**Type**

4. Seat shall be of closed or open pattern.

**Shape**

5. The shape of the seat shall be in conformity with the type of pan specified. The under side of the seat shall be flat and shall not be recessed. For closed pattern seat the hinging devices shall be either of good quality non-ferrous metal or any other corrosion resistant material.

**Bolts**

6. The bolts shall be of non-ferrous material, 2½ inches in length. Two bolts shall be provided with each seat.

**Buffers**

7. Seat shall be provided with rubber buffers of 1″ × 1½″ size and 3/8″ thickness. The buffers shall be rigidly attached to the seat. The metal in contact with buffers shall be non-ferrous. The cover of the seat for closed pattern shall have buffers not less than 2 in number.

**Colour**

8. The colour of the seat shall be black or as specified.

**Measurement**

9. The measurement of the seat shall be in number. The unit of measurement shall be unity.

**Rate**

10. The unit rate shall include the cost of seat, two bolts, buffers, cover for closed pattern, the sorting, packing and delivery at Site of Work, to be defined in the Conditions of Contract.

## FLUSHING CISTERN

### INTRODUCTION

Flushing cisterns are made from materials which are non-corrigible or protected against corrosion. These are either high level or low level type. The materials generally used for the manufacture of high level type are cast iron or pressed steel. The low level type are usually manufactured from materials as are used for pan and have the same colours.

The cistern has a capacity of 2.5 to 3 gallons.

Flushing cisterns are commonly of valve-less type and thus prevent the waste of water. The working parts provide smooth working and efficiency. The cistern is so constructed that water cannot flow down the flush pipe except when the flush is properly delivered. The underside of the bend in the flush pipe is kept at such a height that no water runs down the flush pipe when, after temporarily closing the water pipe, the water level is raised to the overflow level. The water line is kept 2½ inches below the top level of the cistern. The cantilever brackets, one cover, one flush pipe and one ball valve with its component parts, are also required to complete a cistern.

### SPECIFICATIONS

#### No. 13.3 FLUSHING CISTERN

**Source**

1. Cistern shall be obtained from approved source.

**Composition**

2. High level cistern shall be manufactured from cast iron or pressed steel. Low level type shall be of the same manufacture as the pan. The low level cistern shall conform to specifications of pan.

**Capacity**

3. The capacity of the cistern shall be as specified.

**Quality**

4. Cistern shall be soundly constructed and shall be free from defects affecting its utility. The ferrous parts shall be painted with corrosion resistant paint. It shall discharge at the rate of 2 gallons in not more than 5 seconds when fitted with a high level flush pipe and at the rate of 2 gallons in not more than 6 seconds when fitted with low level type.

**Colour**

5. For low type flushing cistern the colour shall be as specified for the pan.

**Brackets**

6. Brackets shall be of iron painted or white porcelain enamelled. The length of the bracket shall be such as to enable 4 inches embedding in the wall or fixed to the wall with the help of screws.

**Cover**

7. For composition and quality the cistern cover shall conform to the corresponding specification of cistern. Either screw or bolts shall be provided for fixing the cover to the cistern.

**Flush pipe**

8. *Flush pipe shall be of 1¼" inch internal diameter.* It shall be manufactured either from steel

or non-ferrous materials. The steel pipe shall be either galvanized or chromium plated as specified both internally and externally. Moulded rubber cone shall be provided for connection with the pan.

**Ball valve and component parts**

9. Ball valve and its component parts shall be either of brass or gun metal or any corrosion resistant alloy. These shall be sound, hard, smooth and well-finished. The mechanism of component parts shall be such that when the piston is in contact with the face of seat, the short arm of the lever shall be in vertical position. Ball valve shall not leak when tested to a pressure of 300 psi. It shall not displace water more than half its volume when left in water.

**Measurement**

10. The measurement of cistern shall be in numbers. The unit of measurement shall be unity.

**Rate**

11. The unit rate shall include the cost of cistern ball valve and its component parts, flushing mechanism, cover, brackets, flush pipe, sorting, packing and delivery at Site of Work, to be defined in the Conditions of Contract.

## LAVATORY BASIN

### INTRODUCTION

The lavatory basin is made as a ceramic ware, in one piece, of a material which is durable, impervious and corrosion resistant. The common sizes of lavatories are: 24″ × 20″, 25″ × 18″, 22″ × 16″, 27″ × 21″, 27″ × 22″, 30″ × 22″, 27″ × 19″, 20″ × 18″, 20″ × 19″, 26″ × 14″, 18″ × 11″, 20″ × 12″, 23″ × 12″, 15″ × 15″, and 21″ × 27″. For angle lavatory basins the common sizes are 24″ × 18″, 27″ × 20″, 30″ × 22″ and 21″ × 21″.

The following are made an integral part of the basin:—Overflow, soap trays or sinking holes for pillar taps, waste outlet, plug chain stay, back skirting to receive splash back and stud slots for brackets. Brackets are required for ordinary lavatory basin and pedestal is supplied with pedestal lavatory basin. Rubber or vulcanite plug with chain, one or two pillar taps waste coupling for combined supply and waste fittings are essential fittings of a lavatory basin.

The materials commonly used for the manufacture of lavatory basin alongwith the weight of two standard sizes are given below:—

| Materials | Size 22 in. × 16 in. | 25 in. × 18 in. |
|---|---|---|
| Earthenware | 24 lb. | 30 lb. |
| Fireclay | 45 lb. | 58 lb. |
| Heavy earthenware | 32 lb. | 40 lb. |
| Stoneware | 32 lb. | 40 lb. |
| Vitreous china | 32 lb. | 40 lb. |

The common colours of lavatory basins are white, yellow, green, blue, pink and ivory.

### SPECIFICATIONS

#### No. 13.4 LAVATORY BASIN

**Source**

1. Lavatory basin shall be of approved manufacture.

**Composition**

2. Lavatory basin shall be made as ceramic ware in one piece of material, as specified.

**Manufacture**

3. Each lavatory basin shall be fired at such a temperature as to produce a satisfactory fused clay.

**Quality**

4. Each lavatory basin shall show good workmanship without dents or faults. The surface and colour shall be uniform, non-corrigible, non-plumber ferous, free from discolouration and imperfections. The basin shall be so designed as to control slopping.

**Colour**

5. Colour of the lavatory basin shall be as specified.

**Type**

6. The type of the lavatory basin shall be as specified.

**Size**

7. The size of the lavatory basin shall be as specified.

**Overflow**

8. Overflow shall be either of open weir type with removable grating or of a slot type as specified. The slot for overflow shall be 2.5 inches long and $\frac{1}{8}$ inch deep. It shall be so designed as to facilitate cleaning.

**Soap tray or sinking**

9. Soap tray or sinking shall be so provided as to drain into the basin.

**Pillar taps**

10. Pillar taps shall be manufactured from gun metal and shall be chromium plated. These shall be of screw down type with jam nut. Internal diameter of the tap shall be $\frac{1}{2}$".

**Tap hole**

11. Tap holes shall be square to fit pillar taps, shall be bevelled around the openings. They shall be so situated as to allow supply pipes to be clear of waste and vent pipes and shall have enough space to prevent the users striking the head on the tap.

**Waste hole**

12. Waste hole shall have a minimum diameter of $2\frac{1}{2}$ inches. The outlet shall be bevelled or rebated. Tap hole shall be square in shape and each side shall be of $1\frac{1}{8}$" length.

**Plug chain and stayhole**

13. Plug shall be of rubber. The diameter of the plug shall be such as to fit snugly in the waste hole. The chain shall be of brass, chromium plated, one end fixed to the plug and the other held in the chain stay hole. The position of stay hole shall not be lower than the overflow slot.

**Back skirting**

14. Back skirting shall be true to receive splash back.

**Combined Supply and Waste fitting**

15. Combined supply and waste fitting shall comprise of $\frac{1}{2}$ inch combined taps with discharge nozzle and $1\frac{1}{4}$" pop up waste. Waste outlet shall be screwed $1\frac{1}{4}$" to B. S. pipe male. All of these fittings shall be of gun metal with chromium plating.

**Brackets**

16. Brackets shall be of painted iron or white porcelain enamelled. The length of the bracket shall be such as to enable 4 inches embedding in the wall or fixed to the wall with the help of screws.

**Stud slots**

17. Stud slots shall be monolithically cast with the lavatory basin. These shall receive the brackets on the inside of the lavatory, shall be so situated that the brackets remain 2" away from the face. These shall not exceed ½" in dia, 5/16" in height and shall be 12" from the back of the basin to the centre of the side. The side studs shall be $2\frac{1}{8}" \times 5" \times 5/8"$ and centre of stud shall be 12" from the back of the basin.

**Pedestals**

18. Pedestal in a pedestal lavatory shall conform to the corresponding specifications of lavatory basin for composition, manufacture and quality. It shall be completely recessed at the back for the reception of supply waste pipes. It shall be such that the basin is tightly and adequately supported and shall be so arranged that the height from the floor to the top of the rim of the basin is 31".

**Measurement**

19. The measurement of the lavatory basin shall be in numbers. The unit of measurement shall be unity.

**Rate**

20. The unit rate shall include the cost of lavatory basin, pillar taps or combined supply and waste fitting as specified; brackets or pedestals as specified, plug chain, sorting, packing and delivery at Site of Work, to be defined in the Conditions of Contract.

## SINK

### INTRODUCTION

Sinks are devices used for washing utensils, vegetables and cleansing bed pans, etc. They are of the following types:—

(a) Sinks with integral drainers.

(b) Sinks without drainers.

(c) Tub and sink set.

The common colours are white, yellow, green, blue, pink and ivory.

Sinks are categorized as below with respect to their uses.

(1) **Domestic Sinks.** Commonly used as pantry sink, it is meant for washing household utensils. It is made as ceramic ware in one piece of material which is durable, impervious and corrosion resistant, with imperishable leadless glazed finish. It is also made of stainless steel. An integral draining board is also incorporated. The overflow is usually combined with the waste and is of the open weir type. The plug for the waste outlet is secured by a chain. The common sizes of domestic sinks are $24" \times 18" \times 10"$, $24" \times 21" \times 10"$; $24" \times 24" \times 18"$; and $30" \times 30" \times 18"$. The tap holes are provided in the back edge and are $1\frac{1}{8}"$ in. square, set at 45° and spaced at 7" between centres. The water is held in the sink by a rubber or vulcanite plug fixed in the waste pipe when required. The waste fitting flanges are $3\frac{3}{8}"$ diameter, the tail $3\frac{1}{2}"$ long, screwed with $1\frac{1}{2}"$ B. S. parallel thread and the siding flange or backnut of $3\frac{1}{4}"$ diameter. The overflow slot is $3" \times 3/4"$. Waste holes are rebated or bevelled and are made to receive the waste fittings. Taps are of ½" diameter made from gun metal and are chromium plated.

(2) **Crockery sink.** They are used in hotels and restaurants for washing crockery utensils. They are manufactured from teak wood jointed with a mixture of white and red lead. Stainless steel or brass is also used for their manufacture. The sides of the sinks manufactured from teak wood are held together with long galvanized iron bolts and the bases are screwed to the sides with brass screws.

(3) **Pantry sink.** It is a small sink used for washing silver and glass ware and is constructed of such materials as will minimise damage. Aluminium is not used for pantry sinks owing to the possibility of damage to silverware due to chemical action.

(4) **Utensil Sink.** It is a large sink for the cleansing of cooking utensils. It is made of galvanized or hard wearing and corrosion resistant metal, with outlet in the base, a useful size being about 36″ × 24″ × 8″. Both supply and waste pipe connections are larger than those used on most other types of sinks to enable quick changes of hot water to be made.

(5) **Vegetable sink.** It is meant for washing vegetables by hand. It is made of fireclay, stoneware or earthenware of a size sufficient to deal with the amount of vegetable to be prepared and washed. It is provided with a standing waste outlet for running water and is fitted with a perforated guard round the waste, or, removable basket, or, cage, to reduce the amount of solid matter passing through the waste pipe.

(6) **Fire Clay sink.** It is commonly used in laboratories and is made of fireclay, fired at a temperature necessary to produce a satisfactorily fused glaze. It has a white glaze inside. It has a combined overflow and two tap holes.

(7) **Bed pan sink.** It is commonly used for cleaning bed pans and urine bottles in hospitals and dispensaries. Fire clay or any material which is durable, impervious and corrosion resistant is used for its manufacture. It is fitted with water jet fitting, flushing system and jet controlling device. Jet control is of such type as can be operated by foot, knee and elbow.

(8) **Macintosh sink.** It is commonly used in hospitals and hotels, etc., for cleaning waterproof draw sheets for bed. It is a combination of sink and slab. The materials like fireclay or stoneware are used for its manufacture. It is provided with a flushing cistern and a hand spray attached to the flexible tubing.

(9) **Slop sink.** It is commonly used in hospitals. It is made of glazed fireclay and is fitted with a trap, a flushing rim and upstanding skirting. A hinged metal grill is provided above the flushing rim and a hard wood is set on the front edge of the rim. The sink is fitted with a flushing cistern for effective cleansing and with taps to discharge hot and cold water over the sink. The taps are so arranged as to enable them to discharge simultaneously into a bucket and to allow the latter to be moved freely without damage to the sink or to the taps.

## SPECIFICATIONS

### No. 13.5 SINK

**Source**

1. Sink shall be of an approved manufacture.

**Type**

2. The type shall be as specified.

**Composition**

3. It shall be made as ceramic ware in one piece of materials as specified, except for crockery sink.

**Manufacture**

4. Sink shall be fired at such a temperature as to produce satisfactory fused clay. Crockery sinks shall be manufactured as specified.

**Quality**

5. Each sink shall show good workmanship without dents or faults. The surface and colour shall be uniform, non-corrogible, non-ferrous, free from discolouration and imperfections.

**Colour**

6. Colour shall be as specified.

**Size**

7. Size shall be as specified.

**Pillar taps**

8. Pillar taps shall be manufactured from gun metal and shall be chromium plated. These shall be of screw down type with jam nut. Internal diameter of the tap shall be $\frac{1}{2}''$.

**Tap hole**

9. Tap holes shall be square to fit pillar taps, and shall be bevelled around the openings. They shall be so situated as to allow supply pipes to be clear of waste and vent pipes.

**Waste hole**

10. Waste hole shall have a minimum diameter of $2\frac{1}{2}''$. The outlet shall be bevelled or rebated, tap hole shall be square in shape and each side shall be of $1\frac{1}{8}''$ length.

**Brackets**

11. Brackets shall be of painted iron or white porcelain enamelled. The bracket shall be either of such a length as to enable 4 inches embedding in the wall or shall be such as to be fixed to the wall with the help of screws.

**Measurement**

12. The measurement of sink shall be in numbers. The unit of measurement shall be unity.

**Rate**

13. The unit rate shall include the cost of sink, pillar taps, two brackets, plug and chain, sorting, packing and delivery at Site of work, to be defined in the Conditions of the Contract.

## DRAINERS

### INTRODUCTION

The drainers are made of a material which is durable, impervious and corrosion resistant. The materials commonly used for the manufacture are Asbestos, cement, cast iron, porcelain enamelled, fire clay, pressed steel sheet, stainless steel and wood. The length of the drainer is kept at 18", 21", 24", 27", 30" or 36" and the width 18" or 21".

Different materials have the following thickensses:—

| | |
|---|---|
| Asbestos cement | 3/8" |
| Cast iron porcelain enamelled | 3/16" |
| Fire clay | 1" |
| Pressed steel sheet | 0.0495" |
| Stainless steel | 0.036" |
| Wood | 1.25" |

Fluting is provided with raised edges on the three sides to prevent spillage. The flutings are made in such a manner as to prevent water running back on the underside of the drainer. The drainer is detachable and does not form an integral part of the sink.

## SPECIFICATIONS

### No. 13.6 DRAINER

**Source**

1. Drainer shall be of an approved manufacture.

**Composition**

2. It shall be made of the specified material.

**Quality**

3. Each drainer shall show good workmanship without any faults. The surface shall be non-corrigible and stainless. With the exception of wood and asbestos cement type, the finished surface shall be resistant to all normal food acids and alkalies and to cleansing material normally used. Wooden drainer shall be of one piece construction jointed with a tonged machine joint. Each drainer shall be provided with the fluting and raised edges on three sides.

**Size**

4. The size shall be as specified.

**Measurement**

5. The measurement of drainer shall be in numbers and the unit of measurement shall be unity.

**Rate**

6. The unit rate shall include the cost of drainer, sorting, packing and delivery at Site of work to be defined in the Conditions of the Contract.

## URINALS

### INTRODUCTION

Urinals are made as ceramic ware in one piece of a material which is durable, impervious and corrosion resistant. The colours of urinals are white, yellow, grey, blue, pink and ivory. Urinals are fitted with either automatic or, hand operated flushing cistern discharged through flush pipe or non ferrous spreaders or perforated pipe.

The following are the common types of urinals:—

(a) **Slab type urinals.** They are manufactured from fire clay or a material which is durable, impervious and corrosion resistant. The surface of the urinal is glazed. A slope back from vertical of 1½″ is kept when fixed to the support.

(b) **Stall type urinals.** They are manufactured from materials as specified for slab type. They are of curved back pattern. The channel is cast either integrally with the spoil or separately.

(c) **Ball type urinals.** They are manufactured from material as specified for the slab types. They are fitted with flushing rims or non-ferrous spreaders or water inlets.

(d) **Asiatic type urinals.** They are manufactured from the materials as specified for slab type. They are of the squatting type. The channels are separate fittings for this type and are made of the same materials as those of urinals. Traps are provided in the circular projections of the channels. The trap sizes vary from 2½″ to 3″ depending upon the number of seats.

The inlet ends of the traps are provided with chromium plated brass discharges of removable type. The urinal slabs are designed with back flush arrangements. The flushing system is an extra annexure for Asiatic Type Urinals. Connections from the flush pipes are provided with spreaders (one to each seat) to flush the front of the urinals.

## SPECIFICATIONS

### No. 13.7 URINALS

**Source**

1. Urinal shall be of an approved manufacture.

**Composition**

2. Urinal shall be made as a ceramic ware in one piece of materials, as specified.

**Manufacture**

3. Each urinal shall be fired at such a temperature as to produce a satisfactory fused clay.

**Quality**

4. Each urinal shall show good workmanship without dents or faults. The surface and colour shall be uniform, non-corrigible, non-plumber ferrous, free from discolouration and imperfections.

**Colour**

5. Colour of the urinal shall be as specified.

**Type**

6. The type of the urinal shall be as specified.

**Measurement**

7. The measurement of urinals shall be in numbers. The unit of measurement shall be unity.

**Rate**

8. The unit rate shall include the cost of the urinal and its fittings for the specified type, sorting, packing and delivery at Site of Work, to be defined in the Conditions of Contract.

## BATH TUBS

### INTRODUCTION

Bath tubs are manufactured as ceramic ware in one piece of material which is durable, impervious and corrosion resistant. The common colours of the tubs are white, yellow, green, blue, pink and ivory. Ordinary bath tubs are made of cast iron with porcelain enamelled inside. The outside may be painted as desired. The following are the common sizes for ordinary bath tubs:—

| | |
|---|---|
| Length | 6′—0″ |
| Width | 2′—6″ |
| Height | 1′—11″ |

The bath tub is provided with a $1\frac{1}{2}$″ trap overflow and antisiphonic arrangements and connected to the waste and antisiphonic stacks on the outside wall. Waste water may be allowed to be discharged through overflow trap, if so desired. It is fitted with two chromium plated pillar taps and a chromium plated chain with a plug. Two control cocks of $1\frac{1}{2}$″ each are provided with every bath tub. The common types of cast iron rectangular bath tubs are 'magna' and tub pattern 'parallel'. These are adequately and evenly coated internally with porcelain enamel and painted externally with one priming coat of rapid drying paint.

The following are the principal dimensions of bath tubs:—

| | Magna<br>in. | Pattern rectangular<br>in. | Tub (parallel Pattern)<br>in. |
|---|---|---|---|
| Length overall .. | 66 | 72 | 60 |
| Width overall .. | 28 | 28 | 29 |
| Depth inside at waste .. | 17½ | 17½ | 17 |
| Height overall exclusive feet and waste | 18 | 18 | 17½ |
| Height overall with feet for 1½" Seal trap | 23 | 23 | 22½ |
| Height overall for 3" seal trap top holes (1⅜" in. Square) centred. | 24½ | 24½ | 24 |
| On roll-distance apart. .. | 7½ | 7½ | 7½ |
| Waste hole 2¼" clear diameter distance from edge of roll at tap and to centre of waste hole .. | 11¼ | 11¼ | 10 |
| Overflow centre distance below top edge | 4 | 4 | 3½ |
| Capacity .. | 20 galls. | 28 galls. | 27 galls. |

The overflow holes on rectangular baths are 4" from top of bath to centre and on tub baths 3½" from top to centre. Such holes are 1¾" in diameter and are intended for 1¼" overflows. A grating is fixed in the overflow hole and a brass bend 2¼" long from centre to tail is attached to it. The tail is screwed 1¼" out so that it can be connected to iron, copper or lead pipes. When overflow discharges directly through walls they should have light copper flaps at the outlet end to prevent draughts.

**Bath tub for hospitals**

Bath tubs for patients are of solid porcelain ware, or best quality enamelled iron with roll set as can stand everywhere entirely free from the walls. Each bath is supplied with hot and cold water taps with detachable handles or keys accessible only to the attendants. A combination nozzle suitable for attaching a rubber hose and hand spray, preferably one with anti-scale pattern valves, is supplied.

## SPECIFICATION

### No. 13.8 BATH TUBS

**Source**

1. Bath tubs shall be of an approved manufacture.

**Composition**

2. Bath tubs shall be made as ceramic ware in one piece of material as specified. Ordinary bath tubs shall be made of cast iron, porcelain enamelled from inside.

**Manufacture**

3. Each bath tub except that made of cast iron shall be fired at such a temperature as to produce a satisfactory fused clay.

**Quality**

4. Each bath tub shall show good workmanship without dents and faults. The surface and colour shall be uniform, non-corrigible, non-plumber ferrous, free from discolouration and imperfections.

**Colour**

5. Colour of the bath tub shall be as specified.

**Type**

6. The type of the bath tub shall be as specified.

**Size**

7. The size of the bath tub shall be as specified.

**Fittings**

8. Each bath tub shall be equipped with fittings as specified.

**Measurement**

9. The measurement of bath tubs shall be in numbers. The unit of measurement shall be unity.

**Rate**

10. The unit rate shall include the cost of bath tub, specified fittings, sorting, packing and delivery at Site of Work, to be defined in the Conditions of Contract.

## MISCELLANEOUS

1. **Bidet.** It is an appliance designed to facilitate cleansing of excretory organs. It is made as ceramic ware in one piece of any material which is impervious and corrosion resistant. Properly planned hot and cold water is supplied to the flushing rim and jet. The drop is usually a separate attachment and is connected to the waste pipe system.

2. **Drinking Fountain.** It is available either as a wall or pedestal mounting. It is used (a) to supply drinking water in jet form at a low velocity to enable the users to drink directly from the jet, or (b) to supply drinking water to the vessels. In either case the receiving bowl is made large enough to prevent a spillage. Stop valve is fitted to the fountain. It is made of a material which is durable, impervious and corrosion resistant.

3. **Bed pan washer.** It is an enclosed cabin with a steel door used for cleansing bed pans. It is manufactured of any material which is durable, impervious and corrosion resistant.

4. **Post mortem table.** It is made of glazed fire clay or any other material which is durable, impervious and corrosion resistant. It is fixed on a pedestal or pedestals, with raised edges, drain flutings falling to the outlet. It is connected to the waste drainage system and is provided with water supply and hand spray attachment.

5. **Shower.** The shower head consists of corrosion resistant, cast or fabricated sheet metal hoses having perforations or some other devices to break up the water into a fine spray. The devices are of adjustable type so as to vary the degrees of spray. Perforated tubes are also used instead of shower heads or in combination with them.

**Telephonic shower** has a length of flexible pipe attached to the shower head so that it can be comfortably moved during use.

6. **Grease trap.** It is an appliance arranged to retain grease until it solidifies and has special arrange-

ment for removal of solidified grease. It is made of glazed ware with easily removable bolted air tight cover. To facilitate removal of grease the trap is fitted with a loose perforated metal tray having a long handle.

7. **Floor trap.** It is used for taking the waste water of bath and kitchen to the gulley trap and check the inflow of foul gases into the bathroom and kitchen. It is made of cast iron and is of self-cleansing type provided with 1" puff pipe.

## SOIL PIPES

### INTRODUCTION

For fixing sanitary appliances in buildings, soil pipes and allied fittings are used for the effective working of the system.

### SPECIFICATIONS

#### No. 13.9 Cast Iron Soil Pipes

**Quality**

1. Cast iron soil pipes and fittings shall be truly cylindrical, of clear internal diameter as specified, of a uniform thickness, smooth and with strong and deep sockets, free from flaws, air bubbles, cracks, sand-holes and other defects. They shall not be brittle but shall allow for ready cutting, chipping or drilling.

**Standards**

2. When used underground, the thickness and weight of cast iron pipes shall not be less than those shown in the following table:—

| Internal Diameter | Thickness of metal not less than | Weight per 6 ft. length (including socket and beaded spigot or flanges, the socket not less than $\frac{3}{8}$" thick) not less than |
|---|---|---|
| 3" | 5/16" | 74 lbs. |
| 4" | 3/8" | 106 " |
| 5" | 3/8" | 127 " |
| 6" | 3/8" | 155 " |

When used above ground the thickness and weight of cast iron soil pipes shall not be less than shown in the following table:—

| Internal Diameter | Thickness of metal not less than | Weight per 6 ft. legnth (including socket and beaded spigot or flanges, the socket not less than $\frac{1}{4}$" thick) not less than |
|---|---|---|
| 3½" | 3/16" | 48 lbs. |
| 4" | 3/16" | 54 " |
| 5" | 1/4" | 69 " |
| 6" | 1/4" | 84 " |

**Treatment**

3. All cast iron pipes and fittings shall be treated with two coats of Angus Smiths composition or the Dower-Barft process or Macarlaine's glass enamel or other approved means of preventing oxidation before use.

**Type**

4. Cast Iron soil pipes shall be either spigotted and socketted or flanged at both ends as specified.

**Length**

5. Cast iron soil pipes shall be in 6 ft. long pieces including socket and beaded spigot or flanges at both ends.

**Plain Bend, Door Bend and plug junction**

6. For quality and treatment the specials shall conform to the corresponding specification of cast iron soil pipe. The size shall be as specified.

**Measurement**

7. The measurement of cast iron soil pipe, shall be in length. The unit of measurement shall be one foot.

**Rate**

8. The unit rate shall include the cost of pipe, spigot and socket or two flanges per piece length; sorting, packing and delivery at Site of Work, to be defined in the Conditions of Contract.

## LEAD SOIL PIPES

Lead soil pipes are used for short branch soil waste or vent connections.

## SPECIFICATIONS

### No. 13.10 Lead Soil Pipes

**Composition**

1. Lead pipe shall be manufactured from 99.9 per cent pure lead.

**Quality**

2. Lead pipe shall be of best quality drawn pipe and the weights per foot length of pipe for different diameters shall be as given below:—

| | |
|---|---|
| 1¼″ pipe | 2½ lbs per foot. |
| 1½″ pipe | 3 lbs per foot. |
| 2″ pipe | 5 lbs per foot. |
| 3″ pipe | 6 lbs per foot. |
| 3½″ pipe | 6.5 lbs per foot. |
| 4″ pipe | 7.4 lbs per foot. |
| 5″ pipe | 9.2 lbs per foot. |
| 6″ pipe | 11 lbs per foot. |

**Measurement**

3. The measurement of lead soil pipes shall be in lengths. The unit of measurement shall be one foot.

**Rate**

4. The unit rate shall include the cost of pipe, sorting, packing and delivery at Site of Work, to be defined in the Conditions of Contract.

## SPECIFICATIONS

## No. 13.11 LEAD CONNECTION

**Composition**

1. Lead connection shall be made from best quality drawn lead pipe.

**Requirement**

2. Lead connection shall have brass coupllings soldered with tin and lead at both ends. It shall be capable of withstanding water pressure with which it is to be used.

**Size**

3. The internal diameter of the lead connection pipe shall be ½". The length shall be either 9" or 12" as specified and it shall be so called.

**Standard**

4. The weight of lead connection pipe shall be 1 lb. per foot length.

**Test**

5. The lead connection pipe shall show no cracks when bent double.

**Measurement**

6. The measurement of lead connections shall be in numbers. The unit of measurement shall be unity.

**Rate**

7. The unit rate shall include the cost of the special lead pipe, brass couplings soldered with tin and lead; sorting, packing and delivery at Site of Work, to be defined in the Conditions of Contract.

## SPECIFICATIONS

## No. 13.12. PIPE SUPPORTS

**Composition**

1. Pipe supports shall be of galvanized iron.

**Size**

2. The size of the pipe support shall be as specified.

**Requirements**

3. Pipe support shall have expansion bolts for fixing to the wall, large screws for fixing to the wood work and pipe clamps for fixing to the girders. Metal stacks shall be used for supporting the vertical lead pipe.

**Type**

4. The type of the pipe support shall be as specified.

**Measurement**

5. The measurement of the pipe support shall be in numbers. The unit of measurement shall be one dozen.

**Rate**

6. The unit rate shall include the cost of pipe support, expansion bolts or screws or pipe clamps for the specified type; sorting packing and delivery at Site of Work to be defined in the Conditions of Contract.

# Pipes

## INTRODUCTION

Pipes are used for conveying drinking water, irrigation water and other liquids. These pipes are divided into two categories, mainly, Pressure pipes and Non-pressure pipes.

Pipes may be of Cast Iron, Galvanised Iron, Mild Steel, Wrought Iron, Concrete and Bitumen lime concrete, Steel Reinforced concrete, Plain concrete and Prestressed concrete, Asbestos cement, Stoneware, Vitrified clay and plastic.

The following are non-pressure pipes used for gravity conduits for water and sewage.

Concrete pipes, "A" class reinforced concrete pipes, vitrified clay and stoneware pipes and non-pressure Abstos cement pipes.

All the rest are pressure type pipes.

All pipes except reinforced concrete pipes and ductile cast iron pipes are classified into A, B, C and D classes according to the test pressure of 200', 400' and 800' of head of water respectively. In case of reinforced concrete pipes the classification is A, B, C and D for test pressure of 15', 75', 150' and 200', head of water respectively.

## A. CAST IRON PIPES AND SPECIALS

### (Except Ductile Cast Iron Pipes)

1. Cast iron pipes may be manufactured by any one of the following three processes:—

   (a) Centrifugal casting in metal moulds,
   (b) Centrifugal casting in sand moulds.
   (c) Vertical casting in sand moulds.

**Cast Iron Special Castings**

The specifications No. 14.2 are applicable to pipes and all special castings with sockets, spigots and flanges defined therein and to pipes and special castings with other types of joints, the general dimensions of which, except those relating to the joints, conform to the requirements of Specification No. 14.1. They are not applicable to the down pipes and their specials used in the building industry.

**Types of Joints**

Socket pipes and special castings for lead joints may be provided with a centring ring in the socket and in this case are supported with a plain spigot end. Alternatively, the sockets may be without centering ring, in which case the spigot ends could be plain or have a head integrally cast or formed by means of a permanent hoop shrunk on it.

Unless otherwise specified, flanges are machined on boss and their dimensions are in accordance with the relevant tables in Specification No. 14.1. Bolt holes may be drilled or cored.

When pipes and special castings are ordered with a joint of a type other than those mentioned, the dimensions and other characteristics of the joint and those applicable to that joint.

**Special Castings**

The special castings are of the thickness shown in the relevant tables except when the working

conditions necessitates some strengthening. The strengthening may be in the form of additional thickness, ribs, bolts, or other means proposed by the manufacturer and finally approved by the purchaser.

If necessary, the reinforcement of the thickness may be obtained by reducing the internal diameter.

**Joints**

The pipes are divided into two main classes as regards their joints, viz:—

(a) Spigot and socket, and
(b) Flanged.

Spigot and socket joints are of two kinds, namely,

(i) Rigid joints, and
(ii) Flexible rubber joints.

**(a) Spigot and Socket Jonits**

(i) **Rigid Joints.** They are available with Spun and vertically cast iron pipes of 2 ins. diameter and above for water, gas or sewage mains. They incorporate lead and yarn or cement caulking compound like PVC. 3 and hemp as the jointing medium. The lead is introduced into the jointing space in molten condition or as lead fibres.

(ii) **Flexible rubber Joints**

(a) **Tyton Joints.** They are Spun Iron Pipes of 2 ins. diameter and above for water and sewage mains. These pipes use an extremely simple "push-in" type of flexible joint with natural rubber gasket.

(b) **Screwed-Gland Flexible Joints.** They are available with Spun Iron Pipes of 2 ins. to 0 i s. diameter for water, gas or sewage mains, in which a lead tipped rubber sealing ring is compressed by a cast iron gland screwed into the socket.

(c) **Bolted-Gland Flexible Joints.** They are available with Spun and Vertically Cast Iron Pipes of 4 ins. diameter and above for water, gas or sewage mains, in which a lead tipped rubber sealing ring is compressed by means of a cast iron gland and a series of high duty cast iron bolts and nuts.

## DUCTILE CAST IRON PIPES

Ductile Cast Iron Pipes are used for higher pressure mains for a working pressure of from 350 lbs. per square inch up to 450 lbs. per square inch. The metal is produced by inoculating molten iron of suitable composition with magnesium resulting in a metal structure in which the graphite formation is spheroidal, or nodular, rather than in the form of graphite flakes obtained with the conventional grey irons. Ductile Iron for this reason is also known as 'spheroidal graphite iron' or 'nodular iron'.

Due to the changed graphitic formation, the characteristics of ductile iron differ from those of grey iron, in that ductile iron possesses the properties of higher mechanical strength and ductility without losing the high resistance to corrosion and good casting qualities inherent in grey iron.

Ductile iron pipe can, therefore offer:

(a) high tensile strength and ductility;
(b) carry high working pressures;
(c) resist severe impact without damage;
(d) retain sufficient rigidity to carry external loading without serious distortion;
(e) be produced with reduced thickness as compared with grey iron, resulting in reduced weight and increased carrying capacity; and
(f) offer resistance to corrosion equal to that of grey iron.

## B. GALVANISED IRON PIPES

Galvanised iron pipes are commonly used for water supply distribution lines (small) service and internal building water supply installations. These are made of iron and galvanised internally and externally.

## C. MILD STEEL PIPES

Mild Steel Pipes are used for water supply mains and branches in hilly areas as well as for tubewell casing. They are made of mild steel and their principal types are classified according to their jointing methods. The following are their principal varieties.

(1) Socketted threaded pipes.
(2) Victaulic patent coupling joints.
(3) Male and female threaded joints.
(4) Continuous welded joints.
(5) Flanged steel pipes.
(6) Rivetted pipes made from mild steel plates.

## CAST IRON AND STEEL PIPES WITH CEMENT LINING

These pipes are used where scaling is expected on iron pipes. They are made of cast iron and steel with a lining of cement mortar in thickness as specified inside and/or outside the pipe. The lining is applied centrifugally. The length ranges from 12 to 18 feet.

## ASBESTOS CEMENT PRESSURE PIPES

These pipes are used in water supply and distribution systems. Their size varies from 50 mm to 1000 mm diameter according to the International Standard Specifications I.S.O. R-160 and B.S.S. 480. They consist solely of cement and Asbestos. These pipes have long life and resist destructive influence except breakage in transit and handling. They are not affected by electric currents and have the further advantage of small drop in pressure. The following is the method of their manufacture.

A thin film of specially prepared Asbestos cement is fed to the rotating mandrel and successive layers firmly consolidated by application of closely controlled hydraulic pressure over the whole length of the pipe. When the required wall thickness has been obtained the pipe is withdrawn from the mandrel leaving a smooth and highly polished bore. Special precautions are taken to maintain perfect circularity of bore until the pipe has set hard.

The pipe is then matured for seven days by total immersion in water tank; afterwards it is trimmed to length and turned at the ends to accurate limits to ensure correct fitting of the joints. After a period of maturity and bitumen immersion, if specified, the pipe is ready for use.

There are two kinds of asbestos cement pipes, namely, those with collar and rubber rings joint and those with collar sleeve, rubber rings pressed together by tightening bolts (Gibault joint). These joints are as resistant to corrosion as the pipe itself and are flexible enough to permit as much as 12° detection in laying pipe around curves.

## PRESTRESSED CONCRETE PIPES

Prestressed concrete pipes are used for water supply mains. These are manufactured in external diameters of 4 ins. to 72 ins, and in lengths of from 6 ft. to 15 ft.

There are two main types of these pipes, viz., (i) those with steel core, and (ii) those without steel core.

The method of manufacture of steel core pipe is given below.

A continuous arc welded steel cylinder is formed from the steel sheet and together with socket and spigot it is subjected to a hydraulic test. The method of testing is such that the water is in contact at all points with the welds. The water pressure is raised to produce a fibre stress in the cylinder of an approximately 2000 lbs per sq. inch. The test is considered satisfactory if no leakage or other defects are visible.

The concrete core below the steel cylinder is then applied centrifugally (spun) by correct control of machine and suitable vibration so as to produce a dense and uniform thickness of concrete free from voids. Prestressing is carried out when the Concrete core in the steel cylinder has reached sufficient strength to withstand the stress induced by initial prestressing operation. The circumferential prestressing of steel cylinder with concrete core is then carried out on a suitably designed machine which is capable of regulating and controlling tension so as to impart the desired stresses in the prestressing.

In non-steel core pipes a cage of longitudinal M. S. bars is fixed in a mandrel and concrete of specified proportions is fed to the rotating mandrel under closely controlled pressure. This forms the concrete core. The concrete core is taken out and prestressing is done, as in the case of steel core pipes.

## SPECIFICATIONS

### No. 14.1 Cast Iron (Grey) Pipes

**Quality of metal used**

1. The metal used for the manufacture of pipes and special castings shall be of good quality. It shall be prepared at the discretion of the manufacturer in a cupola, an active mixer, or other suitable furnace, and made from pig iron or molten iron or good iron and steel scrap with additions of good quality materials suited to the production method, excluding any raw material of inferior quality. Upon fracture the iron shall show a grey, close and uniform grain.

**Quality of pipes and special castings**

2. Pipes and special castings shall be stripped with all precautions necessary to avoid warping or shrinkage defects detrimental to their good quality.

The pipes and special castings shall be sound and free from surface or other defects.

Repairing of defects by soldering or by the application of putty shall not be done without previously securing the consent of the purchaser or his representative. This stipulation also applies to the plugging of leaks of caulking.

Pipes and special castings showing small imperfections inseparable from the method of manufacture and not affecting their use shall not be rejected.

The pipes and special castings shall be such that they can be cut, drilled or machined: in case of dispute the castings are considered as acceptable provided the hardness, measured at the centre of the thickness, does not exceed the Brinell number 215. The superficial hardness of pipes centrifugally cast in metal moulds shall not exceed the Brinell number 230 (for hardness test).

**Tolerances in the external diameter of the Barrel, the internal diameter of the socket and the depth of the socket.**

3. The socket tolerances are as follows:—

(where 'DN' is the nominal diameter of the pipes and special castings in millimetres (f) is the caulking space of the joint in millimetres and equal to f=9+0.005 DN)

| Dimension | Nominal Diameter | Tolerance in mm |
|---|---|---|
| External diameter of barrel DE | All diameters | $\pm\frac{1}{2}f = \pm(4.5+0.0015\ DN)$ |
| Internal diameter of socket DI | All diameters | $\pm\frac{1}{2}f = \pm(3+0.001DN)$ |
| Depth of socket P | Up to and including No. 600 | ±5 |
| | Over No. 600 and up to and including 1000 | ±10 |

The maximum or minimum jointing space resulting from these tolerances shall be such that the jointing of the pipes and special casting is not adversely affected.

**Tolerances on thickness**

4. The tolerances on the wall thickness and flange thickness are limited as follows, where 'e' is the standard thickness of the wall in millimetres and 'b' is the standard thickness of the flange in millimetres:—

| Type of casting | Dimension | Tolerance in mm. |
|---|---|---|
| Pipes | Wall thickness | $-(1+0.05\ e)$* |
| | Flange thickness | $\pm(2+0.05\ b)$* |
| Special castings | Wall thickness | $-(2+0.05\ e)$ |
| | Flange thickness | $\pm(3+0.95\ b)$ |

*No. limit for the plus tolerances has been set for thickness. The limit of tolerance by weight is indicated in clause 7 below.

The thickness of special castings may exceptionally be reduced to not less than the minimum thickness of class B pipes of the same diameter provided that the area of the affected part is not more than 1/10th of the cross-sectional area of the bore.

**Tolerance on Length**

5. The tolerances of normally manufactured lengths of pipes and special castings are as follows:—

| Type of casting | Nominal Diameter | Tolerance in mm. |
|---|---|---|
| Socket and spigot and plain ended pipes | All diameters | $\pm 20$ |
| Socket special castings, flange and spigot pieces | Up to and including No. 450 | $\pm 20$ |
| | Over No. 450 | $+20$<br>$-30$ |
| Flanged pipes and flanged special castings | All diameters | $\pm 10$ |

Should smaller tolerances be demanded, for example, in the case of flanged closing pieces, they are specially fixed, but the minimum tolerance may not be less than $\pm 1$ mm.

Of the total number of socket and spigot pipes to be supplied in each diameter, the manufacturer may supply up to 10 per cent in lengths shorter than specified as follows:—

| Specified length | Decrease in length | | | |
|---|---|---|---|---|
| 4.m. | 0.5m. | 1m. | — | — |
| Over 4m. | 0.5m. | 1m. | 1.5m. | 2m. |

Permissible deviation from the straight lines.

6. The pipes shall be straight. When rolled along two gantries separated by approximately two-third the length of the pipe to be checked, the maxium deviation fm, in millimetres, shall not be greater than 1.25 times the length in metres of this pipe, thus $fm=1.25\%$.

**Tolerances on weight**

7. The standard weights shall be those shown in the attached tables or, for inforced or non-standard special castings, those calculated by taking the specific weight of cast iron as 7.15 kg/dm$^3$.

The tolerances on standard weight shall be as follows:—

| Type of casting | Tolerance |
|---|---|
| Pipes | ±5% |
| Special castings excepted as stated below | ±8% |
| Bends, special castings with more than one branch and non-standard special castings | ±12% |

Note. Castings of a heavier weight than the maximum shall be accepted provided they comply in every other respect with the requirements of this recommendation.

**Mechanical Tests**

8. (a) For pipes centrifugally cast in metal moulds tests shall be made:—

(i) On rings for pipes up to and including the nominal diameter No. 300 and

(ii) On tensile bars for pipes over the nominal diameter No. 300. The rings and bars shall be cut from spigot end of the pipes.

(b) For pipes centrifugally cast in sand moulds.

Tensile tests shall be made on bars for pipes of all nominal diameter. The bars shall be cut from the spigot end of the pipes.

(c) For pipes vertically cast in sand moulds and special castings.

Tensile tests shall be made for pipes and special castings of all nominal diameters on bars cast from the same metal as is used in the castings.

(d) Rings tests for pipes centrifugally cast in metal moulds.

Rings of approximately 25mm width shall be tested on a suitable machine. The rings shall be supported on two knife edges diametrically opposed and the load shall be applied from the inside at these points. The bending strength modulus of the ring is calculated from the breaking load by the following formula:—

$$R = \frac{3P\ (D-e)}{b\ e^2}$$

Where R = Bending strength modulus of the ring in kg/mm$^2$;
P = Breaking load in kilograms;
D = External diameter of ring in millimetres;
e = Thickness of the wall of the ring in millimetres;
b = Breadth of ring in millimetre.

Test on bars for pipes centrifugally cast in metal or sand moulds.

The tensile test bars cut from the pipes shall be about 90 mm. long and have a diameter of about 6 mm. which dimension may vary with the thickness of the pipe. The ends shall be prepared so as to fit the testing machine.

(e) Test on bars for pipes vertically cast in sand moulds and special castings.

The tensile test bars shall be properly moulded and shall be free from defects and are either unmachined or machined to give a diameter of about 20 mm. to 25 mm. The ends shall be selected by the manufacturer to fit the testing machine.

**Testing results**

9. The mechanical tests shall be carried out during manufacture and at the most twice per day of casting. The results obtained shall be representative of all pipes and special castings of all diameters made during the day.

The manufacturer shall be allowed to take three test pieces from the same pipe or during the same run of metal, of which at least two test pieces satisfy the following requirements:—

| Type of casting | Nominal diameter | Type of Test | Minimum Resistance in kg/mm. |
|---|---|---|---|
| Pipes centrifugally cast in metal moulds | Up to and including No. 300 | Deflection on ring | modulus 40 |
| | Over No. 300 and up to and including No. 600 | Tensile on machined test bar | 20 |
| | Over No. 600 | Tensile on machined test bar | 18 |
| Pipes centrifugally cast in sand moulds | Up to and including No. 600 | Tensile on machined test bar | 18 |
| | Over No. 600 | Tensile on machined test bar | 18 |
| Pipes vertically cast in sand moulds and special castings | All diameters | Tensile on cast iron bar | 14 |

Note. The manufacturer and the purchaser may agree to replace the tensile test on machine test bar by a quicker test on ring. The purchaser shall determine the test conditions.

All pipes from which the rings or bars have been cut shall be accepted by the purchaser as complete lengths.

**Brinell Hardness Test**

10. For the checking of the hardness limits, specified in clause 2, Brinel tests shall be carried out on the test rings or bars cut from the pipes and used for the previous tests.

The test shall consist of applying either a load of 3,000 kg. to a ball of 10 mm. diameter for 15 seconds, or a load of 750 kg. to a ball of 5 mm. diameter for 10 sceconds.

**Hydraulic tests**

11. Hydraulic tests shall be carried out in accordance with the following tables:

(a) Centrifugally cast socket and spigot pipes

| Nominal Diameter | Test Pressure in kg/cm² | | |
|---|---|---|---|
| | Class LA | Class A | Class B |
| Up to and including No. 600 | 20 | 25 | 30 |
| Over No. 600 | 15 | 20 | 25 |

(b) Vertically cast pipes

| Nominal Diameter | Test Pressure in kg/cm² | |
|---|---|---|
| | Class A | Class B |
| Up to and including No. 600 | 20 | 25 |
| Over No. 600 | 15 | 20 |

(c) Other pipes and special castings

| Type of Casting | Nominal Diameter | Test pressure in kg/cm² |
|---|---|---|
| Flanged pipes | Up to and including No. 300 | 25 |
| Special castings | Over No. 300 and up to and including No. 600 | 20 |
| Flanged pipes, special castings without branches not greater than half the Principal diameter | Over No. 600 and up to and including No. 1,000 | 15 |
| Special castings with branches greater than half the principal diameter | Over No. 600 and up to and including No. 1,000 | 10 |

Note.—Where pipes or special castings are required for higher test pressures, they are specially considered.

To perform the hydraulic test, the pipes shall be kept under pressure for 15 seconds; they may be struck moderately with a 700 g. hammer and they must withstand the pressure test without showing any leakage, sweating or other defect of any kind.

Wherever practice permits, the hydraulic test shall be applied before coating.

**Coating**

12. Except when otherwise specified, all pipes and special casting shall be coated inside and outside. The coating shall set rapidly with good adherence and not scale off.

The inside coating shall not contain any constituent soluble in water or any ingredient liable to impart any taste or smell whatsoever to the water, after suitable washing out of the main.

**Thickness and weights**

13. For vertically cast iron pipes it shall be as per table TI and T2 14.1 and for spun cast iron pipes as per table T3-14.1.

**Joints**

14. The ends of the pipes shall be provided with spigot and socket for flanges with jointing material as specified by the manufacturers.

**Jointing Material**

15. The jointing material shall be:—

(a) Socket and Spigot pipes-lead, PVC3 (cold caulking compound of cement, hemp, etc.) or cement mortar as specified.

(b) Flexible rubber rings as specified by manufacturer.

(c) 1/8″ rubber insertion bolts and nuts as specified for flanged joints.

(d) Rubber ring of section as specified by manufacturers of pipes, gland, bolts and nuts for mechanical joints.

**Rubber ring**

15.—A. The rubber shall be of wild or plantation type with extracts not exceeding 3.5 per cent by weight. The ring shall be separately vulcanised in moulds, the surface being of plain finish, smooth and free from air mark or any other blemish. The ring shall be tested for permanence, hardness and water absorption and ageing by the manufacturer, according to British Standard Specification No. 486.

**Lengths**

16. The measurements of pipes shall be in lengths measured from the shoulder of the socket to the end of the Spigot or the flange or between the faces of the flanges.

**Rates**

17. The unit rate shall include the cost of pipe with spigot and socket or flanges, rubber rings (if any) in pipe length; sorting, packing and delivery at Site of Work to be specified in the Condition of the Contract.

## TABLE TI (14.1)

## SOCKET AND SPIGOT VERTICALLY CAST IRON PIPES AND SPECIALS

**Standard Thicknesses and External Diameters**

| National Internal Diameter | Classes 'A' and 'B' Straight and Class 'AB' fittings | | | | | | Classes 'C' and 'D' Straight Pipes and Class 'CD' fittings | | | | | | National Internal Diameter. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Thickness | | | | External Dia. of Barrel | Internal Dia. of Socket | Thickness | | | | External Dia. of Barrel | Internal Dia. of Socket | |
| | Class 'A' Straight Pipes T1 | Class 'B' Straight Pipes T1 | Class 'AB' fittings | | | | Class 'C' Straight Pipes T1 | Class 'D' Straight Pipes T1 | Class 'CD' | | | | |
| | | | T1 | T3 | | | | | T1 | T3 | | | |
| In. | In. | In. | In. | In. | In. | In. | In. | In. | In. | In. | In. | In. | In. |
| 2 | .36 | .36 | .36 | .55 | 2.72 | 3.48 | .36 | .36 | .36 | .55 | 2.72 | 3.48 | 2 |
| 3 | .38 | .38 | .38 | .57 | 3.76 | 4.52 | .38 | .40 | .40 | .59 | 3.76 | 4.52 | 3 |
| 4 | .39 | .39 | .39 | .58 | 4.80 | 5.56 | .40 | .46 | .46 | .65 | 4.80 | 5.57 | 4 |
| 5 | .41 | .41 | .41 | .60 | 5.90 | 6.66 | .45 | .52 | .52 | .71 | 5.90 | 6.66 | 5 |
| 6 | .43 | .43 | .43 | .62 | 6.98 | 7.74 | .49 | .57 | .57 | .76 | 6.98 | 7.74 | 6 |
| 7 | .45 | .45 | .45 | .64 | 8.06 | 8.82 | .53 | .61 | .61 | .80 | 8.06 | 8.82 | 7 |
| 8 | .47 | .47 | .47 | .66 | 9.14 | 9.90 | .57 | .65 | .65 | .84 | 9.14 | 9.90 | 8 |
| 9 | .49 | .49 | .49 | .68 | 10.20 | 10.96 | .60 | .69 | .69 | .88 | 10.20 | 10.96 | 9 |
| 10 | .52 | .52 | .52 | .71 | 11.26 | 12.02 | .63 | .73 | .73 | .92 | 11.26 | 12.02 | 10 |
| 12 | .55 | .57 | .57 | .76 | 13.14 | 13.90 | .69 | .80 | .80 | .99 | 13.60 | 14.36 | 12 |
| 14 | .57 | .61 | .61 | .80 | 15.22 | 15.98 | .75 | .86 | .86 | 1.05 | 15.72 | 16.42 | 14 |
| 15 | .59 | .63 | .63 | .82 | 16.26 | 17.02 | .77 | .89 | .89 | 1.08 | 16.78 | 17.54 | 15 |
| 16 | .60 | .65 | .65 | .84 | 17.30 | 18.06 | .80 | .92 | .92 | 1.11 | 17.84 | 18.60 | 16 |
| 18 | .63 | .69 | .69 | .88 | 19.38 | 20.26 | .85 | .98 | .98 | 1.17 | 19.96 | 20.84 | 18 |
| 20 | .65 | .73 | .73 | .92 | 21.46 | 22.34 | .89 | 1.03 | 1.03 | 1.22 | 22.06 | 22.94 | 20 |
| 21 | .67 | .75 | .75 | .94 | 22.50 | 23.38 | .92 | 1.06 | 1.06 | 1.25 | 23.12 | 24.00 | 21 |
| 22 | .68 | .77 | .77 | .96 | 23.54 | 24.42 | .94 | 1.08 | 1.08 | 1.27 | 24.16 | 25.04 | 22 |
| 24 | .71 | .80 | .80 | .99 | 25.60 | 26.48 | .98 | 1.13 | 1.13 | 1.32 | 26.26 | 27.14 | 24 |
| 26 | .74 | .83 | .83 | 1.02 | 27.66 | 28.54 | 1.02 | 1.18 | 1.18 | 1.37 | 28.36 | 29.24 | 26 |
| 27 | .75 | .85 | .85 | 1.04 | 28.70 | 29.58 | 1.04 | 1.20 | 1.20 | 1.38 | 29.40 | 30.28 | 27 |
| 28 | .76 | .86 | .86 | 1.05 | 29.72 | 30.60 | 1.06 | 1.22 | 1.22 | 1.41 | 30.44 | 31.32 | 28 |
| 30 | .79 | .89 | .89 | 1.08 | 31.78 | 32.66 | 1.09 | 1.26 | 1.26 | 1.45 | 32.52 | 33.40 | 30 |
| 32 | .82 | .92 | .92 | 1.11 | 33.84 | 34.72 | 1.13 | 1.31 | 1.31 | 1.50 | 34.62 | 35.50 | 32 |
| 33 | .83 | .94 | .94 | 1.13 | 34.88 | 35.76 | 1.15 | 1 33 | 1.33 | 1.52 | 35.66 | 36.54 | 33 |
| 36 | .87 | .98 | .98 | 1.17 | 37.96 | 38.84 | 1.20 | 1.38 | 1.38 | 1.57 | 38.76 | 39.64 | 36 |
| 38 | .90 | 1.01 | 1.01 | 1.20 | 40.02 | 40.90 | 1.23 | 1.42 | 1.42 | 1.61 | 40.84 | 41.72 | 38 |
| 39 | .91 | 1.02 | 1.02 | 1.38 | 41.04 | 41.92 | 1.25 | 1.44 | 1.44 | 1.63 | 41.88 | 42.76 | 39 |
| 40 | .92 | 1.03 | 1.03 | 1.22 | 42.06 | 42.94 | 1.26 | 1.46 | 1.46 | 1.65 | 42.92 | 43.80 | 40 |
| 42 | .95 | 1.06 | 1.06 | 1.25 | 44.12 | 39.00 | 1.30 | 1.50 | 1.50 | 1.69 | 39.00 | 39.88 | 42 |
| 44 | .98 | 1.08 | 1.08 | 1.27 | 46.16 | 47.04 | 1.33 | 1.53 | 1.53 | 1.72 | 47.06 | 47.94 | 44 |
| 45 | .99 | 1.09 | 1.09 | 1.29 | 47.18 | 48.06 | 1.35 | 1.55 | 1.55 | 1.74 | 48.10 | 48.98 | 45 |
| 46 | 1.00 | 1.11 | 1.11 | 1.30 | 48.22 | 49.10 | 1.36 | 1.57 | 1.57 | 1.76 | 49.14 | 50.02 | 46 |
| 48 | 1.03 | 1.13 | 1.13 | 1.32 | 50.26 | 51.14 | 1.38 | 1.60 | 1.60 | 1.79 | 51.20 | 52.08 | 48 |

These dimensions are subject to the Deviation Clauses as specified in B.S. 78: 1938.
Class 'A' Straight Pipes tested 200 feet head.
" 'B' " " " 400 " "
" 'AB' fittings tested 400 feet head.

These dimensions are subject to the Deviation Clauses as specified in B.S. 78: 1938.
Class 'C' Straight Pipes tested 600 feet head.
" 'D' " " " 800 " "
" 'CD' fittings tested 800 head.

## TABLE T2 (14.1)

## SOCKET AND SPIGOT VERTICALLY CAST IRON PIPES

### (B. S. 78 1938)

**Table of Lengths, Thicknesses and Weights of Pipes suitable for Various Test Pressures**

| Nominal Internal Diameter. | Length | Class 'A' Test Pressure, 200 Feet Head | | Class 'B' Test Pressures, 400 Feet Head | | Class 'C' Test Pressure, 600 Feet Head | | Class 'D' Test Pressure, 800 Feet Head | |
|---|---|---|---|---|---|---|---|---|---|
| | | Thickness | Weight | Thickness | Weight | Thickness | Weight | Thickness | Weight |
| In. | Ft. | In. | Lb. | In. | Lb. | In. | Lb. | In. | Lb. |
| 3 | 9 | .38 | 129 | .38 | 129 | .38 | 129 | .40 | 134 |
| 4 | 9 | .39 | 171 | .39 | 171 | .40 | 174 | .46 | 195 |
| 4 | 12 | .39 | 221 | .39 | 221 | .40 | 226 | .46 | 253 |
| 5 | 9 | .41 | 222 | .41 | 222 | .45 | 239 | .52 | 269 |
| 5 | 12 | .41 | 286 | .41 | 286 | .45 | 310 | .52 | 349 |
| 6 | 9 | .43 | 276 | .43 | 276 | .49 | 307 | .57 | 348 |
| 6 | 12 | .43 | 357 | .43 | 357 | .49 | 399 | .57 | 453 |
| 7 | 9 | .45 | 334 | .45 | 334 | .53 | 383 | .61 | 431 |
| 7 | 12 | .45 | 433 | .45 | 433 | .53 | 498 | .61 | 562 |
| 8 | 9 | .47 | 403 | .47 | 403 | .57 | 473 | .65 | 528 |
| 8 | 12 | .47 | 520 | .47 | 520 | .57 | 614 | .65 | 687 |
| 9 | 9 | .49 | 468 | .49 | 468 | .60 | 555 | .69 | 624 |
| 9 | 12 | .49 | 605 | .49 | 605 | .60 | 721 | .69 | 813 |
| 10 | 9 | .52 | 546 | .52 | 546 | .63 | 642 | .73 | 728 |
| 10 | 12 | .52 | 707 | .52 | 707 | .63 | 835 | .73 | 950 |
| 12 | 9 | .55 | 677 | .57 | 697 | .69 | 868 | .80 | 984 |
| 12 | 12 | .55 | 876 | .57 | 904 | .69 | 1125 | .80 | 1279 |
| 14 | 12 | .57 | 1066 | .61 | 1131 | .75 | 1425 | .86 | 1604 |
| 15 | 12 | .59 | 1179 | .63 | 1248 | .77 | 1563 | .89 | 1773 |
| 16 | 12 | .60 | 1278 | .65 | 1371 | .80 | 1727 | .92 | 1950 |
| 18 | 12 | .63 | 1505 | .69 | 1629 | .85 | 2056 | .98 | 2328 |
| 20 | 12 | .65 | 1722 | .73 | 1907 | .89 | 2382 | 1.03 | 2707 |
| 21 | 12 | .67 | 1860 | .75 | 2055 | .92 | 2580 | 1.06 | 2921 |
| 22 | 12 | .68 | 1995 | .77 | 2224 | .94 | 2775 | 1.08 | 3132 |
| 24 | 12 | .71 | 2266 | .80 | 2516 | .98 | 3147 | 1.13 | 3565 |
| 26 | 12 | .74 | 2550 | .83 | 2821 | 1.02 | 3545 | 1.18 | 4028 |
| 27 | 12 | .75 | 2682 | .85 | 2995 | 1.04 | 3747 | 1.20 | 4247 |
| 28 | 12 | .76 | 2817 | .86 | 3141 | 1.06 | 3954 | 1.22 | 4474 |
| 30 | 12 | .79 | 3132 | .89 | 3480 | 1.09 | 4346 | 1.26 | 4938 |
| 32 | 12 | .82 | 3460 | .92 | 3831 | 1.13 | 4801 | 1.31 | 5469 |
| 33 | 12 | .83 | 3614 | .94 | 4034 | 1.15 | 5034 | 1.33 | 5723 |
| 36 | 12 | .87 | 4123 | .98 | 4582 | 1.20 | 5715 | 1.38 | 6466 |
| 38 | 12 | .90 | 4493 | 1.01 | 4977 | 1.23 | 6175 | 1.42 | 7012 |
| 39 | 12 | .91 | 4659 | 1.02 | 5156 | 1.25 | 6439 | 1.44 | 7298 |
| 40 | 12 | .92 | 4830 | 1.03 | 5339 | 1.26 | 6654 | 1.46 | 7581 |
| 42 | 12 | .95 | 5229 | 1.06 | 5764 | 1.30 | 7201 | 1.50 | 8174 |
| 44 | 12 | .98 | 5644 | 1.08 | 6153 | 1.33 | 7712 | 1.53 | 8732 |
| 45 | 12 | .99 | 5831 | 1.09 | 6351 | 1.35 | 8003 | 1.55 | 9045 |
| 46 | 12 | 1.00 | 6022 | 1.11 | 6607 | 1.36 | 8245 | 1.57 | 9365 |
| 48 | 12 | 1.03 | 6466 | 1.13 | 7021 | 1.38 | 8730 | 1.60 | 9954 |

## TABLE T3 (14.1)

## DIMENSIONS AND WEIGHTS OF SPUN IRON PIPES

These pipes conform to B. S. 1211:1959 except for the sizes marked which are not included in this Standard.

Class 'E' Hydraulically tested at works to 500 lbs/sq. inch.
The maximum hydraulic test pressure after installation—400 ft. head.

| Nom Int Dia | Thickness | Outside Diameter | Weight | | | |
|---|---|---|---|---|---|---|
| | | | 3 meters long (9 ft. 10 in). | 4 meters long (13 ft. 1½ in.) | 12 ft. long | 18 ft. long |
| In. | In. | In. | Lb. | Lb. | Lb. | Lb. |
| 2 | .26 | 2.72 | 70 | — | — | — |
| 2½ | .27 | 3.24 | — | 112 | — | — |
| 3 | .29 | 3.76 | — | 142 | — | — |
| 4 | .30 | 4.80 | — | — | — | 190 |
| 5 | .31 | 5.90 | — | — | 224 | 324 |
| 6 | .33 | 6.98 | — | — | 283 | 410 |
| 7 | .34 | 8.06 | — | — | 339 | 491 |
| 8 | .36 | 9.14 | — | — | 408 | 591 |
| 9 | .37 | 10.20 | — | — | 472 | 683 |
| 10 | .39 | 11.26 | — | — | 549 | 794 |
| 12 | .43 | 13.14 | — | — | 702 | 1018 |
| 14 | .46 | 15.22 | — | — | 878 | 1272 |
| 15 | .47 | 16.26 | — | — | 960 | 1389 |
| 16 | .49 | 17.30 | — | — | 1063 | 1540 |
| 18 | .52 | 19.38 | — | — | 1266 | 1834 |
| 20 | .55 | 21.46 | — | — | — | 2146 |
| 21 | .56 | 22.50 | — | — | — | 2292 |
| 24 | .60 | 25.60 | — | — | — | 2816 |
| 27 | .68 | 28.70 | — | — | — | 3591 |

## TABLE 4 (14.1)

Class 'C' Hydraulically tested at works to 500 lb/sq. inch.
The maximum hydraulic test pressure after installation-600 ft. head

| Nom Int Dia | Thickness | Outside Diameter | Weight | | | |
|---|---|---|---|---|---|---|
| | | | 3 meters long. (9 ft. 10 in). | 4 meters long. (13 ft.1½ in). | 12 ft long | 18 ft long |
| In. | In. | In. | Lb. | Lb. | Lb. | Lb. |
| 2 | .26 | 2.72 | 70 | — | — | — |
| 2½ | .27 | 3.24 | — | 112 | — | — |
| 3 | .29 | 3.76 | — | 142 | — | — |
| 4 | .31 | 4.80 | — | — | 181 | 262 |
| 5 | .34 | 5.90 | — | — | 242 | 351 |
| 6 | .37 | 6.98 | — | — | 312 | 454 |
| 7 | .40 | 8.06 | — | — | 390 | 567 |
| 8 | .43 | 9.14 | — | — | 476 | 693 |
| 9 | .45 | 10.20 | — | — | 559 | 913 |
| 10 | .47 | 11.26 | — | — | 645 | 939 |
| 12 | .52 | 13.60 | — | — | 868 | 1262 |
| 14 | .56 | 15.72 | — | — | 1090 | 1582 |
| 16 | .58 | 16.78 | — | — | 1206 | 1750 |
| 16 | .60 | 17.84 | — | — | 1324 | 1923 |
| 18 | .64 | 19.96 | — | — | 1584 | 2300 |
| 20 | .67 | 22.06 | — | — | — | 2661 |
| 21 | .69 | 23.12 | — | — | | 2871 |
| 24 | .74 | 26.26 | — | — | — | 3523 |
| 27 | .83 | 29.40 | — | — | — | 4445 |

## TABLE 5 (14.1)

Class 'D' Hydraulically tested at works to 500/lbs/sq. inch.

The Maximum hydraulic test pressure after installation 800 ft. head

| Nom Int Dia | Thickness | Outside Diameter | Weight | | | |
|---|---|---|---|---|---|---|
| | | | 3 meters long. (9 ft.10 in). | 4 meters long. (13 ft.1½ in). | 12 ft. long | 18 ft. long |
| In. | In. | In. | Lb. | Lb. | Lb. | Lb. |
| 2 | .26 | 2.72 | 70 | — | — | — |
| 2½ | .27 | 3.24 | — | 112 | — | — |
| 3 | .30 | 3.76 | — | 145 | — | 195 |
| 4 | .35 | 4.80 | — | — | 200 | 291 |
| 5 | .39 | 5.92 | — | — | 272 | 396 |
| 6 | .43 | 6.98 | — | — | 355 | 518 |
| 7 | .46 | 8.06 | — | — | 440 | 642 |
| 8 | .49 | 9.14 | — | — | 533 | 778 |
| 9 | .52 | 10.20 | — | — | 634 | 925 |
| 10 | .55 | 11.26 | — | — | 740 | 1081 |
| 12 | .60 | 13.60 | — | — | 983 | 1435 |
| 14 | .65 | 15.72 | — | — | 1241 | 1809 |
| 15 | .67 | 16.78 | — | — | 1368 | 1993 |
| 16 | .69 | 17.83 | — | — | 1496 | 2182 |
| 18 | .74 | 19.96 | — | — | 1799 | 2623 |
| 20 | .77 | 22.06 | — | — | — | 3019 |
| 21 | .80 | 23.12 | — | — | — | 3284 |
| 24 | .85 | 26.26 | — | — | — | 3949 |
| 27 | .96 | 29.40 | — | — | — | 5068 |

## SPECIFICATIONS

### No. 14.1—A. Ductile Cast Iron Pipe

**Metal**

1. The metal employed shall be low phosphorous cast iron alloying with a small significant quantity of magnesium.

**Dimensions**

2. The dimensions of the pipes shall conform generally to those specified in British Standard Specification No. 1211: 1958 for Spun Iron Pipes, except in regard to thickness and a special allowance concerning length (see clauses 3 and 8 below).

**Thickness**

3. The thickness of Ductile Spun Iron Pipes shall be 70% of that specified for the corresponding diameter of class 'B' Spun Iron Pipe in British Standard Specification No. 1211:1958, vide table 'T' 14.1—A. The tolerance on thickness shall be as given in B. S. S. 1211.

**TABLE T 14.1-A**

| Nominal Internal Diameter | Thickness | Outside Diameter | WEIGHT | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 12 ft. long | | | 18 ft. long | | |
| Inches | Inches | Inches | cwt. | qts. | lbs. | cwt. | qts. | lbs. |
| 4 | .21 | 4.80 | 1 | 0 | 22 | 1 | 2 | 21 |
| 5 | .22 | 5.90 | 1 | 2 | 4 | 2 | 0 | 20 |
| 6 | .23 | 6.98 | 1 | 3 | 21 | 2 | 2 | 27 |
| 7 | .24 | 8.06 | 2 | 1 | 6 | 3 | 1 | 3 |
| 8 | .25 | 9.14 | 2 | 2 | 24 | 3 | 3 | 12 |
| 9 | .26 | 10.20 | 3 | 0 | 14 | 4 | 1 | 24 |
| 10 | .27 | 11.26 | 3 | 2 | 10 | 5 | 0 | 13 |
| 12 | .30 | 13.14 | 4 | 3 | 2 | 6 | 3 | 1 |

**Hydraulic Testing**

4. Each pipe shall be hydraulically tested at the manufacturers works as follows:—

| Diameter | Works Test Pressure |
|---|---|
| Up to and including 12 ins. | 900 lbs/in$^2$ |
| Over 12 ins. up to and including 24 ins. | 750 lbs/in$^2$ |

5. Where the pipes are intended for water mains, the works test pressure shall be at least 1½ time the intended working pressure; in special cases this may call for an increase in the works test pressure tabulated above. The works hydraulic test pressure for Ductile Iron Fittings shall be at least 1½ times the working pressure or 400 lbs. per square inch, whichever is the greater.

6. Ductile Iron Fittings for use in gas mains shall be works tested with air at a pressure of 50 lbs/in$^2$.

**Physical Properties**

7. (i) Ductile Spun Iron Pipes. Tensile and elongation tests shall be made on bars cut from pipes and the results of such tests conform to the following requirements, Ultimate tensile strength not less than 27 tons/in$^2$., Elongation not less than 8 per cent.

(ii) Ductile Iron fittings. Tensile and elongation tests shall be made on bars cast separately but from the same iron as used in the castings. To fulfil test requirement the Ultimate tensil strength shall not be less than 27 tons/in$^2$. and Elongation not less than 5 per cent.

**Length**

8. Ductile Spun Iron Pipes shall be made in 18 ft. and 12 ft. lengths. Up to 25 per cent of the pipes supplied to any one order may be 4 in. shorter than the standard length to provide for the physical test pieces which are taken for control purposes.

**Joints**

9. Ductile Iron Pipes and fittings shall be available with Tyton or Bolted-Gland joints. These pipes shall have either bolted gland joints or tightening joints. The joining material shall be as specified by manufacturers. Glands and bolts for the Bolted-Gland joint shall also be of ductile iron. Dimensions of pipes and joints shall be such that Ductile Iron Pipes shall be interchangeable with grey iron.

**Marking**

10. For identification purposes, the socket face of ductile spun iron pipes shall be painted red, and the word 'Ductile' shall appear in red paint on the body of the pipe near the socket. Fittings shall similarly have the socket face painted red, and the word 'Ductile' (or an abbreviation thereof) cast on the body. The ductile Iron glands and bolts for Bolted-Gland Joints shall also be marked with red paint.

**Specials**

11. The specials shall have the thickness specified in table below:—

| Nominal Internal Diameters | Thickness | Outside Diameter | Inside Diameter |
|---|---|---|---|
| Inches | Inches | Inches | Inches |
| 4 | .30 | 4.80 | 4.2 |
| 5 | .31 | 5.90 | 5.28 |
| 6 | .33 | 6.98 | 6.32 |
| 7 | .34 | 8.06 | 7.38 |
| 8 | .36 | 9.14 | 8.42 |
| 9 | .37 | 10.20 | 9.46 |
| 10 | .39 | 11.26 | 10.48 |
| 12 | .43 | 13.14 | 12.28 |

**Measurements**

12. The measurement of pipes shall be in length. The unit of measurements shall be one foot.

**Rate**

13. The unit rate shall include the cost of pipe with spigot and socket or flanges, in a pipe length; sorting, packing and delivery at Site of Work, to be defined in the Conditions of Contract.

## SPECIFICATIONS

### No. 14.2 Galvanised Iron Pipes

**Source**

1. Galvanised iron pipes shall be of an approved manufacture.

**Composition**

2. Pipe shall be of best galvanized iron.

**Quality**

3. Pipe shall be sound, easily workable with drill or file and free from imperfections. Its inner and outer surface shall be smooth. Each pipe shall be properly galvanised. It shall have screw threads on both ends for jointing with sockets.

**Socket**

4. Socket shall conform to the above specifications of galvanized iron pipes for composition and quality.

**Requirements**

5. All straight lengths of pipes and its threads shall be protected with socket and jute covering.

**Test**

6. Pipe shall be capable of withstanding a pressure of 20 ft. head of water.

**Measurement**

7. The measurement of pipes shall be in length. The unit of measurement shall be one foot.

**Rate**

8. The unit rate shall include the cost of pipe and one socket for each pipe length; sorting, packing and delivery at Site of Work, to be defined in the Conditions of Contract.

The pipes shall comply with Specification No. 789 BSS of 1938.

**Galvanized Iron Specials**

The specials shall normally be of G. I. manufactured to the same specifications as the pipes, but where those are not available locally manufactured, Gun metal specials can be used. It shall be ensured that the threads are not worn out, the fittings shall be tested by jointing at least 5 per cent of the local supplies to straight pipes in pipe vices with sufficient pressure, to the satisfaction of the Engineer-in-charge. Defective fittings invariably crack on application of pressure. The fittings shall also be examined to detect blisters and minor cracks. The fittings shall also be hydraulically tested to a pressure of 100 ft. of water head.

## SPECIFICATIONS

### No. 14.3 Mild Steel Pipes

**Quality**

1. The Mild steel pipes shall be of approved manufacture and all pipes and tabular specials shall be made from steel, the analysis of which shows not more than 0.06 per cent of sulphur or of phosphorus.

**Physical Properties**

2. The pipe shall comply with the following requirements:

| Tensile strength tons per square inch | 22 to 30 On gauge length of | |
|---|---|---|
| Minimum percentage elongation | 8 inches | 2 inches |
| Up to and including 1/4 in. thick | 15 | 25 |
| Over 1/4 in. thick | 20 | 32 |

**Thickness**

3. The thickness of the pipes shall be as per tables T1—14.3 and T2—14.3 for welded steel pipes and stainless steel pipes respectively.

**Joints**

4. Steel pipes shall be supplied with joints giving angular and longitudinal flexibility, such as Viking Johnson couplings or Victaulic joints, with joints giving complete rigidity, such as welded joints or fixed flange joints; or with any of a wide variety of joints which includes spigot and socket joints for lead and yarn, taper joints and loose flange joints.

**Coating**

5. This shall consist of a simple coating of bituminous composition which is applied to pipes intended for conveying water or sewage by immersing them in a bath of bituminous composition maintained at a suitable temperature.

**Bitumen Lining**

6. This shall be continuous seamless lining of bituminous composition applied centrifugally to a pipe after it has been completely descaled and coated.

It shall be supplied in two thicknesses—Standard and Thick. The thickness in which these linings shall be supplied are:—

| | Minimum thickness of lining | |
|---|---|---|
| | Standard | Thick |
| On pipes up to and including 12 ins. bore | 1/16″ | 1/8″ |
| On pipes over 12 ins. up to and including 24 ins. bore | 1/16″ | 3/16″ |
| On pipes over 24 ins. up to and including 48 ins. bore | 3/32″ | 1/4″ |
| On pipes over 48 ins. bore | 1/8″ | 5/16″ |

For acid water and sewage, thick bitumen lining is recommended. The thicknesses of these linings shall be as above.

**External Protection**

7. General specific external protection in the form of sheeting or security wrapping shall be provided. This form of protection can be applied to pipes of 3 ins. bore and larger. The pipes, after being coated, shall be covered with an intimate mixture of bitumen and short asbestos fibres; this shall be applied as a hot plastic mass so as to form a tough seamless sheating of the following thickness.

| Nominal size of pipe or special | Thickness not less than |
|---|---|
| Up to and including 6 ins | 1/8″ |
| Over 6 ins and up to and including 12 ins | 3/16″ |
| Over 12 ins | 1/4″ |

**Security Wrapping**

8. There shall be three stages in the application of this protection. The pipes shall be first coated: then they shall be covered with hot bitumen about 3/64″ thick; and finally the protection shall be completed by wrapping spirally round the pipes a layer of dried and chemically treated hessian cloth, impregnated with bitumen. Security wrapping shall be applied to pipes up to 16 ins. outside diameter.

All sheets and wrapping shall be lime washed before despatch.

**Joints**

9. The joints shall be as specified by the manufacturer for services under consideration and as per following table:

| Service | Position in which pipes are to be laid | | |
|---|---|---|---|
| | Buried | Above ground | |
| | | On low supports | On high supports |
| Water Mains and their distribution pipes | Viking Johnson coupling Spigot and socket joint for lead and yarn. | Viking Johnson Coupling Victaulic Joint. | Flange joint |
| Gas and Air Mains and their distribution pipes | Welded Joints Viking Johnson Coupling Spigot and Socket joint for lead and yarn. Victaulic Joint. | Welded Joint Viking Johnson Coupling Victaulic joint. | Sleeve Welded Joint Flanged Joint |
| Gas or Water Service pipes | Screwed and socketed joint | Screwed and socketed joint | |
| Sewers | Viking Johnson Coupling. Spigot and socket joint for lead and yarn Welded joint. Victaulic joint long sleeve taper joint 3. | Sleeve spigot and socket joint for lead and yarn, fitted with security belts. Viking Johnson Coupling Welded joint, Victaulic joint. | Sleeve Spigot and Socket Joint for lead yarn, fitted with security bolts. Sleeve Welded Joint Flange Joint. |

1. Not available on bitumen lined pipes.
2. Not available on sizes smaller than about 24" bore,
3. Suitable only for gravitational sewers.

(a) **Viking Johnson Couplings**

These joints shall be used for radii of pipes as specified in the table below. It consists of a sleeve and two fingers which hold two wedge-shaped joint rings in contact with the sleeve and the pipe and, at the same time, enclose them and protect them from damage. The sleeve normally has a centre register as illustrated, which acts as a locating step. Sleeves without this register can also be supplied if required and in this form the joint is suitable for use as a closing connection and also permits the removal of individual lengths without disturbance of the adjoining pipes.

The joint is sufficiently flexible to permit many curves to be negotiated without the use of bends. The maximum angles at joints and the minimum radii of curves are:—

| Nom. Bores | Maximum angle between adjacent pipes | Equivalent radius for pipes of lengths of | | Equivalent deviation from straight |
|---|---|---|---|---|
| | | 20 ft. | 25 ft. | per ft. of length |
| 24" and smaller | 6° | 56 yds. | 80 yds. | 1.2 inch |
| Over 24" to 30" | 5° | 80 yds. | 100 yds. | 1.0 inch |
| Over 30" to 36" | 4° | 100 yds. | 125 yds. | 0.8 inch |
| Over 36" to 48" | 3° | 130 yds. | 165 yds. | 0.6 inch |
| Over 48" to 72" | 2° | 200 yds. | 250 yds. | 0.4 inch |

(b) **Spigot and Socket Joints for Lead and Yarn**

This shall only be used for a maximum pressure of 300 lbs per sq. inch and a radius allowing up to a minimum of 250 yds.

(c) **Welded Joints**

The pipes shall be manufactured to suit the Butt Welded Joints. Externally welded sleeve joints, and Spherical welded joints as specified. These joints shall be for pipes above 24" internal diameter.

(d) **Victaulic Joints**

The joints shall be ordered to suit pressure requirements. The dimensions of the joints shall be as per tables T3—14.3 T4—14.3.

**T I—14.3**

**STANDARD BITUMEN LINED WELDED STEEL PIPES**

| Nominal Bore | Outside Diameter | Thickness | | Test Pressure | Weight per foot | Feet per ton | Tons per mile | Approx. lined bore |
|---|---|---|---|---|---|---|---|---|
| in. | in. | S.W.G or Fraction | Decimal inch | Feet head | lb. | | | in. |
| 2 | 2⅜ | 11 | .116 | 1,600 | 2.799 | 800 | 6.598 | 2.02 |
| 3 | 3½ | 10 | .128 | 1,600 | 4.610 | 486 | 10.87 | 3.12 |
| 4 | 4½ | 9 | .144 | 1,600 | 6.700 | 334 | 15.79 | 4.09 |
| 5 | 5½ | 7 | .176 | 1,600 | 10.009 | 224 | 23.59 | 5.02 |
| 6 | 6⅝ | 7 | .176 | 1,600 | 12.124 | 185 | 28.58 | 6.15 |
| 7 | 7⅝ | 6 | .192 | 1,600 | 15.224 | 147 | 35.93 | 7.12 |
| 8 | 8⅝ | 6 | .192 | 1,600 | 17.295 | 130 | 40.77 | 8.12 |
| 9 | 9⅝ | 6 | .192 | 1,500 | 19.346 | 116 | 45.60 | 9.12 |
| 10 | 10⅝ | 6 | .192 | 1,300 | 21.653 | 103 | 51.04 | 10.24 |
| 12 | 12¾ | 5 | .212 | 1,200 | 28.392 | 78.9 | 66.92 | 12.20 |
| — | 14 | ¼ | .25 | 1,200 | 36.718 | 61.0 | 86.55 | 13.38 |
| — | 16 | ¼ | .25 | 1,100 | 42.059 | 53.3 | 99.14 | 15.38 |
| 18 | 18½ | ¼ | .25 | 1,000 | 48.734 | 46.0 | 114.0 | 17.88 |
| 21 | 21½ | ¼ | .25 | 850 | 56.745 | 39.5 | 133.8 | 20.88 |
| 24 | 24½ | ¼ | .25 | 750 | 64.756 | 34.6 | 152.6 | 23.88 |
| 27 | 27¾ | 9/32 | .2813 | 750 | 82.520 | 27.1 | 194.5 | 27.0 |
| 30 | 30¼ | 5/16 | .3125 | 750 | 101.599 | 22.0 | 239.5 | 29.94 |
| 33 | 33¾ | 5/16 | .3125 | 700 | 111.612 | 20.1 | 263.1 | 32.94 |
| 36 | 36¾ | 5/16 | .3125 | 650 | 121.626 | 18.4 | 286.7 | 35.94 |
| 42 | 43 | ⅜ | .375 | 650 | 170.736 | 13.1 | 402.4 | 42.06 |
| 48 | 49 | ⅜ | .375 | 600 | 194.769 | 11.5 | 459.1 | 48.06 |
| 54 | 55 | 7/16 | .4375 | 600 | 254.977 | 8.8 | 601.0 | 53.88 |
| 60 | 61 | ½ | .5 | 600 | 323.113 | 6.9 | 761.6 | 59.75 |
| 66 | 67¼ | 9/16 | .5625 | 600 | 400.678 | 5.6 | 944.4 | 65.88 |
| 72 | 73¼ | 9/16 | .625 | 600 | 484.836 | 4.6 | 1142.8 | 71.75 |

## STANDARD BITUMEN LINED SEAMLESS STEEL PIPES

| Nominal Bore | Outside Diameter | Thickness | | Test Pressure | Weight per foot | Feet per ton | Tons per mile | Approx. lined bore |
|---|---|---|---|---|---|---|---|---|
| in. | in. | S.W.G. or Fraction | Decmial inch | Feet head | lb. | | | in. |
| 2 | 2⅜ | 8 | .160 | 2,300 | 3.785 | 582 | 8.922 | 1.93 |
| 3 | 3½ | 7 | .176 | 2,300 | 6.249 | 358 | 14.73 | 3.02 |
| 4 | 4½ | 7 | .176 | 2,300 | 8.129 | 276 | 19.16 | 4.02 |
| 5 | 5½ | 7 | .176 | 2,300 | 10.009 | 224 | 23.59 | 5.02 |
| 6 | 6½ | 7 | .176 | 2,200 | 11.889 | 188 | 28.02 | 6.02 |
| | 6⅝ | 7 | .176 | 2,200 | 12.124 | 185 | 28.58 | 6.15 |
| 7 | 7⅝ | 5 | .212 | 2,200 | 16.786 | 133 | 39.57 | 7.08 |
| 8 | 8⅝ | 5 | .212 | 2,100 | 19.051 | 118 | 44.91 | 8.08 |
| 9 | 9⅝ | 4 | .232 | 2,100 | 23.277 | 96.2 | 54.287 | 9.04 |
| 10 | 10¾ | 3 | .2813 | 2,100 | 31.450 | 71.2 | 74.13 | 10.06 |
| 12 | 12¾ | 1 | .3125 | 2,100 | 41.516 | 54.0 | 97.86 | 12.00 |
| — | 14 | 3/8 | .375 | 2,100 | 54.575 | 41.0 | 128.6 | 13.13 |
| — | 16 | 3/8 | .375 | 2,000 | 62.586 | 35.8 | 147.5 | 15.13 |

The limited range of thicknesses shown in the tables covers normal requirements for this class of pipe. Thicker pipes may be supplied if required to meet special conditions.

All particulars, except the normal bores and test pressures, are subject to manufacturing tolerances.

These weights do not include bituminous protections or joints.

This dimension applies to standard bitumen lining. If thick bitumen lining not ordinarily applied on water mains were used, the dimension would be slightly reduced.

These sizes are not in frequent production, and should be avoided where possible.

## DIMENSIONS OF SHOULDERED STEEL PIPES AND VICTAULIC JOINTS

| Pipes | | | | | Joints | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Nominal Bore | Outside Diameter | Ds | L | E | A | B | C | Weight | Working pressure |
| in | in | in | in | in | in | in | in | in | in |
| 2 | 2 3/8 | 2 5/8 | 5/8 | 1/8 | **3 15/16** | **5 11/16** | **1 13/16** | **3** | 600 |
| 3 | 3 1/2 | 3 11/16 | 5/8 | 1/8 | **5 3/8** | **7 1/4** | **1 7/8** | **5 1/2** | 600 |
| 4 | 4 1/2 | 4 13/16 | 1 1/16 | 1/8 | **6 9/16** 6 1/2 | **8 7/8** 8 3/4 | **2** 2 1/16 | **7 1/4** 7 | 600 |
| 5 | 5 1/2 | 5 13/16 | 1 1/16 | 1/8 | **7 1/2** | **9 1/2** | 2 1/16 | **8 1/4** | 500 |
| 6 | 6 1/2 | 6 7/8 | 1 1/16 | 1/8 | 8 9/16 | 10 3/8 | 2 1/16 | 9 1/2 | 400 |
| 7 | 10 3/4 | 11 1/4 | 1 1/16 | 1/8 | 9 11/16 | 11 9/16 | 2 1/16 | 10 1/2 | 400 |
| 8 | 8 5/8 | 9 1/8 | 1 1/16 | 1/8 | **11 1/4** | **13 7/8** | **2 1/2** | **20 1/4** | 400 |
| 9 | 9 5/8 | 10 1/8 | 1 1/16 | 1/8 | **12 1/2** | **14 15/16** | **2 1/2** | **21 3/4** | 400 |
| 10 | 10 3/4 | 11 1/4 | 1 1/16 | 1/8 | **13 5/8** | **16 1/8** | **2 1/2** | **23 1/2** | 400 |
| 12 | 12 3/4 | 13 1/4 | 1 1/16 | 1/8 | **15 5/8** | **17 13/16** | **2 1/2** | **27** | 400 |
| — | 14 | 14 1/2 | 1 1/16 | 1/4 | **17 1/2** | **20 7/16** | **3** | **46 1/4** | 250 |

Joints for which sizes are given in bold type are made of malleable cast iron. The other joints made from rolled steel.

The working pressures shown are for water or oil.

Working pressures for air are:—

(i) Upto and including 5 in. nominal bore 200 lbs. per sq. in.

(ii) Over 5 in up to and including 12 in. nominal bore: (150 lbs. per sq. in.)

Ds Dia of shoulder

L—Length of shoulder

E—Distance between Pipes

A—outside dia. of joint.

B—Outside distance between edges of bolts.

C—Width of joint.

T4—14.3

## PIPES AND VICTAULIC JOINTS

| Pipes | | | | | Joints | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Nominal Bore | Outside Diameter | Ds | L | E | A | B | C | Weight | Working water pressure |
| in | in | in | in | in | in | in | in | lb. | lb. per sq. in |
| — | 16 | 16½ | 1 | ¼ | **19½**<br>19¾ | **22⅛**<br>22½ | **3**<br>3½ | **52¾**<br>44 | 225<br>150 |
| 18 | 18½ | 19 | 1 | ¼ | **22**<br>22½ | **25⅛**<br>25¼ | **3**<br>3½ | **58¾**<br>50 | 200<br>150 |
| 21 | 21½ | 22 | 1 | ¼ | **25**<br>25½ | **28⅝**<br>28½ | **3**<br>3½ | **67**<br>68 | 175<br>150 |
| 24 | 24½ | 25 | 1 | ¼ | **28**<br>28¾ | **31¼**<br>32½ | **3**<br>3½ | **75½**<br>87 | 150<br>150 |
| 27 | 27¾ | 28⅜ | 1 | ¼ | 32 | 36 | 3½ | 100 | 150 |
| 30 | 30¾ | 31⅜ | 1 | ¼ | 35½ | 39 | 4 | 127 | 150 |
| 33 | 33¾ | 34⅜ | 1 5/16 | ⅜ | 38¾ | 42¼ | 4⅛ | 151 | 150 |
| 36 | 36¾ | 37⅜ | 1 5/16 | ⅜ | 42 | 45¾ | 4½ | 186 | 150 |

Joints for which s zes are given in bold type are made in three parts of rolled steel, others are made in four parts of malleable cast iron.

## SPECIFICATIONS

### No. 14.4 Concrete Lined (Mild Steel or Cast Iron) Pipes

**Source**

1. The pipe shall be of an approved manufacture.

**Composition**

2. The Pipe shall be manufactured from steel, cast iron, mild steel with a lining of 1/2" to 2" cement mortar inside and outside. The lining shall be centrifugally spun on the pipes.

**Requirements**

3. Each pipe shall be provided with cast iron or mild steel spigot and socket welded to the ends of pipes. The joints shall be watertight metallic joints.

**Measurements**

4. The measurement of pipes shall be in length. The unit of measurement shall be one foot.

**Rate**

5. The unit rate shall include the cost of pipe, spigot and socket in a pipe length, sorting, packing and delivering at Site of Work, to be defined in the Conditions of Contract.

The thickness of lining is as per table below:

| Nominal Diameter (DN) | Length of Pipe | Approximate thickness of concrete | Approximate weight of concrete per pipe |
|---|---|---|---|
| No. | Meters | mm. | kg. |
| 80 | 4 | 5 | 11 |
| 80 | 5.5 | 5 | 15 |
| 100 | 5.5 | 5 | 18.5 |
| 125 | 5.5 | 5 | 23.5 |
| 150 | 5.5 | 5 | 28 |
| 200 | 5.5 | 5 | 37.5 |
| 250 | 5.5 | 5 | 47 |
| 300 | 5.5 | 6.5 | 75.5 |
| 350 | 5.5 | 6.5 | 88 |
| 400 | 5.5 | 6.5 | 101 |
| 500 | 5.5 | 6.5 | 126 |
| 600 | 5.5 | 6.5 | 151 |
| 700 | 5.5 | 9.5 | 264 |

## SPECIFICATIONS

### No. 14.5 Asbestos Cement Pressure Pipe

**Source**

1. Asbestos cement pipe shall be of an approved manufacture.

### GENERAL REQUIREMENTS

**Manufacture**

2.1. The pipe shall be composed of an intimate mixture of Portland Cement or Portland puzzolana cement and asbestos fibre, with or without the addition of curing agents, shall be free from organic substances and shall be formed under pressure and thoroughly cured.

**Classes of Pipe**

2.2. The pipe shall be made in three classes, namely, for maximum working pressures of 100,150 and 200 lbs per sq. inch, designated as Class 100, Class 150 and Class 200, respectively.

**Pipe diameters**

2.3. The pipe shall be made in nominal inside diameters of 4, 6, 8, 10, 12, 14, 16, 18, 20, 24, 30, and 36 ins. For the 4, 6, 8, 10 and 12 ins sizes, the actual diameters may be less than the nominal by not more than 5.0 per cent when measured approximately 3 in. from the ends of the pipe.

**Pipe lengths**

2.4. The standard length of pipe shall be not less than 13 ft. At least 90 per cent of the total footage of pipe of any one class and size, excluding short lengths, as specified below, shall be furnished in standard lengths, with a tolerance of 1 in. The remaining 10 per cent may be in random lengths and shall be cut only from standard lengths that have met the requirements of Sec. 5.

Short lengths for making connections to valves fittings and structures, and for making closures, shall be furnished in such numbers and lengths as specified by the purchaser. Short lengths shall be not more than 3 ft. 3 in. long for the 4 in. and 6 in. sizes and not more than 6 ft. 6 ins. long for the 8 in. and large sizes.

**Table 1 (14.5)**

**Flexural Strength**

| Nominal Diameter | Total Applied Load—lbs. | | |
|---|---|---|---|
| Inches | Class 100 | Class 150 | Class 200 |
| 4 | 900 | 1,100 | 1,400 |
| 6 | 2,100 | 2,800 | 3,700 |
| 8 | 4,000 | 5,700 | 7,600 |

The Coupling areas of all standard and random lengths shall be machined or otherwise rendered suitable for making a tight joint with the couplings. The short lengths shall be properly machined for their purpose, whether at ends only or over their entire length, as specified by the purchaser.

**Couplings**

2.5. One coupling of the size and class specified shall be furnished with each standard, random and short length of pipe. Unless otherwise specified by the purchaser, each coupling shall comprise an asbestos cement sleeve of the same composition as the pipe and two rubber rings.

## DETAILS OF REQUIREMENTS

**Wall thickness**

3.1. The wall thickness at the machined portions of any pipe shall not deviate from the manufacturer's standard by more than+0.16 in. or—0.08 in. for pipe having a design thickness of 1 in or less, nor by more than+20 in or—10 in. for pipe having a design thickness greater than 1 in.

**Straightness**

3.2. No pipe shall have a variance from straightness, measured as an outside middle ordinate of more than 0.625 in. for 13 ft. lengths, or of more than a proportionate amount for shorter lengths.

**Imperfections**

3.3. Each pipe shall be free from bulges, dents, and tears on the inside surface that result in a variation in diameter of more than 0.187 in. from the diameter of adjacent unaffected portions of the surface.

The coupling areas of the barrel of each pipe shall be free from dents and gauges that will affect the tightness of the joint.

The exterior surface or edge of machined ends shall be free from flaking that extends back more than ½" in. from the end, that has a depth of more than 1/8th in. or that extends around the perimeter more than ½" in. at one location.

## STRENGTH REQUIREMENTS

**Bursting strength**

4.1. Each pipe and each coupling shall be designed to have sufficient strength to withstand an internal hydrostatic pressure of four times the rated working pressure for the class of pipe.

**Flexural strength**

4.2. Each standard length of pipe of 4, 6 and 8 ins. nominal diameter shall, when tested in flexure as specified in Sec. 5.3, support the load indicated in Table 1.

**Crushing strength**

4.3. Each pipe shall have sufficient strength if submitted to the three-edge bearing test as specified in Sec. 5.4 to support not less than the load indicated in Table 2.

**Table 2. (14.5)**

**Crushing Strength**

| Nominal Diameter | Applied Load per foot of length—lbs. | | |
|---|---|---|---|
| Inch | Class 100 | Class 150 | Class 200 |
| 4 | 4,100 | 5,400 | 8,700 |
| 6 | 3,900 | 5,400 | 9,000 |
| 8 | 3,700 | 5,500 | 9,300 |
| 10 | 3,700 | 7,000 | 11,000 |
| 12 | 4,000 | 7,600 | 11,800 |
| 14 | 4,400 | 8,600 | 13,500 |
| 16 | 4,800 | 9,200 | 15,400 |
| 18 | 5,200 | 10,100 | 17,400 |
| 20 | 5,600 | 10,900 | 19,400 |
| 24 | 6,300 | 12,700 | 22,600 |
| 30 | 7,500 | 15,900 | 28,400 |
| 36 | 8,800 | 19,600 | 33,800 |

## SAMPLING AND TESTING METHODS

**Test specimens**

5.1. All pipe and couplings tested under this specifications shall be in a normal air-dried condition.

**Hydrostatic test**

5.2. Each standard, random, and short length of pipe and each coupling sleeve shall be tested under an internal hydrostatic pressure as follows:

| Class | Pressure psi |
|---|---|
| 100 | 350 |
| 150 | 525 |
| 200 | 700 |

The water pressure shall be applied gradually and maintained at the specified test level for at least 5 sec. Any pipe or coupling sleeve showing any leakage, sweating or other defect shall be rejected.

From each 300 lengths of pipe, or fraction thereof, of each size and class, which have passed the routine hydrostatic and flexural tests, one length shall be selected by the inspector. Each selected length shall be hydrostatically tested to a pressure of four times the rated working pressure for the class of pipe, such pressure to be maintained for at least 5 secs. The pipe shall not fail under this pressure. Each pipe so tested shall be retested in the manner specified in the paragraph immediately preceding.

**Flexture tests**

5.3. Each standard length of pipe of 4, 6 and 8 ins. nominal diameter shall be tested in flexure. The supports shall be 12 ft. apart. The total load shall be divided equally and applied at the third point clear span. Each pipe so tested shall support, without evidence of cracks or other defects, the applicable total load shown in Table 1. The load shall be applied at a uniform rate.

**Three-edge bearing tests**

5.4. When specified by the purchaser, from each 300 lengths of pipe, or fraction thereof, of each size and class, one length shall be selected by the inspector for a three-edge bearing test. From each selected length there shall be cut one unmachined section of pipe 1 ft. long. This section shall be tested by the three-edge bearing method and shall not fall until the total applied load exceeds the applicable value shown in Table 2 above. After 75 per cent of the specified load is reached, the load shall be applied at a uniform rate of approximately 2,000 lb. per minute.

For this test, the two lower bearings shall consist of two straight wooden strips with vertical sides, each strip having its interior top edge rounded to a radius of approximately $\frac{1}{2}$ inch. The strips shall be securely fastened to a rigid block with the interior vertical faces parallel and a distance apart of not less than $\frac{1}{2}$ inch, nor more than 1 inch per foot of diameter of the pipe. The upper bearing shall be a rigid wooden block, at least 6 inches by 6 inches in cross section, straight and true from end to end. The upper and lower bearings shall extend the full length of the test section.

**Machines for testing**

5.5. The machine used for the hydrostatic tests shall have gaskets that seal the ends of the pipe without materially counteracting the hydrostatic test pressure.

The machines used for the flexure and three-edge bearing tests shall be substantial and rigid throughout, so that the distribution of the load will not be appreciably affected by the deformation or yielding of any part of the machine.

**Retests and rejection**

5.6. The failure of any specimen tested for crushing strength to support 75 per cent of the crushing load required in Sec. 5.3 shall be cause for rejection of the entire lot of that size and class manufactured during the same shift as the test specimen.

If any specimen tested for crushing strength supports more than 75% but less than 100% of the crushing load required in Sec. 5.3, one specimen shall be cut from each of 5 additional pipe sections of the same size and class manufactured during the same shift and shall be subjected to the crushing test. The failure of two of these additional specimens to meet the crushing strength requirement of Sec. 5.3 shall be cause for ejrection of the entire lot of that size and class manufactured during the same shift as the test specimens.

If any pipe subjected to higher hydrostatic test fails to withstand the specified pressure, five additional lengths of the same size and class shall be selected from the pipe manufactured during the same shift and shall be subjected to the higher hydrostatic test. The failure of two of these additional lengths to withstand the specified pressure shall be cause for rejection of the entire lot of that size and class manufactured during the same shift as the test lengths.

## MARKINGS

6.1. Each standard and random length of pipe shall be clearly marked on the outside surface with the trade name, nominal inside diameter, class, hydrostatic test pressure, and date and shift of manufacture.

6.2. Each short length of pipe shall be clearly marked on the outside surface with the nominal inside diameter, the class and the letter T to indicate that it has been hydrostatically tested.

6.3. All component parts of each coupling shall be clearly marked with the make and the size nda class of pipe for which they are intended. Each coupling sleeve shall also be marked with the letter T to indicate that it has been hydrostatically tested.

6.4. When factory inspection is made by the purchaser, each pipe and each coupling sleeve shall receive an additional special marking of not more than three letters, as required by the purchaser.

**Preparation of Shipment**

7. All pipe and couplings shall, unless otherwise specified, be prepared for standard commerical shipment, so as to insure acceptance by common or other carriers.

**Measurement**

8. The measurement of pipe shall be in length. The unit of measurement shall be one foot.

**Rate**

9. The unit rate shall include the cost of pipe, asbestos cement collar and sleeve in a pipe length, sorting, packing and delivering at Site of Work, to be defined in the Conditions of Contract.

## ASBESTOS CEMENT PIPE FITTING

### C. I. Collar, saddles and flanges, etc.

Cast iron collars, saddles, flanges shall conform to Specification No. 14.12 in so far as workmanship and tests are concerned.

**Malleable C. I. Collars, saddles and flanges, etc.**

They shall conform to Specification No. 14.3 in so far as workmanship and tests are concerned.

**Rubber Rings**

The rubber shall be from wild or plantation type with extracts not exceeding 3½ per cent by weight. The rings shall separately be vulcanised in moulds, the surface being plain finish, smooth and free from air mark or any other blemish. The ring shall be tested for permanent test, hardness and water absorption and ageing, by the manufacturer, according to Specification No. 14.7.

**Collar and coupling joints**

Collar and coupling joints shall conform to Specification No. 14.3

TABLE 3 (14.5)

## TABLE OF DIMENSIONS TRANSIT RING-TITE PRESSURE PIPE AND COUPLINGS

**All Dimensions Are in Inches**

| Pipe size | D | D2(D4) | D3 | Angle A° | D9* | D10 | D5 | D6 | D7* | D8 | N | Q | C | E |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | All classes | | | |
| **Class 100** | | | | | | | | | | | | | | |
| 3 | 3.00 | 3.74 | 3.90 | 12° | 4.00 | 3.00 | 4.03 | 4.48 | 5.48 | 3.86 | 7.00 | .92 | 2.40 | 3.90 |
| 4 | 4.00 | 4.64 | 4.80 | 12° | 4.90 | 4.00 | 4.93 | 5.38 | 6.38 | 4.76 | 7.00 | .92 | 2.40 | 3.90 |
| 6 | 6.00 | 6.91 | 7.07 | 15° | 7.17 | 6.00 | 7.20 | 7.65 | 8.85 | 7.03 | 7.00 | .92 | 2.40 | 3.90 |
| 8 | 8.00 | 9.11 | 9.27 | 15° | 9.37 | 8.00 | 9.40 | 9.85 | 11.05 | 9.23 | 7.00 | .92 | 2.40 | 3.90 |
| 10 | 9.85 | 10.89 | 11.05 | 15° | 11.23 | 9.85 | 11.28 | 11.63 | 12.83 | 11.01 | 7.00 | .92 | 2.40 | 3.90 |
| 13 | 12.70 | 12.99 | 13.15 | 15° | 13.30 | 11.70 | 13.28 | 13.73 | 15.13 | 13.11 | 8.00 | .92 | 2.90 | 4.40 |
| 14 | 13.59 | 15.07 | 15.23 | 18° | 15.33 | 13.59 | 15.39 | 15.95 | 17.59 | 15.20 | 9.00 | 1.00 | 3.25 | 4.75 |
| 16 | 15.50 | 17.15 | 17.31 | 18° | 17.41 | 15.50 | 17.47 | 18.03 | 19.86 | 17.28 | 9.00 | 1.00 | 3.25 | 4.75 |
| **Class 150** | | | | | | | | | | | | | | |
| 3 | 3.00 | 3.84 | 4.00 | 15° | 4.10 | 3.00 | 4.13 | 4.58 | 5.58 | 3.96 | | | | |
| 4 | 4.00 | 4.81 | 4.79 | 15° | 5.07 | 4.00 | 5.10 | 5.55 | 6.55 | 4.93 | | | | |
| 6 | 5.85 | 6.91 | 7.07 | 15° | 7.17 | 5.85 | 7.20 | 7.65 | 8.85 | 7.03 | | | | |
| 8 | 7.85 | 9.11 | 9.27 | 15° | 9.37 | 7.85 | 9.40 | 9.85 | 11.25 | 9.23 | | | | |
| 10 | 10.00 | 11.66 | 11.82 | 15° | 11.92 | 10.00 | 11.95 | 12.40 | 14.14 | 11.78 | | | | |
| 12 | 12.00 | 13.92 | 14.08 | 15° | 14.18 | 12.00 | 14.21 | 14.66 | 16.79 | 14.04 | | | | |
| 14 | 14.00 | 16.22 | 16.38 | 22° | 16.48 | 14.00 | 16.54 | 17.10 | 19.62 | 16.35 | | | | |
| 16 | 16.00 | 18.46 | 18.62 | 22° | 18.72 | 16.00 | 18.78 | 19.34 | 22.14 | 18.59 | | | | |
| **Class 200** | | | | | | | | | | | | | | |
| 3 | 3.00 | 3.84 | 4.00 | 15° | 4.23 | 3.00 | 4.13 | 4.58 | 5.59 | 3.96 | | | | |
| 4 | 4.00 | 4.81 | 4.97 | 15° | 5.33 | 4.00 | 5.10 | 5.55 | 6.67 | 4.93 | | | | |
| 6 | 5.70 | 6.91 | 7.07 | 15° | 7.32 | 5.60 | 7.20 | 7.65 | 9.10 | 7.03 | | | | |
| 8 | 7.60 | 9.11 | 9.27 | 15° | 9.50 | 7.50 | 9.40 | 9.85 | 11.66 | 9.23 | | | | |
| 10 | 9.63 | 11.66 | 11.82 | 15° | 11.92 | 9.63 | 11.95 | 12.40 | 14.69 | 11.78 | | | | |
| 12 | 11.56 | 13.92 | 14.08 | 15° | 14.18 | 11.56 | 14.21 | 14.66 | 17.48 | 14.04 | | | | |
| 14 | 13.59 | 16.22 | 16.38 | 22° | 16.59 | 13.46 | 16.54 | 17.10 | 20.42 | 16.35 | | | | |
| 16 | 15.50 | 18.46 | 18.62 | 22° | 18.90 | 15.32 | 18.78 | 19.34 | 23.11 | 18.59 | | | | |

**LENGTH OF PIPE STANDARD**

Size 3″ and 4″..... 10 ft. (3″ also available in 6′-6″ lengths) (4″ also available in 13′ lengths)
Size 6″ thr. 16″ (16″ also available in 10′ lengths)

**SHORT LENGTHS**

Size 3″, 4′-6″ in 10 ft. lengths; 3′-3″ MOA and and 6′-9″ MEE
6′-6″ MEE available on order to be cut in two for poured bell fittings).
Size, 4″ and 6″ in 13 ft. lengths; 3′-3″ MOA and 6′-6″ MEE and MOA
Size 8″ throu. 16″ (13 ft. lengths): 6′-6″ MEE and MOA

*Subject to Manufacturing Tolerance.

## TOLERANCES TRANSIT PRESSURE PIPE AND RING-TITE COUPLINGS

**All Dimensions in Inches**

| Pipe Size | Class 100 | | | Classes D2 150—200 | | | All Classes | | |
|---|---|---|---|---|---|---|---|---|---|
| | D2 | D3 | D4 | D2 | D3 | D4 | D5 | D8 | D6 |
| 3—4—6—8 | +.04—.03 | | | ±.02 | +.04—.03 | | +.04—.02 | | ±.02 |
| 10—12 | +.04—.03 | | | +.02—.03 | +.04—.03 | | +.04—.02 | | ±.02 |
| 14—16 | +.04—.04 | | | +.04—.04 | +.04—.04 | | +.04—.03 | | ±.03 |

N = ±.26
Q = ±.03
r—Radium Maximum 1/4″
Minimum 1/8″

C = +.03—.09
E = +.03—.09
Angle A° = ±2°

**LENGTH OF PIPE**

13′ and 10′ lengths.....+0.0″—1.0″
6′-9″ = 6′-6″ and 3′-3″ lengths.....±3/8″

Note.—RUBBER RING IDENTIFICATION

Rings are mould marked to indicate size and class of Pipe with which they are to be used. Exception: For 6″ and 8″ Cl. 100 pipe use 6″ and 8″ rings marked class 150—200

## TABLE OF DIMENSIONS TRANSIT RING-TITE PRESSURE PIPE AND COUPLINGS

**All Dimensions are in Inches**

| Pipe Size | D(D10) | D2(4) | D3* | D9 | D5 | D6 | D7* | D8 | N | Q | C | E | Angle A° |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Class 100 | | | | | All Classes | | | | |
| 18 | 18.00 | 19.90 | 20.06 | 20.26 | 20.22 | 20.78 | 23.01 | 20.03 | 10.00 | 1.00 | 3.75 | 5.25 | 22° |
| 20 | 20.00 | 22.12 | 22.28 | 22.48 | 22.44 | 23.00 | 25.32 | 22.25 | 10.00 | 1.00 | 3.75 | 5.25 | 22° |
| 24 | 24.00 | 26.48 | 26.64 | 26.84 | 26.80 | 27.36 | 30.10 | 26.61 | 10.00 | 1.00 | 3.75 | 5.25 | 22° |
| 30 | 30.00 | 33.12 | 33.28 | 33.54 | 33.46 | 34.02 | 37.63 | 33.27 | 11.00 | 1.00 | 4.25 | 5.75 | 22° |
| 36 | 36.00 | 39.78 | 39.94 | 40.20 | 40.12 | 40.68 | 44.92 | 39.93 | 11.00 | 1.00 | 4.25 | 5.75 | 22* |
| | | | | Class 150 | | | | | | | | | |
| 18 | 18.00 | 20.94 | 21.10 | 21.30 | 21.26 | 21.82 | 25.12 | 21.07 | LENGTH OF PIPE<br>Standard 13′-0″ MEE<br>Short Length: 6′-6″ MEE or MOA. | | | | |
| 20 | 20.00 | 23.28 | 23.44 | 23.64 | 23.60 | 24.16 | 27.65 | 23.41 | | | | | |
| 24 | 24.00 | 27.96 | 28.12 | 28.32 | 28.28 | 28.84 | 32.92 | 28.09 | | | | | |
| 30 | 30.00 | 35.00 | 35.16 | 35.42 | 35.34 | 35.90 | 41.20 | 35.15 | | | | | |
| 36 | 36.00 | 42.04 | 42.20 | 42.46 | 42.38 | 42.94 | 49.28 | 42.19 | | | | | |
| | | | | Class 200 | | | | | | | | | |
| 18 | 18.00 | 22.18 | 22.34 | 22.54 | 22.50 | 23.06 | 27.73 | 22.31 | NOTE: RUBBER RING IDENTIFICATION<br>Rings are marked to indicate size and class of pipe with which they are to be used. | | | | |
| 20 | 20.00 | 24.66 | 24.82 | 25.02 | 24.98 | 25.54 | 30.71 | 24.79 | | | | | |
| 24 | 24.00 | 29.62 | 29.78 | 29.98 | 29.94 | 30.50 | 36.71 | 29.75 | | | | | |
| 30 | 30.00 | 37.06 | 37.22 | 37.48 | 37.40 | 37.96 | 45.92 | 37.21 | | | | | |
| 36 | 36.00 | 44.52 | 44.68 | 44.94 | 44.86 | 45.42 | 45.94 | 44.67 | | | | | |

## TOLERANCES PIPE AND COUPLINGS

| ALL CLASSES | | ALL SIZES AND CLASSES | |
|---|---|---|---|
| Pipe size | D2, D3, D4 | D5 D6 D8 | +.04,—.03 |
| 18 | +.045—.04 | | |
| 20 | +.045—.04 | | |
| 24 | +.045—.04 | | |
| 30 | ±.05 | | |
| 36 | ±.05 | | |

N = ±.26
Q = ±06
r = radius max. 1/4″
min. 1/8″
C and E = +.03—.09
A° = ±2°

Length of Pipe
Standard: 13′-00″+0.0″-1.0″
Short Length 6′-6″±3/8 ″

Note 3′-3″ Lengths are not available in these pipe sizes.

## SPECIFICATIONS

### No. 14.6 Prestressed Cement Concrete Pipes

**Source**

1. Prestressed cement concrete pipes shall be of approved manufacture.

**Composition**

2. Pipe shall be made by prestressing concrete.

**Quality**

3. Pipe shall be of uniform internal diameter and thickness throughout its length. The internal surface shall be made to ensure smooth finish.

**Requirements**

4. Pipe shall withstand the specified pressure.

**Measurement**

5. The measurement of pipe shall be in length. The unit of measurement shall be one foot.

**Rate**

6. The unit rate shall include the cost of pipe and the specified joint in a pipe length; sorting, packing and delivering at Site of Work, to be defined in the Conditions of Contract.

Note.—For detailed specifications of the manufacture of Prestressed cement concrete Pipes see Appendix A.

## APPENDIX A

## SPECIFICATIONS FOR PRESTRESSED CEMENT CONCRETE PIPES ADOPTED BY THE CAPITAL DEVELOPMENT AUTHORITY

## PART A

**General**

1. These specifications cover the manufacture of circumferential pre-stressed reinforcement concrete water pipes of sizes varying between 6" to 48" in diameter, exclusively designed for static heads ranging from a minimum of 100 ft. to a maximum of 400 ft. The specifications do not include laying or sterilization of pipes.

**Purchaser**

2. The words "Purchaser" shall mean Capital Development Authority entering into a contract or agreement to purchase any materials or to get any work performed according to these specifications.

**Contractor**

3. The word "Contractor" shall mean a person, firm or corporations executing the contract or agreement with the purchaser to furnish any materials or to perform any work according to these specifications.

**Engineer**

4. The word "Engineer" shall mean the Engineer employed by the purchaser and acting as its representative; the purchaser itself acting as its own engineer and its respective assistants and inspectors.

**Approval**

5. The term "approval" shall mean having the approval of the engineer.

**Essential Requirements**

6. The pipes shall have the following principal features.

**Manufacture.** 6.1. A strong hollow cylinder termed "Shell" be made of cement concrete of uniform internal diameter and thickness of walls throughout its length except for the joint. The joint shall be spigot and socket. The internal and external diameters at one end are enlarged to form a socket into which the spigot end of a similar pipe can enter to form a joint. The shell shall have reinorcements (a cage or longitudinals) consisting of bright steel wire (conforming B.S.S. 785/38) or M.S. bars sufficient to make the shell strong enough to act as a beam and/or carry a burden of 6 ft. of earth backfill when placed in a trench. This shell shall be wound with high tensile steel wire at a predetermined stress and securely fastened at its end; a coating of dense mortar or concrete covering the shell and wire shall be given to make it water-tight under all conditions of service.

**Plans and Data of pipe furnished by the purchaser.** 6.2. The purchaser shall furnish to the contractor, plans and profiles of pipe line. The design head shall have each portion of pipe line and such special details as are necessary for manufacture of pipes and specials.

**Data submitted by the Contractor.** 6.3. The drawings and schedule showing full details of the requirements, concrete, joints, dimensions for the pipes shall be furnished by the contractor in quadruplicate copies for approval.

This shall include a tabulated schedule, showing the pressure zones for each design applicable therein and the point of charge from one zone to the next shall be clearly indicated by special number.

The diameter of pipe, the design head and the thickness of pipe valve and area of steel per lineal foot of pipe shall be listed for each portion of pipe length as fixed by the purchaser.

**Marking.** 6.4. Each pipe (or specials) shall have plainly marked on the bell end, the identification marks specified by the purchaser. These shall include the static heads for each pipe as designed. The proper location where the pipe is to be delivered, the date of manufacture and manufacturers' particulars, the particulars of inspection and approval, final stamp or stencilled marking of the inspector approving the same.

**Inspection.** 6.5. The purchaser or his representative shall have access to the work wherever it is in preparation of progress and the contractor shall provide proper facilities for access and inspection.

Inspection by the purchaser or his representatives or failure of the purchaser or his representative to provide inspection shall not relieve the contractor of his responsibility to furnish materials and to perform work.

Material, fabricated parts and the pipes which are discovered to be defective or which do not conform to the requirements of these specifications will be subjected to rejection at any time, prior to the final acceptance of the pipe. The rejected material and pipes will promptly be removed from the site of the work.

**Material and workmanship.** 6.6. All materials furnished by the contractor shall be new and the quality as specified. All work shall be done in a thorough workmanlike manner by mechanics skilled in their various trades.

**Tests.** 6.7. The contractor shall furnish in advance to the manufacturer all details of the reinforcements/reinforcing cages, mill test reports from which steel is rolled.

The contractor shall provide test specimen or certificates of high tensile steel wire used by them, as directed by the engineer.

Frequent samples of the mixed concrete shall be taken for making up compression test cubes as specified herein below.

If required by the engineer, the contractor shall submit test results showing the chemical and physical properties of rubber used in the gasket.

**Expenses.** 6.8. The expenses of the required tests of materials and all testing of the completed pipes shall be borne by the contractor.

Particulars to be furnished by the contractor are listed below:—

(i) Type of joints.

(ii) Type of cement used.

(iii) Sample of aggregate and sieve analysed.

(iv) Process of manufacture and number of finished pipes inspected.

(v) Whether the pipes or specials tested during the presence of the purchaser or his representative.

(vi) Results of hydraulic tests carried on the completed pipe.

(vii) Whether any variation in dimension exceeded the tolerable limits.

(viii) Whether any pipes are supplied from stock, in which case the manufacturers shall submit to the responsibility of removing the defective pipes.

(ix) A certificate confirming the date of manufacture and other details specified in para. above shall be furnished, duly signed and certified.

**Pipes to be delivered sound.** 6.9. All the pipes shall be delivered in all respects sound and in conformity with these specifications. The inspection shall not relieve the manufacturer of any of his obligations in this respect and any defective pipes which may have passed the purchaser at the works or elsewhere shall be at all times liable to rejection when discovered until the final completion and adjustment of the contract, provided however, that the manufacturer shall not be held liable for pipe found to be damaged after it has been accepted at the agreed point of delivery, until there shall be unmistakeable evidence that the casting was originally defective or damaged before acceptance. Care shall be taken in handling the pipe not to injure the coating or lining and no pipe or other material of any kind shall be placed in the pipe during transport or at any time after they have received the coating or lining.

## PART B

### (A) Pipe

The term "Pipe" signifies a hollow cylinder made of cement concrete of uniform internal diameter and having uniform thickness of wall throughout its length, except for the joint.

### (B) Barrel

The term "Barrel" signifies that portion of a pipe throughout which the internal diameter and thickness of wall remains uniform.

### Ends

The "Ends" of the pipe shall be so formed that when pipes of the same class and diameter are laid together and the joints made a continuous conduit with a smooth and uniform interior surface will be formed.

### Joints

The "Joints" are termed spigot and socket.

### (C) Moulds

The "Moulds" manufactured shall be such that the form and dimension of the finished work are accurate within the limits specified under various heads in the above clauses. The surface and edges clean and true, the ends square with the longitudinal axis and the concrete dense and homogeneous.

### (D) Effective Length

The "Effective Length" will be the distance measured along the axis of the faces at the socket end and spigot end which form the barrel and having uniform diameter.

### (E) Shell

The "Shell" stripped out of the mould consists of reinforcement and concrete, having internal and external diameters as per drawings specified by the purchaser, sketch enclosed.

**(F) Dimensions of Spigot and Socket joints**

| Dimension of pipes Diameter | Wall thickness without coating (Not less than) | Length |
|---|---|---|
| 6″ | 1¼″ | 6 ft. excluding socket |
| 9″ | 1¼″ | do |
| 12″ | 1⅜″ | 8 ft. excluding socket |
| 15″ | 1⅜″ | do |
| 18″ | 1⅜″ | do |
| 21″ | 1⅝″ | do |
| 24″ | 1¾″ | do |
| 27″ | 1⅞″ | do |
| 30″ | 2″ | do |
| 33″ | 2⅛″ | do |
| 36″ | 2¼″ | do |
| 39″ | 2½″ | do |
| 42″ | 2⅝″ | do |
| 48″ | 2¾″ | do |

The pipe shall have uniform internal diameter and thickness of wall throughout its length, except for joints which shall be spigot and socket. Pipes should have grooves for seating of rubber rings on spigot ends, before pushing in, in pipes and for a smooth internal surface. There will be tapers on socket and spigot ends correct to compress rubber ring to 40% of its original diameter in its final position.

**Permissible variations**

Any variation from the designated or specified dimensions, straightness and plainness of ends of pipes shall not exceed the limits set out in sub-clauses (a) to (d) below.

**(a) Internal diameter**

The actual internal diameter of a pipe shall not vary from the diameter designated by the Manufacturer by more than the amount shown in Table I.

**Table I**

**PERMISSIBLE VARIATION IN DIAMETER**

| Designated internal diameter | Permissible variation in diameter (plus or minus) |
|---|---|
| Up to but not including 15 ins. | 1/8″ |
| 15 ins. up to but not including 24 ins. | 3/16″ |
| 24 ins. up to but not including 48 ins. | 1/4″ |
| Over 48 ins. | 3/8″ |

**(b) Wall thickness**

The actual wall thickness of a pipe shall not differ from the thickness designated by the manufacturers by more than the amount shown in Table II, except that an increase in wall thickness to provide a flat base for pipes shall be permitted.

**Table II**

**PERMISSIBLE VARIATIONS IN WALL THICKNESS**

| Designated wall thickness | Permissible variation in wall thickness (plus or minus) |
|---|---|
| Up to and including 1" in. | 1/16 in. |
| Over 1" in. up to and incl. 1½" ins. | 3/32 in. |
| Over 1½" ins. up to and incl. 2 ins. | 1/8 in. |
| Over 2 ins. | 1/8 in. plus 1/32 in. for each 1/2 in. or part thereof of wall thickness over 2 ins. |

**(c) Straightness**

When tested by means of a straight edge paralleled to the longitudinal axis of the pipe, the deviation from straightness shall not exceed 1/8 in. per 3 ft. of effective length.

**(d) Length**

Unless otherwise specified by the purchaser the actual effective length of each pipe shall not differ from the designated length by more than the amount shown in Table III.

**Table III**

**PERMISSIBLE VARIATION IN LENGTH**

| Designated Length | Permissible variation in length (plus or minus) |
|---|---|
| Under 6 ft. 0 ins. | ¼ in. |
| 6 ft. 0 in and over. | ½ in. |

**(G) Cover.** The minimum clear cover of the reinforcement in any pipe shall be as shown in Table IV appropriate to the wall thickness of the pipe.

**Table IV**

**MINIMUM COVER OVER REINFORCEMENT**

| Wall thickness of pipe | Minimum clear cover |
|---|---|
| Up to and including 1 in. | ¼ in. |
| Over 1 in. | 3/8 in. |

**(H) Material**

(i) **Cement:** Zeal Pak, Dalmia or any other make complying with the provisions of B.S.S. 12.

(ii) **Aggregate:** Cubitised gravel of hard and durable material which does not split into elongated particles and free from loan, clay, organic matter and screened free from dust. The aggregate shall comply with provision of Clause 3 and 3a. B.S.S. 382.

(iii) **Grading:** The contractor should submit details of sieve analysis of various gradings, conforming to limits defined in the B.S.S. No. 63. The concrete produced should confirm to B.S.S. 884.

(iv) **Sand:** To be clean, sharp coarse grit, entirely free of any silt, loan, clay, organic or foreign matter. Where graded should conform to B.S.S. 63.

(v) **Water Ratio:** Varying between 0.35 to 0.45 depending upon mixture. (Composition of cement and concrete is acceptable) Sieve analysis of the aggregate should be furnished by the contractor.

**(I) Mixing and Feeding**

(a) All ingredients are to be measured separately by weight, the batching machine or boxes of such dimension that a complete bag of cement can be added to make a batch of concrete.

(b) **Mixing:** The mixing should be done in an efficient mixer electrically or mechanically driven.

(c) **Feeding:** This may be done by hand or machine, belt feeders may be used. Concrete should be fed in revolving mould.

**(J) Reinforcements**

Longitudinal bars of bright steel wire conforming to B.S.S. 785/38 should be used. Their anchoring in the pipe mould should be such as to provide enough of loop beading on welding of a nut to ensure pretensioning of the longitudinals to a stress of 1000 lbs.

**(K) The Shell**

The shell stripped out of mould shall be free of all defects and pits and irregular surface or cracks. Repairs of shells are not allowed. Retouching of minor deformities is allowed. The shell shall be strong enough to act as a beam and withstand lead test or backfill of 6 ft.

**(L) High Tensile Steel Wire**

High tensile steel wire conforming to B.S.S. 2692/55 Clause 5 and having tensile strength of 110 to 120 tons p.s.i. should be used. Prestressing to limits of 120,000 lbs. is permissible. Stress in the wire may be gauged by taking into account reduction in the area. (75% of the ultimate strength is limited).

**(M) Manufacturing of pipe**

Centrifugal action, tamping, pressure vibration, shall be used to consolidate material. The mould should be in motion while concrete is fed in the mould mechanically or manually. The speed of rotation should be such that even distribution and specified thickness and compactness is assured. Inside of the pipe should be made smooth to reduce friction in the flow of water. If necessary hardening should be used.

**(N) Wire winding**

This should be done with pre-stressed wire as per limits shown in para 7 and should be conducted with a mechanical contrivance. The anchoring of wire should be such as to maintain the stress in wire, even when pipes are cut in short lengths. No pitted or rusty wire should be used.

**(O) Cover (Mortar coating)**

Application of cement mortar in ratio 1:1½ is required. The coat thickness may vary from ½" ro ¾" depending upon the diameter of pipe.

**(P) Curing period**

After a cover of cement mortar is applied, curing should be conducted for 10 days if water is sprayed or 8 hours if steam curing is applied.

**(Q) Tests**

Test load for water pipes (Please see Appendix B for details):—

(a) 6" diameter pipe 2600 lbs. per linear foot.

| | | | |
|---|---|---|---|
| 9" | do. | 2600 lbs. | do. |
| 12" | do. | 3000 lbs. | do. |

(b) **Hydraulic Pressure Test.** During the hydraulic pressure test sweating shall be allowed while dripping of leakage shall render the pipe liable to rejection.

(c) **Application of Hydrostatic Pressure.** The cover or end pieces shall be placed in position on the pipe in a manner that will ensure that no leakage will occur through or pass them at the test pressure.

The pipe shall be filled with water and all air expelled. The pressure in the pipe, measured at the lowest point of the pipe, shall be increased gradually until the test pressure of 175 lbs. per sq. in. is reached.

The test pressure shall be maintained on the pipe for 15 seconds for each 1/4 in. (or part thereof) of wall thickness of the pipe.

While the pipe is under the test pressure it shall be tapped with a wooden mallet weighing 1 lb. approximately and having a handle 8 to 9 inches long.

**(R) Workmanship and Finish**

The pipe should be straightened with ends in planes normally to the longitudinal axis. Interior and external surface of the pipe shall be smooth, dense and hard.

Pipes shall be free from cracks, all irregular patterns, should be free from defects which result from faulty material or faulty methods of manufacture.

**(S) Joints**

The ends of the joints shall be so formed that when pipes of the same class and diameters are laid together and joints made, the conduit shall form a smooth and uniform interior surface. The dimensions of spigot and socket joints should comply with the proportions shown in the sketch.

**(T) Inspections**

The purchaser or his representative shall at reasonable times have free access to the place where the pipes or fittings along with other accessories are manufactured for the purpose of examining, and sampling the materials of pipes and specials and for supervising, testing and marking as necessary.

In addition a representative of the indenting office shall be authorized to inspect the details of manufacture and samples of materials used. The contractor shall carry tests to prove that these samples comply with the provisions of the specifications. Each pipe and fitting shall be stenciled to indicate the size of the pipe, the date of manufacture, serial number and class of pipe to indicate its history definitely.

The manufacturers shall provide, free of extra charge full facilities and all labour required for such examination, sampling, inspection, testing and marking before delivery, and shall provide and maintain in good working order, suitable convenient apparatus for testing samples of pipes and accessories and specials. Failing facilities at his end or in his own workshop for making the prescribed tests, the manufacturer shall bear the cost of testing of pipes elsewhere.

**(U) Maturing**

Unless otherwise authorized in writing by the purchaser, no pipe or special shall be supplied under these specifications until they have been allowed to mature under suitable conditions for periods of not less than 12 days.

**(V) Templates**

These shall be provided by the manufacturer for verifying the form and dimensions of the spigot and socket for inspection of the purchaser or his representative.

**(W) Moulds**

The moulds for manufacture shall be such that the form and dimensions of the finished work are accurate within the limits specified under various heads in the above clause. The surface and edges clean and true, the ends square with the longitudinal axis and the concrete dense and homogeneous.

**(X) Aggregate**

Aggregate should comply with the provisions of clauses 3 and 3A of B.S.S. 882. When required they shall be submitted for approval of the purchaser and a sieve analysis should be furnished to the purchaser.

**(Y) Percentage of Testing**

From each batch of pipe, the inspector if he so desires, may subject 100 per cent of the pipes to test or he may decide upon some percentage for testing from each batch. If any pipe fails, the purchaser or his representative may select the same for a re-test and, if that fails in another test, it may be rejected. The repair or retouching of the pipe is not allowed. This will be termed as rejected pipe and not to be supplied.

**(Z) Concrete Cube Crushing Test**

Concrete sampled during manufacture is to be tested in accordance with the sample described below.

**(a) Size of Test Cube**

The test specimen shall be 6" Cube.

Sample of making the test cube shall be taken as the concrete is being delivered at the point of deposit. Each sample shall be representative of the concrete being used in the mixer for manufacture of pipe and it shall be sufficient in size to make at least three test cubes. This shall be placed in a quality pail or container where it can be completed.

(b) **Compacting**

Concrete test cubes shall be placed in a container in three layers. Each layer being well ramped with a steel bar having a ramping face of 1" sq. and weighting 4 lbs. At least 35 strokes of the bar shall be given for each layer.

(c) **Curing**

The test cubes shall be cured for a period of 7 days and tested in a crushing machine for compression test, while another batch of cubes shall be cured for a period of 28 days and tested for compression.

(d) **Method of Testing (Cubes)**

Testing should be conducted in a standard machine, graduated in lb. p.s.i. and shall have an upper limit of 200 tons p.s.i. The method is indicated in the Appendix B.

(e) **Resistance**

Minimum resistance to crushing in lb. p.s.i. shall be as follows:—

Cubes tested after 7 days of manufacture—4500 lbs. p.s.i.
Cubes tested after 28 days of manufacture—6500 lbs. p.s.i.

**(ZZ) Certificate**

The contractor shall submit a certificate of compliance with the standard specifications detailed above.

## APPENDIX B

### Method for the load Testing of Pipes—General
### Three Edge Bearing Method

The following apparatus is required for the Three Edge Bearing Method.

(a) **Testing Machine.** The testing machine shall be so substantial and rigid that the distribution of the test load along the length of the barrel of the pipe will not be appreciably affected by the deformation or yielding of any part of the machine during the application of the load.

(b) **Bearing Blocks.** Three softwood bearing blocks shall be of the shape indicated in the figure below and of a length not less than the length of the pipe to be tested, exclusive of the socket. The portions of the blocks which will be in contact with the pipe shall be protected by rubber packing not less than 1/2 in. and not more than 1 in. thick.

(c) **Crack Measuring Gauge.**

(d) **Positioning of pipe in Testing machine.** The bearing blocks and the pipe shall be set up in the testing machine in such a manner that a longitudinal plane through a vertical diameter of the pipe and a vertical plane containing the line passing through the centre of the upper bearing blocks and a point midway between the two lower bearing blocks, coincide.

In the case of pipes which are elliptically reinforced they shall be so placed in the machine that the word "TOP" is in the vertical plane containing the axis of the pipe.

(e) **Application of Load.** The load shall be supplied vertically along the centre of the pipe through the upper bearing block, in a manner that will ensure a uniform distribution of the load throughout the length of the pipe. The load shall be increased at a continuous rate of 10 lbs. per inch per second, until the specified test load is applied. The test load shall be maintained on the pipe for no longer than is necessary to observe and record the load and examine the pipe.

(f) **Calculation of Test Load per Linear Foot.** The test load per linear foot shall be calculated by dividing the length of the pipe exclusive of the socket, by the total load sustained by the pipe.

## SPECIFICATION No. 14.7

## NATURAL RUBBER RINGS FOR

## GAS MAINS, WATER MAINS AND SEWERS

### General

1. Rubber joint rings shall be of six classes, as provided for in clause 4 below. They shall be supplied in the class specified by the engineer-in-charge. Rings of any class shall be effectively protected in mains carrying crude water gas or natural gas.

### Materials

2. The rubber used in the manufacture of the rings shall be first grade wild or plantation rubber and the finished rings shall not contain any reclaimed rubber vulcanized waste or any substance which will cause the rubber to impart a taste or smell to the water.

### Hardness

3. The hardness of rings shall be as provided for in Table I.

**Table I. HARDNESS**

| Class | Hardnesss (D. S. Degrees) |
|---|---|
| A | 45± 5 |
| B | 55± 5 |
| C | 60± 5 |
| D | 70± 5 |
| E | 80± 5 |
| F | 85± 5 |

### Tensile Strength, Elongation and Compression Tests

4. The tensile strength, elongation at break and compression tests (constant deflection method)

at room temperature shall comply with the requirements given in Table 2 below.

**Table 2. PHYSICAL REQUIREMENTS**

| | Before ageing | | | | After ageing | | |
|---|---|---|---|---|---|---|---|
| Class in benzole | Tensile strength (min) | Elongation at break (min) | Per centage of original thickness | Compression set (after 60 minutes recovery Max) | Tensile (min) | Elongation at break (min) | Swelling (max) |
| | lb.sq. in. | per cent | per cent | per cent compression | per cent of unaged value | per cent of unaged value | per cent |
| A | 3000 | 500 | 40 | 35 | 80 | 80 | 425 |
| B | 2750 | 500 | 30 | 35 | 80 | 80 | 325 |
| C | 2500 | 300 | 30 | 35 | 80 | 80 | 275 |
| D | 2250 | 275 | 25 | 40 | 80 | 80 | 230 |
| E | 1500 | 150 | 25 | 40 | 75 | 75 | 200 |
| F | 1200 | 130 | 25 | 50 | 75 | 75 | 175 |

Note.—Rings of classes A and B are only appropriate for use in joints when the rubber is efficiently protected from direct contact with fluid passing through the main.

**Accelerated Ageing Test**

5. After ageing in an air oven at 70 + 1 °C for a period of 240 hours the rubber forming the ring shall comply with the requirements specified in Table 2 for the appropriate class.

**Swelling in Benzole**

6. When tested by immersion in 90's benzole for 72 hours at a temperature of (25°+1°C) by the volumetric method—the rubber shall show a swelling not exceeding the value specified in Table 2 for the appropriate class.

**Water Absorption**

7. When tested by immersion in water at a temperature of 25°+ 1°C for 7 days by the volumetric swelling method in B. S. 903 using a test piece 0.6 + 0.1 in diameter and 0.15 + 0.01 in. thick, the rubber shall not absorb more than 20 per cent of water.

**Construction and Workmanship**

8. The rings shall be smooth and free from air marks and other blemishes and the rubber forming the rings shall be homogeneous, free from impurity and grit as judged visually on the surface or on any out section of the test samples.

Moulded rings shall be separately vulcanized and the fin or mould mark reduced to a reasonable minimum.

**Sampling for Testing**

9. For the purpose of testing the rings shall be divided into lots which shall remain undisturbed

(i. e. in bond) and identifiable until the conclusion of all test. The lots shall be made up as follows:—

Rings up to and including 12 ins. diameter in lots of not more than 500 from each batch.

Rings above 12 ins. diameter up to and including 24 ins. diameter in lots of not more than 250 from each batch.

Rings above 24 ins. diameter in lots of not more than 100 from each batch.

From each lot one sample ring for testing shall be selected by the purchaser or his representative. The test pieces shall be cut from these rings except that rings over 2¼ ins. diameter may by agreement between manufacturer and the purchaser be put forward together with test samples. Similarly test samples shall be put forward where the size or design of the rings is such that test pieces for any specified test cannot be prepared from them. Where these methods are adopted three test samples shall be provided with each lot. The rubber in the samples shall be from the same mix and shall have been moulded and vulcanized under the same conditions and at the same time as the lot rings which it represents.

**Re-Test**

10. Should any ring or test sample fail to comply with the requirements of this standard, a further ring or two test samples shall be selected from the same lot for re-testing.

Should either of the sets fail to comply with any of the test requirements the lot from which they were taken shall be deemed not to comply with the requirements of this British Standard.

**Marking**

11. Wherever practicable each ring shall be plainly and clearly marked in a suitable position with:

(a) The manufacturers name or trade mark.
(b) The month and year of manufacture.
(c) The class of ring.

In cases where marking of the actual rings is not practicable, or is likely to be detrimental to their effective use, the rings shall be supplied, fastened together in parcels of suitable size, each bearing a label giving the above particulars.

**Dimensions** 12.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| For | 12″ | pipes | Rubber | Rings | 13″ | Inside | diameter | 5/8″ | cord |
| ,, | 15″ | ,, | ,, | ,, | 16″ | ,, | ,, | 5/8″ | ,, |
| ,, | 18″ | ,, | ,, | ,, | 19″ | ,, | ,, | 11/16″ | ,, |
| ,, | 24″ | ,, | ,, | ,, | 24″ | ,, | ,, | 3/4″ | ,, |
| ,, | 27″ | ,, | ,, | ,, | 27″ | ,, | ,, | 3/4″ | ,, |
| ,, | 33″ | ,, | ,, | ,, | 33″ | ,, | ,, | 3/4″ | ,, |
| ,, | 36″ | ,, | ,, | ,, | 36″ | ,, | ,, | 3/4″ | ,, |
| ,, | 42″ | ,, | ,, | ,, | 42″ | ,, | ,, | 7/8″ | ,, |
| ,, | 48″ | ,, | ,, | ,, | 48″ | ,, | ,, | 7/8″ | ,, |
| ,, | 54″ | ,, | ,, | ,, | 54″ | ,, | ,, | 7/8″ | ,, |

**Manufacturers' Certificate**

13. The manufacturers shall, upon request, furnish the purchaser or his agent with each lot of rings a certificate worded as follows:—

> "We hereby warrant that the rings supplied conform to Specification 14.7. Identification marks on the rings are 'Rubber joint rings for gas mains, water main and sewer's class, etc.'

14. Rings separately moulded in full circle moulds are preferred but for economy in the large scale manufacture using 3/4 cord or over, rings may be made from round cord, cut to length and joined. The joint is made by cutting the cord at a flat angle and vulcanizing the two ends carefully so that the joints are barely visible to the eye. The strength of the rubber ring at the joint should be the same as that of the rubber ring for all purposes.

**Measurement.** The measurement of rubber rings shall be by number. The unit of measurement shall be unity.

**Rates.** Normally the cost of rubber rings shall be included in the cost of pipes and specials. However when the number of rings exceed the number of normal joints in the pipe, the additional number of rings, shall be paid for separately. The unit rate in this case shall include the cost of rubber rings, sorting, testing as per above specifications and delivering at site of work to be defined in the Conditions of Contract.

## SPECIFICATIONS

### No. 14.8 REINFORCED CEMENT CONCRETE PIPES

**Source**

1. Reinforced cement concrete pipes shall be of approved manufacture.

**Composition**

2. Pipe shall be made of reinforced cement concrete.

**Quality**

3. Pipe shall be of uniform internal diameter and thickness throughout its length. The amount of reinforcement for different diameters of pipes shall be as given in Tables No. T1 14.7 and T2 14.7.

**Collars and sockets**

4. Collars and sockets shall conform to the above specifications for composition, quality and reinforcement.

**Standard**

5. The standard thickness, weights and reinforcement for different diameters of pipes and collars shall be as given in Table No. T2 14.7.

**Tolerance**

6. The internal diameter of pipe shall not deviate from the nominal internal diameter by more than 1/8″ up to 19″ diameter; 1/4″ up to 48″ diameter. The radial thickness of the wall of pipe or its

fittings shall not vary more than specified below:—

| Pipe diameters in inches | Variation in radial thickness in inches |
|---|---|
| 3 to 18 | ±1/16 |
| 20 to 36 | ±3/32 |
| 38 to 48 | ±1/8 |

The internal diameter of the socket or collar shall have a minimum clearance when fixed to the pipes as specified below:—

| Nominal internal diameter of pipe in inches | Minimum clearance between spigot and socket or collar in inches |
|---|---|
| 3 to 8 | 3/8 |
| 10 to 18 | 5/8 |
| 24 to 48 and above | 3/4 |

**Hydraulic test**

7. Pipe barrel shall withstand the specified internal pressure without showing any sign of injury or sweating. The pressure shall be applied at a rate not exceeding 10 p. s. i. in 5 second and full pressure shall be maintained for at least thirty seconds.

**Measurement**

8. The measurement of pipe shall be in length. The unit of measurement shall be one foot.

**Rate**

9. The unit rate shall include the cost of pipe, socket or collar in a pipe length; sorting, packing and delivering at Site of Work, to be defined in the Conditions of Contract.

**Table No. ($T_1$ 14.7)**

**R. C. C. PIPES AND COLLARS**

| Diameter | Steel reinforcement for Pipes | | | | Steel reinforcement for Collars | | | |
|---|---|---|---|---|---|---|---|---|
| | Spirals | | Straight Rod | | Spirals | | Straight Rods | |
| | Gauge | Weight per pipe | Size | Weight per pipe | Gauge | Weight per Collar | Size | Weight per Collar |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Inches | | lbs. | | lbs. | | lbs. | | lbs. |
| 3 | 14 | 0.56 | 3/16" | 2.80 | 12 | 0.07 | 3/16" | .36 |
| 4 | 12 | 0.76 | 3/16" | 2.94 | 12 | 0.10 | 3/16" | .43 |
| 5 | 12 | 1.32 | 3/16" | 3.03 | 12 | 0.16 | 3/16" | .52 |
| 6 | 12 | 1.47 | 3/16" | 3.25 | 12 | 0.24 | 3/16" | .60 |
| 7 | 12 | 2.31 | 3/16" | 5.25 | 12 | 0.27 | 3/16" | .67 |
| 8 | 12 | 2.75 | 3/16" | 5.35 | 12 | 0.34 | 3/16" | .75 |
| 9 | 12 | 3.14 | 3/16" | 6.4 | 12 | 0.39 | 3/16" | .80 |
| 10 | 11 | 3.56 | 3.16 | 7.0 | 11 | 0.42 | 4G | .90 |
| 12 | 11 | 5.22 | 4G | 10.2 | 11 | 0.85 | 4G | 1.1 |
| 15 | 11 | 8.16 | 4G | 15.2 | 10 | 1.2 | 1/4" | 1.3 |
| 18 | 9 | 15.04 | 1/4" | 16.4 | 9 | 2.28 | 1/4" | 1.6 |

Table No. ($T_1$ 14.7)—Contd.

B CLASS PIPES AND COLLARS

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 3 | 14 | 1.81 | 3/16″ | 4.67 | 12 | 0.31 | 3/16″ | .5 |
| 4 | 12 | 1.90 | 3/16″ | 5.0 | 10 | 0.33 | 1/4″ | .53 |
| 5 | 12 | 2.13 | 3/16″ | 5.25 | 10 | 0.35 | 3/16″ | .57 |
| 6 | 12 | 3.09 | 3/16″ | 5.25 | 10 | 0.39 | 3/16″ | .65 |
| 7 | 12 | 4.97 | 3/16″ | 5.83 | 10 | 0.56 | 3/16″ | .8 |
| 8 | 12 | 6.0 | 1/4″ | 6.0 | 9 | 0.85 | 1/4″ | .85 |
| 9 | 12 | 6.02 | 1/4″ | 7.6 | 9 | 0.73 | 3/16″ | .9 |
| 10 | 11 | 7.8 | 4G | 8.5 | 8 | 1.05 | 4G | 1.0 |
| 10 | 11 | 12.40 | 4G | 10.2 | 7 | 1.74 | 4G | 1.1 |
| 15 | 11 | 18.5 | 3G | 12.1 | 6 | 2.13 | 1/4″ | 1.7 |
| 18 | 9 | 33.62 | 3G | 18.7 | 6 | 2.24 | 1/4″ | 2.3 |

C CLASS

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 3 | 12 | 2.17 | 3/16″ | 4.67 | 10 | 0.35 | 3/16″ | .5 |
| 4 | 12 | 3.28 | 3/16″ | 5.0 | 9 | 0.51 | 3/16″ | .53 |
| 5 | 10 | 4.35 | 3/16″ | 5.25 | 9 | 0.63 | 3/16″ | .57 |
| 6 | 10 | 5.87 | 3/16″ | 5.25 | 8 | 0.74 | 3/16″ | .65 |
| 7 | 9 | 7.61 | 3/16″ | 5.85 | 8 | 0.88 | 4G | .8 |
| 8 | 9 | 11.27 | 1/4″ | 6.0 | 7 | 1.31 | 4G | .85 |
| 9 | 8 | 11.85 | 1/4″ | 7.0 | 7 | 1.46 | 1/4″ | .9 |
| 10 | 8 | 15.87 | 4G | 8.5 | 6 | 1.05 | 1/4″ | 1.0 |
| 12 | 7 | 24.16 | 4G | 10.2 | 5 | 3.2 | 1/4″ | 1.1 |
| 15 | 6 | 36 8 | 3G | 12.1 | 4 | 4.4 | 1/4″ | 1.7 |
| 18 | 4 | 66.31 | 3G | 18.7 | 3 | 8.33 | 1/4″ | 2.3 |

Table No. ($T_2$ 14.7)

R. C. C. PIPES

| S. No. | Bore dia of all | A—None Pressure | | B—Tested to 75—Head | | C—Tested to 150—Head | | D—Tested to 200—Head | |
|---|---|---|---|---|---|---|---|---|---|
| | | Thick-ness | Weight | Thick-ness | Weight | Thick-ness | Weight | Thick-ness | Weight |
| | inches | inches | lbs. | inches | lbs. | inches | lbs. | inches | lbs. |
| 1 | 3 | 1 | 14 | 1 | 14 | 1 | 14 | 1 | — |
| 2 | 4 | 1 | 18 | 1 | 18 | 1 | 18 | 1 | — |
| 3 | 5 | 1 | 21 | 1 | 21 | 1 | 21 | 1 | 10 |
| 4 | 6 | 1 | 25 | 1 | 25 | 1 | 25 | 1 | — |
| 5 | 8 | 1 | 32 | 1 | 32 | $1\frac{1}{2}$ | 50 | — | 95 |
| 6 | 9 | 1 | 36 | 1 | 36 | 1 | — | $1\frac{5}{8}$ | — |
| 7 | 10 | $1\frac{1}{8}$ | 42 | $1\frac{1}{8}$ | 42 | $1\frac{1}{2}$ | 60 | — | 62 |
| 8 | 12 | $1\frac{3}{1\,8}$ | 54 | $1\frac{3}{1\,8}$ | 54 | $1\frac{1}{2}$ | 70 | — | — |
| 9 | 15 | $1\frac{1}{4}$ | 71 | $1\frac{1}{4}$ | 71 | $1\frac{7}{8}$ | 114 | — | 92 |
| 10 | 18 | $1\frac{3}{8}$ | 95 | $1\frac{3}{8}$ | 95 | 2 | 114 | — | — |

## SPECIFICATIONS

### No. 14.8 Plastic Pipes

These shall be made of polythylene and/or Polyviny Chloride (PUC) with diameters ranging from ½″ to 12″, in lengths up to 40 feet. The jointing shall be done by slipping a collar over recess at the ends of pipes. The space between the collar and pipes shall be filled by a plastic solution.

**Tolerances**

The variations of the thicknesses shall be plus or minus 8%.

## SPECIFICATIONS

### No. 14.9 Salt glazed Stoneware Pipes

**Quality**

1. Stoneware pipes shall be of best quality stoneware or fireclay, salt-glazed, thoroughly burnt throughout the whole thickness, of a close and even texture, free from air blows, fire blisters, cracks and other imperfections and the surfaces—external and internal—shall be smooth and perfectly glazed.

**Water absorption**

2. A piece of stoneware pipe about 2 inches square from any part of the pipe, shall not absorb after 48 hours immersion in water, more than 4 per cent of its own dry weight of water.

**Pressure**

3. The stoneware pipe shall be capable of resisting a bursting pressure of 30 lbs. per square inch, without showing signs of leakage.

**Strength**

4. The breaking weight of stoneware pipe shall not be less than 1,700 lbs. applied by means of a lever or otherwise to the centre of a flat board of hard wood, of the same length as the pipe, laid along the top of the pipe throughout its length exclusive of the socket. The pipe when subjected to this test shall be supported on a similar flat board underneath, the socket overhanging, and a layer of flat being laid between the boards.

**Cross section**

5. The thickness of the stoneware pipes shall not be less than one-twelfth of the internal diameter and of the fireclay pipes not less than one-tenth, and shall be uniform throughout the body of the pipe. The socket shall be made in one with the pipe. The cross section of the pipes at right angles to the axis shall be circle and the ends square to the axis. The pipes to be used for straight drains shall be straight longitudinally and those used for curved drains shall be segments of a circle in plan and when laid and jointed in position shall form a drain free from any obstruction.

**Socket**

6. The depth of the socket shall not be less than 1½ ins. for all pipes under 9 ins. in diameter, 2 ins. for 9-inch pipes, and 2½ ins. for all sizes over 12 ins. The internal diameter of the socket shall be sufficiently large to allow a joint of ¼" in. all round the outside of the pipe intended to enter it, so that a caulking of tarred gasket may be inserted.

**Test**

7. To test the freedom, of the material of which the pipe is made, from lime, pulverize a small piece of the pipe, weigh and boil in hydrochloric acid; subsequently wash on a filter and dry. If there is no loss in weight then the material may be considered free from lime.

**Weight**

8. The weights of pipes shall be as per Table T1. 13.10.

**Measurement**

9. The measurement of pipe shall be in length. The unit of measurement shall be one foot.

**Rates**

10. The unit rate shall include the cost of pipe, socket or collar in a pipe length; sorting, packing and delivering at Site of Work, to be defined in the Conditions of Contract.

Table T1—14.9

## BRITISH STANDARD SALT GLAZED WARE PIPES

| Int. dia of pipe | Minimum Mean thickness of barrel | Minimum Mean thickness of socket | Minimum internal depth of socket | Minimum jointing space | Length of grooving on spigot $1\frac{1}{2}C$ | Minimum depth of grooving |
|---|---|---|---|---|---|---|
| ins. | ins. | ins. | ins. | ins. | ins. | ins. |
| 3 | $\frac{7}{16}$ | 7/16 | 2 | 5/16 | 3 | 1/16 |
| 4 | $\frac{1}{2}$ | $\frac{1}{2}$ | 2 | $\frac{3}{8}$ | 3 | 1/16 |
| 5 | $\frac{9}{16}$ | 9/16 | $2\frac{1}{4}$ | 7/16 | $\frac{3}{8}$ | 1/16 |
| 6 | $\frac{5}{8}$ | $\frac{5}{8}$ | $2\frac{1}{4}$ | 7/16 | $\frac{3}{8}$ | 1/16 |
| 7 | $\frac{11}{16}$ | 11/16 | $2\frac{1}{4}$ | 7/16 | $\frac{3}{8}$ | 1/16 |
| 8 | $\frac{11}{16}$ | 11/16 | $2\frac{1}{2}$ | 1/2 | $\frac{3}{4}$ | 1/16 |
| 9 | $\frac{3}{4}$ | $\frac{3}{4}$ | $2\frac{1}{2}$ | 1/2 | $\frac{3}{4}$ | 1/16 |
| 10 | $\frac{13}{16}$ | 13/16 | $2\frac{3}{4}$ | 5/8 | $4\frac{1}{8}$ | 1/16 |
| 12 | 1 | 1 | $2\frac{3}{4}$ | 5/8 | $4\frac{1}{16}$ | 1/16 |
| 13 | $1\frac{1}{16}$ | $1\frac{1}{16}$ | 3 | 5/8 | $4\frac{1}{16}$ | 1/16 |
| 14 | $1\frac{3}{16}$ | $1\frac{3}{16}$ | 3 | 5/8 | $4\frac{1}{2}$ | 1/16 |
| 15 | $1\frac{1}{4}$ | $1\frac{1}{4}$ | 3 | 5/8 | $4\frac{1}{2}$ | 1/16 |
| 18 | $1\frac{1}{2}$ | $1\frac{1}{2}$ | 3 | 5/8 | $4\frac{1}{2}$ | 1/16 |
| 21 | $1\frac{5}{8}$ | $1\frac{5}{8}$ | $3\frac{1}{4}$ | $\frac{3}{4}$ | $4\frac{7}{8}$ | 1/16 |
| 24 | $1\frac{3}{4}$ | $1\frac{3}{4}$ | $3\frac{1}{2}$ | $\frac{3}{4}$ | $5\frac{1}{4}$ | 1/16 |
| 27 | $1\frac{7}{8}$ | $1\frac{7}{8}$ | $3\frac{1}{2}$ | $\frac{3}{4}$ | $5\frac{1}{4}$ | 1/16 |
| 30 | 2 | 2 | $3\frac{1}{2}$ | $\frac{3}{4}$ | $5\frac{1}{4}$ | 1/16 |
| 36 | $2\frac{1}{2}$ | $2\frac{1}{2}$ | $3\frac{1}{2}$ | 1 | $5\frac{1}{4}$ | 1/16 |

## PIPES SPECIAL

**Valves**

Valves are needed in the water supply distribution system for controlling, regulating and efficient working of the system. The common types of valves used in the water supply distribution system are described below:—

(i) Sluice or gate valves are required to be placed at control points usually street corners or at points where the distribution lines intersect. When a part of the water supply line needs repair and replacement, or connection is needed the sluice valve is shut off and the distribution system is controlled.

(ii) Pressure valves and reducing valves are required where a distribution system supply by gravity through pipes from a high pressure district. These are hand adjusted or automatic pressure reducing valves, and are used to maintain constant pressure on down stream side of valve.

(iii) Check valve is required in suction and delivery lines of the pump in order to ensure the flow in one direction only. It is also used in distribution system where flow in only one direction is required.

(iv) Air valves are placed at every summit in the pipe line to permit the escape of air. They are also placed on long stretches of nearly level distribution lines to permit the escape of air accumulated therein.

(v) Scour valves are placed at the bottom of depression in distribution mains for emptying it or removing the sediments.

(vi) Reflex valves are placed on ascending parts of mains. They allow flow in one direction and get automatically closed if a burst occurs and the water flows back.

(vii) Safety or relief valves are fixed at down stream ends of long length mains or where water hammer is expected to occur. They reduce the excessive pressure to normal pressure.

## SPECIFICATION

### No. 14.10 Sluice Valve and Gate Valve

**Source**

1. Sluice valve and gate valves shall be of an approved manufacture.

**Composition**

2. These valves shall be manufactured from cast iron. The valve gates which are less than 3 ins. in diameter shall be of solid bronze. For larger diameters the gates shall have cast iron discs with bronze rings. Composition of other components shall be:—

(i) Valve seating, thrust bearing, packing glands, gear spindles, wedding devices, guide rollers and indicator mechanism shall be of gunmetal.

(ii) Valve stem collars and nuts shall be made of manganese bronze having a tensile stress of 60,000 lbs. per square inch.

(iii) Stuffing box shall be packed with graphited hydraulic packing made of jute.

(iv) Wrench nuts shall be of cast iron 2 ins. square.

(v) Gears of large valves shall be of cast iron or steel if enclosed in an oil tight cast iron gear core.

**Quality**

3. These valves shall be of clear diameters specified. Its component parts shall be free from flaws, air bubbles, cracks, sand holes and other defects. All ferrous parts of valves except finished or bearing surface shall have three coats of bitumastic pipe dip.

**Type**

4. These valves shall be of inside screw type.

**Size**

5. The diameter of the water way in the valves shall not be less than the pipe diameter.

**Test**

6. The valves shall withstand test pressure of 300 p.s.i. and shall operate satisfactorily with a pressure of 150 p.s.i. working pressure of the main whichever is the greater.

**Measurement**

7. Measurement of these valves shall be in numbers. The unit of measurement shall be unity.

**Rate**

8. The unit rate shall include the cost of valve, sorting, packing and delivering at Site of Work, to be defined in the Conditions of Contract.

## SPECIFICATIONS

### No. 14.11 Pressure Valve and Reducing Valve

**Source**

1. Pressure valve and reducing valve shall be of an approved manufacture.

**Composition**

2. These valves shall conform to Specification No. 14.10, item No. 2. for the composition of corresponding parts.

**Quality**

3. For quality of the component parts, the valve shall conform to Specification No. 14.10, item No. 3.

**Type**

4. These valves shall be either hand adjusted or automatic type as specified.

**Size**

5. Size of the valve shall be as specified.

**Measurement**

6. Measurement of the valve shall be in numbers. The unit of measurement shall be unity.

**Rate**

7. The unit rate shall include the cost of valve, sorting, packing and delivering at Site of Work, to be defined in the Conditions of Contract.

## SPECIFICATIONS

### No. 14.12 Check Valve

**Source**

1. Check valve shall be of an approved manufacture.

**Composition**

2. The valve shall conform to Specification No. 14.10, item No. 2. for the composition of corresponding parts.

**Quality**

3. For quality of component parts of the valve, it shall conform to Specification No. 14.10, item No. 3.

**Requirements**

4. The valve shall be of substantial construction and the loss of head as specified shall be guaranteed by the suppliers. The gate or flap on the valve shall be easily accessible for cleaning and repairs.

**Size**

5. Size of the valve shall be as specified.

**Measurement**

6. Measurement of the valve shall be in numbers, The unit of measurement shall be unity.

**Rate**

7. The unit rate shall include the cost of valve, sorting, packing and delivering at Site of Work, to be defined in the Conditions of Contract.

## SPECIFICATIONS

### No. 14.13 Air Valve

**Source**

1. Air valve shall be of an approved manufacture.

**Composition**

2. The valve shall conform to Specification No. 14.10, item No. 2. for the composition of corresponding parts.

**Quality**

3. For quality of component parts of the valve, it shall conform to Specification No. 14.10, item No. 3.

**Requirements**

4. The valve shall have ball valves lighter than water.

**Size**

5. The Size of the valve shall be as specified.

**Measurement**

6. Measurement of the valve shall be in numbers. The unit of measurement shall be unity.

**Rate**

7. The unit rate shall include the cost of valve, sorting, packing and delivering at Site of Work, to be defined in the Conditions of Contract.

## SPECIFICATIONS

### No. 14.14 Scour Valve

**Source**

1. Scour valve shall be of an approved manufacture.

**Composition**

2. The valve shall conform to Specification No. 14.10, item No. 2 for the composition of the component parts.

**Quality**

3. For quality of component parts of the valve it shall conform to Specification No. 14.10, item No. 3.

**Type**

4. The valve shall be of inside screw type.

**Size**

5. Size of the valve shall be as specified.

**Measurement**

6. Measurement of the valve shall be in numbers. The unit of measurement shall be unity.

**Rate**

7. The unit rate shall include the cost of valves, sorting, packing, and delivering at Site of Work, to be defined in the Conditions of Contract.

## SPECIFICATIONS

### No. 14.15 Reflex Valve

**Source**

1. Reflex valve shall be of an approved manufacture.

**Composition**

2. It shall conform to Specification No. 14.10, item No. 2 of its corresponding parts.

**Quality**

3. For quality of component parts of the valve, it shall conform to Specification No. 14.10, item No. 3.

**Size**

4. The size of the valve shall be as specified.

**Measurement**

5. Measurement of the valve shall be in numbers. The unit of measurement shall be unity.

**Rate**

6. The unit rate shall include the cost of valve, sorting, packing and delivering at Site of Work, to be defined in the Conditions of Contract.

## SPECIFICATIONS

### No. 14.16 Safety and Relief Valve

**Source**

1. Safety and relief valve shall be of an approved manufacture.

**Composition**

2. The valve shall conform to Specification No. 14.10, item No. 2. for the composition of its

3. The quality of the component parts of the valve shall conform to Specification No. 14.10, item No. 3.

**Size**

4. Size of the valve shall be as specified.

**Measurement**

5. Measurement of the valve shall be in numbers. The unit of measurement shall be unity.

**Rate**

6. The unit rate shall include the cost of valve, sorting, packing and delivering at Site of Work, to be defined in the Conditions of Contract.

## FIRE HYDRANT

A fire hydrant is fixed in water supply distribution lines in populated areas for use of fire fighting equipment. It consists of a cast iron barrel with a bell or flang fitting at the bottom to connect to a branch from the water main, a valve of the gate or compression type, a long wall stem terminating in a nut above the barrel and one or more outlets. Generally two 2½" hose outlets are furnished with one 4" pumper outlet where needed. Other sizes of hydrants are 4" for two hose, 5" for three hose, 6" for four hose connections. Hydrants are either post type with a vertical barrel extending two or three feet above the ground surface or flush type in which type the top of the barrel is underground in a box whose cast iron cover is flushed with the ground surface. These are further classified as one way; two way; three way; or four way according to the number of hose outlets.

## SPECIFICATIONS

### No. 14.17 Hydrant

**Source**

1. The fire hydrant shall be of an approved manufacture.

**Composition**

2. Head valve gate and nozzle cap shall be made of cast iron. Outlet nozzle, valve seat, drain valve, stuffing box glands, gland box, butt and operating stem shall be of bronze or any other corrosion resistant alloy.

**Quality**

3. The component parts of the hydrant shall be free from flaws, air bubbles, cracks and holes and other defects. The main valve shall be faced with rubber or leather and in case of slide gate tubes shall have bitumastic barrel rings. All exposed surfaces shall be painted with a paint in three coats. The capacity of hydrant shall be given at hydrant top and nozzle cap. It shall be self-lubricating type.

**Requirements**

4. The requirements of fire hydrants shall be:—

(i) Pitch of the stem thread shall be such that water hammer shall not exceed working pressure.

(ii) In case the upper portion of the barrel is broken off, hydrants shall remain reasonably tight.

(iii) In case it is discharging 250 gallons per minute from each 2½" outlet the total friction loss of the hydrant shall not exceed 2 lbs. for two-way, 3 lbs. for three-way, and 4 lbs for four-way hydrant.

(iv) To prevent freezing a non-corrigible drip valve shall be provided to drain the barrel when the main valve is closed. Main valve shall be faced with a yielding material such as rubber for the compression type or a bronze ring for the gate type, and a seat of bronze or other non-corrigible material.

(v) Outlet threads shall conform to those used in the system.

**Type**

5. Type of hydrant shall be as specified.

**Size**

6. Size of the hydrant shall be as specified.

**Measurement**

7. The measurement of hydrant shall be in numbers. The unit of measurement shall be unity.

**Rate**

8. The unit rate shall include the cost of hydrant, its accessories, sorting, packing and delivering at Site of Work, to be defined in the Conditions of the Contract.

## EXTERNAL FITTINGS

Bends, duck foot bends, elbows collars, split collars, tees, tapers, angle branches, crosses, tail pieces and caps are used in laying water supply distribution system to complete the grid and facilitate the fixing of valves and fire hydrants, etc.

## SPECIFICATIONS

### No. 14.18 External fittings

**Source**

1. The external fittings shall be of an approved source.

**Composition**

2. The external fittings shall be made of cast iron.

**Quality**

3. Each fitting shall be of the clear diameter as specified of uniform thickness with smooth and strong spigot and socket or flanges as specified. It shall be free from flaws and air bubbles, cracks and holes and other defects.

**Standard**

4. Each fitting shall conform to the respective standards as given in Table Numbers ($T_1$ 14.18 —$T_{16}$ 14.18).

**Size**

5. Size of each fitting shall be as specified.

**Measurement**

6. The measurement of each fitting shall be in numbers. The unit of measurement shall be unity.

**Rate**

7. The unit rate shall include the cost of the specified fitting, sorting, packing and delivering at Site of Work, to be defined in the Conditions of Contract.

## SERVICE METER

A Service Meter is used for measuring the consumption of liquid or gas supply. In water supply system, the common type of meter used is called service meter.

## SPECIFICATIONS

### No. 14.19 Water Service Meter

**Source**

1. Service meter shall be of an approved manufacture.

**Composition**

2. The measuring chamber and case of meter shall be either of bronze or non-ferrous metal as specified. Gear trains and strainers shall be of non-ferrous metal, wheel measuring disc and wheel shall be of vulcanized rubber.

**Quality**

3. The service meters shall have a protected coating of bronze.

**Standards**

4. The registration of new meter shall be accurate within normal test flow limits as given in Table No. 14.17 to 1.5% for disc meters and to 3% for other types. The registered flow at minimum test flow shall not be less than 95% of the actual flow.

The pressure loss at the upper normal test flow limit shall not exceed 15 p.s.i. for meter up to 1 inch size and 20 p.s.i. for vane disc current and compound meters and 4 p.s.i. for fire service meters.

**Calibration**

5. The ratings of meters shall be in imperial gallons with the lowest count of 10 gallons.

**Requirements**

6. The meters shall have removable strainers which can be easily cleaned without interrupting service more than 15 minutes.

The meter shall have necessary isolating valves for the purpose of cleaning strainers.

The connecting ends of meters shall be of union and flanged type. It shall be supplied with one spare set of bearing. The meter shall be capable of being lubricated without its dismantlement.

**Size**

7. Size of meter shall be as specified.

**Measurement**

8. The measurement of meter shall be in numbers. The unit of measurement shall be unity.

**Rate**

9. The unit rate shall include the cost of the meter, its accessories, sorting, packing and delivering at Site of Work, to be defined in the Conditions of Contract.

## INTERNAL FITTINGS

**Internal Fittings.** Taps, valves and cocks are termed as internal fittings. These are fixed to control and regulate the flow of liquid or gases. Cocks are commonly screw down valves. These are fitted with internal plug, a quarter turn of which closes the line. These are usually used to control domestic water supply and gas lines at outlet points, on coolers and for emptying holders. Following are the different types of taps, valves or cocks commonly used:—

(i) **Bib tap** is a draw off tap with a horizontal inlet and free outlet. It is used over sinks to fill cistern or buckets and hospital baths. The common sizes are 1/4", 3/8", 1/2", 3/4", 1", 1¼", 1½" and 2". The inlet is kept horizontal and is always fitted with a tail having external paralleled thread.

(ii) **Hose tap** is a bib tap with a screw or union on the outlet for the attachment of a flexible pipe.

(iii) **Pillar tap** is a draw off tap with a vertical inlet and a horizontal outlet, the nose of which is kept down to give a vertical discharge. The flanges on the base of the body rests on the top of a bath roll or lavatory shelf and beneath it is a square section fitting the tap holes. From the square portion there is a tail 2½" long screwed with a parallel thread riding on which is a backnut for tightening to the ware. The common sizes are 1/½", 3/4", 1".

(iv) **Globe tap** is a draw off tap with a horizontal inlet and vertical free outlet. It is used in baths or similar apparatus. It is made in sizes $\frac{1}{2}''$, $\frac{3}{4}''$ and $1''$. The inlet has internal thread usually connected to a bent tail pipe which passes through and should have a union below the tap hole.

(v) **Screw down tap or stop valve** is a tap or stop valve closed by means of a disc carrying a renewable non-metallic washer which shuts against the water pressure on a seating at right-angles to the axis of the screwed spindle which operates it.

(vi) **Self closing taps** are used in factories and schools to avoid waste of water and are fixed vertically or horizontally. These are made in such a manner as when the button head is pressed the water flows and when the hand is removed the spring control causes the head to rise and the water is shut off. These taps are used for low pressure service only except where desired.

(vii) **Stop valve** is a valve with suitable means of connection for insertical free outlet. The common sizes are $\frac{1}{4}''$, $\frac{3}{8}''$, $\frac{1}{2}''$, $\frac{7}{8}''$, $\frac{3}{4}$, $1''$, $1\frac{1}{4}''$, $1\frac{1}{2}''$ and $2''$. They are intended for the isolation of pipe lines and individual service connections to sink lavatories, bath and W. C. cisterns and they facilitate repair and replacement of washers. Its tail is made for lead pipe connection with external parallel threads or with one and having external threads and the other having internal thread as desired.

## SPECIFICATIONS

### No. 14.20 Taps and Cocks

**Source**

1. Tap or cock shall be of an approved manufacture.

**Composition**

2. The bodies and heads shall be of brass or gun metal or hot pressings of brass or manganese bronze. Spindles, glands, crutches, washer plates and nuts shall be of brass or manganese.

**Quality**

3. Castings shall be from metal poured into the moulds, while hot pressings shall be metal pressed between dies. Pressing shall be smoother and shall present a better appearance. These shall be plated with nickel or chromium as specified.

**Requirements**

4. Tap and cock shall be fitted with a cover of pressed sheet metal threaded for attachment to the head and which can be cleaned easily. The stem of washer plate (called a jumper) shall be either loose or fixed by screwing to the spindle with the help of a grub screw.

**Size**

5. Size of the tap and cock shall be as specified.

**Measurement**

6. The measurement of tap or cock shall be in number. The unit of measurement shall be one dozen.

**Rate**

7. The unit rate shall include the cost of tap or cock as specified, sorting, packing and delivering at site of Work, to be defined in the Conditions of Contract.

**Table No. (T1 14.18)**

**Dimensions of standard ¼ Bends (90°)**

| Nominal internal diameter in inches | A in inches | B in inches | C in inches | G in inches | R in inches | Classes A & B Thickness in inches | Classes C & D Thickness in inches |
|---|---|---|---|---|---|---|---|
| 1½ | 9½ | 11 | 4½ | 3 | 6½ | 0.35 | 0.35 |
| 2 | 9½ | 11 | 4½ | 3 | 6½ | 0.36 | 0.36 |
| 2½ | 10½ | 12 | 4½ | 3 | 7½ | 0.37 | 0.37 |
| 3 | 12½ | 15 | 6 | 3½ | 9 | 0.38 | 0.40 |
| 4 | 15½ | 18 | 6 | 3½ | 12 | 0.39 | 0.46 |
| 5 | 15½ | 18 | 6 | 3½ | 12 | 0.41 | 0.52 |
| 6 | 18½ | 21 | 6 | 3½ | 15 | 0.43 | 0.57 |
| 7 | 18½ | 22 | 7 | 3½ | 15 | 0.45 | 0.61 |
| 8 | 22 | 26 | 8 | 4 | 18 | 0.47 | 0.65 |
| 9 | 22 | 27 | 9 | 4 | 18 | 0.49 | 0.69 |
| 10 | 25 | 31 | 10 | 4 | 21 | 0.52 | 0.73 |
| 12 | 25 | 33 | 12 | 4 | 21 | 0.57 | 0.80 |

**Table No. (T2 14.18)**

**Dimension of Standard 1/8 Bends (45°)**

| Nominal internal diameter in inches | A in inches | B in inches | C in inches | G in inches | R in inches | Classes A & B Thickness in inches | Classes C&D Thickness in inches |
|---|---|---|---|---|---|---|---|
| 1½ | 8 5/16 | 10 5/16 | 4½ | 3 | 14 | 0.35 | 0.35 |
| 2 | 8 5/16 | 10 5/16 | 4½ | 3 | 14 | 0.36 | 0.36 |
| 2½ | 10½ | 12 | 4½ | 3 | 18 | 0.37 | 0.37 |
| 3 | 13½ | 16⅛ | 6⅛ | 3½ | 24 | 0.38 | 0.40 |
| 4 | 13½ | 16⅛ | 6⅛ | 3½ | 24 | 0.39 | 0.46 |
| 5 | 14¾ | 17⅝ | 6⅜ | 3½ | 27 | 0.41 | 0.52 |
| 6 | 14¾ | 17⅝ | 6⅜ | 3½ | 27 | 0.43 | 0.57 |
| 7 | 16 | 18½ | 6⅜ | 3½ | 30 | 0.45 | 0.61 |
| 8 | 16½ | 19 | 6½ | 4 | 30 | 0.47 | 0.65 |
| 9 | 17¾ | 19⅞ | 6½ | 4 | 33 | 0.49 | 0.69 |
| 10 | 17¾ | 19⅞ | 6½ | 4 | 33 | 0.52 | 0.73 |
| 12 | 19 | 21⅜ | 6¾ | 4 | 36 | 0.57 | 0.80 |

**Table No. (T3 14.18)**

**Dimension of Standard 1/16 Bends (22½°)**

| Nominal internal diameter in inches | A in inches | B in inches | C in inches | G in inches | R in inches | Classes A & B Thickness in inches | Classes C&D Thickness in inches |
|---|---|---|---|---|---|---|---|
| 1½ | 8 9/16 | 10 11/16 | 4½ | 3 | 28 | 0.35 | 0.35 |
| 2 | 8 9/16 | 10 11/16 | 4½ | 3 | 28 | 0.36 | 0.36 |
| 2½ | 10⅛ | 11⅝ | 4½ | 3 | 36 | 0.37 | 0.37 |
| 3 | 13⅛ | 15¾ | 6 | 3½ | 48 | 0.38 | 0.40 |
| 4 | 13⅛ | 15¾ | 6⅛ | 3½ | 48 | 0.39 | 0.46 |
| 5 | 14¼ | 17⅛ | 6⅛ | 3½ | 54 | 0.41 | 0.52 |
| 6 | 14¼ | 17⅛ | 6⅜ | 3½ | 54 | 0.43 | 0.57 |
| 7 | 15½ | 18 | 6⅜ | 3½ | 60 | 0.47 | 0.61 |
| 8 | 16 | 18¼ | 6⅜ | 4 | 60 | 0.47 | 0.65 |
| 9 | 17¼ | 19⅜ | 6½ | 4 | 66 | 0.49 | 0.69 |
| 10 | 17¼ | 19⅜ | 6¾ | 4 | 66 | 0.52 | 0.73 |
| 12 | 18¾ | 21 | 6¾ | 4 | 72 | 0.57 | 0.80 |

**Table No. (T4 14.18)**

**Dimensions of Standard 1/32 Bends (11¼°)**

| Nominal internal diameter in inches | A in inches | B in inches | C in inches | G in inches | R in inches | Classes A & B Thickness in inches | Classes C&D Thickness in inches |
|---|---|---|---|---|---|---|---|
| 1½ | 8½ | 10 | 4½ | 3 | 56 | 0.35 | 0.35 |
| 2 | 8½ | 10 | 4½ | 3 | 56 | 0.36 | 0.36 |
| 2½ | 10 | 11½ | 4½ | 3 | 72 | 0.37 | 0.37 |
| 3 | 13 | 15⅜ | 6⅛ | 3½ | 96 | 0.38 | 0.40 |
| 4 | 13 | 15⅜ | 6⅛ | 3½ | 96 | 0.39 | 0.46 |
| 5 | 14⅛ | 17 | 6⅜ | 3½ | 108 | 0.41 | 0.52 |
| 6 | 14⅛ | 17 | 6⅜ | 3½ | 108 | 0.43 | 0.57 |
| 7 | 15⅜ | 17⅞ | 6⅜ | 3½ | 120 | 0.45 | 0.61 |
| 8 | 15⅞ | 18⅜ | 6½ | 4 | 120 | 0.47 | 0.65 |
| 9 | 17 | 19⅛ | 6⅝ | 4 | 132 | 0.49 | 0.69 |
| 10 | 17 | 19⅛ | 6⅝ | 4 | 132 | 0.52 | 0.73 |
| 12 | 18¼ | 20⅞ | 6¾ | 4 | 144 | 0.57 | 0.80 |

**Table No. (T5 14.18)**

**Dimensions of Standard 1/64 Bends ($5\frac{5}{8}°$)**

| Nominal internal diameter in inches | A in inches | B in inches | C in inches | G in inches | R in inches | Classes A & B Thickness in inches | Classes C&D Thickness in inches |
|---|---|---|---|---|---|---|---|
| $1\frac{1}{2}$ | $8\frac{1}{2}$ | 10 | $4\frac{1}{2}$ | 3 | 112 | 0.35 | 0.35 |
| 2 | $8\frac{1}{2}$ | 10 | $4\frac{1}{2}$ | 3 | 112 | 0.36 | 0.36 |
| $2\frac{1}{2}$ | 10 | $11\frac{1}{2}$ | $4\frac{1}{2}$ | 3 | 144 | 0.37 | 0.37 |
| 3 | 13 | $15\frac{5}{8}$ | $6\frac{1}{8}$ | $3\frac{1}{2}$ | 192 | 0.38 | 0.40 |
| 4 | 13 | $15\frac{5}{8}$ | $6\frac{1}{8}$ | $3\frac{1}{2}$ | 192 | 0.39 | 0.46 |
| 5 | $14\frac{1}{8}$ | 17 | $6\frac{3}{8}$ | $3\frac{1}{2}$ | 216 | 0.41 | 0.52 |
| 6 | $14\frac{1}{8}$ | 17 | $6\frac{3}{8}$ | $3\frac{1}{2}$ | 216 | 0.43 | 0.57 |
| 7 | $15\frac{1}{4}$ | $17\frac{3}{4}$ | $6\frac{3}{8}$ | 4 | 240 | 0.45 | 0.61 |
| 8 | $15\frac{1}{4}$ | $18\frac{1}{2}$ | $6\frac{3}{8}$ | 4 | 240 | 0.47 | 0.65 |
| 9 | 17 | $19\frac{1}{8}$ | $6\frac{5}{8}$ | 4 | 264 | 0.49 | 0.69 |
| 10 | 17 | $19\frac{1}{8}$ | $6\frac{5}{8}$ | 4 | 264 | 0.52 | 0.73 |
| 12 | $18\frac{1}{8}$ | $20\frac{7}{8}$ | $6\frac{3}{4}$ | 4 | 285 | 0.57 | 0.80 |

Table No. (T6 14.1a)

**Dimensions of Standard 90° Duck Foot Bends**

| Nominal Int. Dia. | A | B | C | G | R | Classes A and B | | | | | | Classes C and D | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | I | H | X | Y | M | N | I | H | X | Y | M | N |
| inches | inches | inches | inches | inches | inches | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| 1½ | 9⅛ | 11 | 4½ | 3 | 6½ | 0.35 | 3 | 6 | 4.63 | 5/8 | 1/2 | 0.35 | 3 | 6 | 4.63 | 5/8 | 1/2 |
| 2 | 9½ | 11 | 4½ | 3 | 7½ | 0.36 | 3½ | 6 | 5.38 | 5/8 | 1/2 | 0.36 | 3½ | 6 | 5.38 | 5/8 | 1/2 |
| 2½ | 10½ | 12 | 4½ | 3 | 7½ | 0.37 | 3½ | 7 | 5.88 | 5/8 | 1/2 | 0.37 | 3½ | 7 | 5.88 | 5/8 | 1/2 |
| 3 | 12⅛ | 15 | 6 | 3½ | 9 | 0.38 | 4 | 8 | 6.51 | 3/4 | 9/16 | 0.40 | 4 | 8 | 6.51 | 3/4 | 9/16 |
| 4 | 15⅛ | 18 | 6 | 3½ | 12 | 0.39 | 5 | 10 | 7.55 | 13/16 | 9/16 | 4.46 | 5 | 10 | 7.55 | 13/16 | 5/8 |
| 5 | 15½ | 18 | 6 | 3½ | 12 | 0.41 | 6 | 12 | 8.90 | 7/8 | 5/8 | 0.52 | 6 | 12 | 8.90 | 7/8 | 5/8 |
| 6 | 18½ | 21 | 6 | 3½ | 15 | 0.43 | 6½ | 13 | 10.23 | 7/8 | 11/16 | 0.57 | 6½ | 13 | 10.23 | 7/8 | 11/16 |
| 7 | 18½ | 22 | 7 | 3½ | 15 | 0.45 | 7 | 14 | 11.31 | 15/16 | 3/4 | 0.61 | 7 | 14 | 11.31 | 15/16 | 3/4 |
| 8 | 22 | 26 | 8 | 4 | 18 | 0.47 | 8 | 16 | 12.52 | 1 | 3/4 | 0.65 | 8 | 16 | 12.52 | 1 | 3/4 |
| 9 | 22 | 27 | 9 | 4 | 18 | 0.49 | 8 | 16 | 13.76 | 1 | 3/4 | 0.69 | 8 | 16 | 13.76 | 1 | 3/4 |
| 10 | 25 | 31 | 10 | 4 | 21 | 0.52 | 9 | 18 | 14.95 | 1 1/16 | 13/16 | 0.73 | 9 | 18 | 14.95 | 1 1/16 | 7/8 |
| 12 | 25 | 33 | 12 | 4 | 21 | 0.57 | 10 | 20 | 17.14 | 1 1/16 | 13/16 | 0.80 | 10⅛ | 21 | 17.60 | 1¼ | 1 |

## Table No. (T7 14.18)

### Dimensions of Standard 90° Elbow

| er es | A in inches | Nominal internal B in inches | C in inches | G in inches | R in inches | Thickness in inches | | Classes A & B Thickness in inches | Classes C&D | diamete in inch |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6 | 12 | 9 | 3 | 3 | 0.35 | | 0.35 | | 1½ |
| | 6 | 12 | 9 | 3 | 3 | 0.36 | | 0.36 | | 2 |
| | | 2½ | 6 | 15 | 12 | 3 | 3 | | 0.37 | 0.37 |
| | | 3 | 6½ | 15 | 12 | 3½ | 3 | | 0.38 | 0.40 |
| | | 4 | 9 | 18 | 12½ | 3½ | 5½ | | 0.39 | 0.46 |
| | | 5 | 9 | 18 | 12½ | 3½ | 5½ | | 0.41 | 0.52 |
| | | 6 | 12 | 21 | 12½ | 3½ | 8½ | | 0.43 | 0.53 |
| | | 7 | 12 | 21 | 12½ | 3½ | 8½ | | 0.45 | 0.61 |
| | | 8 | 14 | 24 | 14 | 4 | 10 | | 0.47 | 0.65 |
| | | 9 | 14 | 24 | 14 | 4 | 10 | | 0.49 | 0.69 |
| | | 10 | 15 | 27 | 16 | 4 | 11 | | 0.52 | 0.73 |
| | | 12 | 15 | 30 | 19 | 4 | 11 | | 0.57 | 0.80 |

## Table No. (T8 14.18)

### Dimensions of Standard Collars

| Nominal Int. d.a. in inches | H in inches | K in inches | Classes A and B | | | Classes C and D | | |
|---|---|---|---|---|---|---|---|---|
| | | | J in inches | M in inches | P in inches | J in inches | M in inches | P in inches |
| 1½ | 7 | 1.20 | 0.95 | 0.69 | 3.00 | 0.95 | 0.69 | 3.00 |
| 2 | 7 | 1.22 | 0.97 | 0.69 | 4.56 | 0.97 | 0.69 | 3.56 |
| 2½ | 7 | 1.25 | 1.00 | 0.75 | 4.56 | 1.00 | 0.75 | 4.06 |
| 3 | 9 | 1.29 | 1.04 | 0.75 | 4.56 | 1.04 | 0.75 | 4.56 |
| 4 | 9 | 1.34 | 1.09 | 0.81 | 5.53 | 1.09 | 0.81 | 5.63 |
| 5 | 10½ | 1.36 | 1.11 | 0.81 | 6.69 | 1.11 | 0.81 | 6.69 |
| 6 | 10½ | 1.40 | 1.15 | 0.88 | 7.81 | 1.15 | 0.88 | 7.81 |
| 7 | 10½ | 1.43 | 1.18 | 0.88 | 8.88 | 1.18 | 0.88 | 9.88 |
| 8 | 12 | 1.50 | 1.24 | 0.94 | 9.94 | 1.24 | 0.94 | 9.94 |
| 9 | 12 | 1.51 | 1.26 | 0.94 | 11.00 | 1.25 | 0.94 | 11.00 |
| 10 | 12 | 1.54 | 1.29 | 1.00 | 12.06 | 1.29 | 1.00 | 12.06 |
| 12 | 15 | 1.65 | 1.40 | 1.06 | 13.94 | 1.63 | 1.25 | 14.44 |

## Table No. ($T_9$ 14.18)

### Dimensions of Standard Split Collars Classes A and B

All in inches

| Nominal Int. dia. | A | B | C | D | D1 | E | F | G | H | J | K | L | M | N | P | Nolt No. | Nolt Size | Nolt Length |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1½ | 3 | 2½ | 9 | 5⅜ | — | 6⅝ | 0.95 | 11/16 | 3 | ⅜ | 1.20 | 1¼ | 2 | 5 | ¾ | 4 | ⅜ | 3½ |
| 2 | 3 9/16 | 3 1/16 | 9 | 5¾ | — | 7¼ | 0.97 | 11/16 | 3 | ⅜ | 1.22 | 1⅜ | 2 | 5 | ¾ | 4 | ⅜ | 3¾ |
| 2½ | 4 1/16 | 3 9/16 | 9 | 6⅜ | — | 7⅞ | 1.00 | ¾ | 3 | ⅜ | 1.25 | 1½ | 2 | 5 | ¾ | 4 | ⅜ | 4 |
| 3 | 4 9/16 | 3 1/16 | 11 | 7½ | — | 9 | 1.04 | ¾ | 3½ | ⅜ | 1.29 | 1 9/16 | 1 | 4½ | ¾ | 6 | ⅜ | 4½ |
| 4 | 5⅛ | 5⅛ | 11 | 8¾ | — | 10⅛ | 1.09 | 13/16 | 3½ | ⅜ | 1.34 | 1⅝ | 1 | 4½ | ¾ | 6 | ⅜ | 4½ |
| 5 | 6 1/16 | 6 3/16 | 12 | 9¾ | — | 11¼ | 1.11 | 13/16 | 3½ | ⅜ | 1.36 | 1 3/16 | 1 | 5 | ¾ | 6 | ⅜ | 4¾ |
| 6 | 7 3/16 | 7 5/16 | 12 | 11 | — | 12⅛ | 1.15 | ⅞ | 3½ | ⅜ | 1.40 | 1⅝ | 1 | 5 | ¾ | 6 | ⅜ | 5 |
| 7 | 8⅞ | 8⅜ | 12 | 12¼ | — | 14 | 1.18 | ⅞ | 3½ | ⅜ | 1.43 | 2 1/16 | 1 | 5 | ⅞ | 6 | ⅜ | 5½ |
| 8 | 9 5/16 | 9 7/16 | 13 | 13⅜ | — | 15⅛ | 1.24 | 15/16 | 4 | ⅜ | 1.50 | 2⅜ | 1 | 5⅛ | ⅞ | 6 | ⅜ | 6 |
| 9 | 11 | 10½ | 13 | 14½ | — | 16¼ | 1.26 | 15/16 | 4 | ⅞ | 1.51 | 2 7/16 | 1 | 5⅛ | ⅞ | 6 | ⅜ | 6½ |
| 10 | 12 1/16 | 11 9/16 | 13 | 15⅝ | — | 17⅛ | 1.29 | 1 | 4 | ⅞ | 1.54 | 2½ | 1 | 5½ | ⅞ | 6 | ⅜ | 6½ |
| 12 | 13 1/16 | 13 7/16 | 15 | 17⅞ | — | 20 | 1.40 | 1 1/16 | 4 | ⅞ | 1.65 | 2 5/16 | 1¼ | 6½ | 1 1/16 | 6 | ⅞ | 7½ |

## Table No. ($T_{10}$ 14.18)

### Dimensions of Standard Split Collars Classes C and D

| Nominal Int. dia. | A inches | B | C | D | D1 | E | F | G | H | J | K | L | M | N | P | Rate No. | Rate Size | Rate Length |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1½ | 3 | 2½ | 9 | 5⅛ | — | 6⅝ | 0.95 | 11/16 | 3 | ⅜ | 1.20 | 1 5/16 | 2 | 5 | ½ | 4 | ⅜ | 3⅜ |
| 2 | 3 9/16 | 3 1/16 | 9 | 5¾ | — | 7¼ | 0.97 | 11/16 | 3 | ⅜ | 1.22 | 1 7/16 | 2 | 5 | ¾ | 4 | ⅜ | 4 |
| 2½ | 4 1/16 | 3 9/16 | 9 | 6⅜ | — | 8⅛ | 1.00 | ¾ | 3 | ⅜ | 1.25 | 1 9/16 | 2 | 5 | ⅞ | 4 | ⅜ | 4½ |
| 3 | 4 9/16 | 4 1/16 | 11 | 7½ | — | 9½ | 1.04 | ¾ | 3½ | ⅜ | 1.29 | 1⅝ | 1 | 4½ | ⅞ | 6 | ⅜ | 4½ |
| 4 | 5⅝ | 5⅛ | 11 | 8¾ | — | 10½ | 1.09 | 13/16 | 3½ | ⅜ | 1.34 | 1 1/16 | 1 | 4½ | ⅞ | 6 | ⅜ | 4½ |
| 5 | 6 1/16 | 6 3/16 | 12 | 9¾ | — | 11½ | 1.11 | 13/16 | 3½ | ⅜ | 1.36 | 1⅞ | 1¼ | 4¾ | ⅞ | 6 | ⅜ | 5 |
| 6 | 7 3/16 | 7 5/16 | 12 | 11⅛ | — | 13¼ | 1.15 | ⅞ | 3½ | ⅜ | 1.40 | 2¼ | 1¼ | 4¾ | 1 1/16 | 6 | ⅞ | 6 |
| 7 | 8⅞ | 8⅜ | 12 | 12¼ | — | 14⅝ | 1.18 | ⅞ | 3½ | ⅜ | 1.43 | 2½ | 1¼ | 4¾ | 1 1/16 | 6 | ⅞ | 6½ |
| 8 | 9 5/16 | 9 7/16 | 13 | 13 | — | 15⅝ | 1.24 | 15/16 | 4 | ⅜ | 1.50 | 2 1/16 | 1¼ | 5¼ | 1 1/16 | 6 | ⅞ | 6½ |
| 9 | 11 | 10 | 13 | 14½ | — | 16⅝ | 1.26 | 15/16 | 4 | ⅞ | 1.51 | 2 1/16 | 1¼ | 5¼ | 1 1/16 | 6 | ⅞ | 6¾ |
| 10 | 12 1/16 | 11 9/16 | 13 | 15¾ | — | 18¼ | 1.29 | 1 | 4 | ⅞ | 1.54 | 2 5/16 | 1⅜ | 5⅜ | 1¼ | 6 | 1 | 7½ |
| 12 | 14 7/16 | 13 15/16 | 15 | 18⅞ | — | 21⅜ | 1.63 | 1¼ | 4 | ⅞ | 1.65 | 3 3/16 | 1½ | 4 | 1¼ | 8 | 1 | 8 |

## Table No. (T11 14.18)

### Dimensions of Standard Tees

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Nom. Dia. | Int. | E | F | F1 | G | Classes A and B | | | Classes C and D | | |
| | | | | | | Thickness | | | Thickness | | |
| D1 | D2 | | | | | T1 | T2 | T3 | T1 | T2 | T3 |
| in. | in. | ft in. | ft. in. | ft. in. | ft. in. | in. | in. | in. | in. | in. | in. |
| 1½ | 1½ | 2—0 | 0—4½ | 0—4½ | 0—4½ | 0.35 | 0.54 | 0.54 | 0.35 | 0.54 | 0.54 |
| 2 | 1½ | 2—0 | 0—4½ | 0—4½ | 0—4½ | 0.36 | 0.54 | 0.55 | 0.36 | 0.54 | 0.55 |
| 2 | 2 | 2—0 | 0—4½ | 0—4½ | 0—4½ | 0.36 | 0.55 | 0.55 | 0.36 | 0.55 | 0.55 |
| 2½ | 1½ | 2—0 | 0—4½ | 0—4½ | 0—5 | 0.37 | 0.54 | 0.56 | 0.37 | 0.54 | 0.56 |
| 2½ | 2½ | 2—0 | 0—4½ | 0—4½ | 0—5 | 0.37 | 0.55 | 0.56 | 0.37 | 0.55 | 0.56 |
| 2½ | 2½ | 2—0 | 0—5 | 0—5 | 0—5 | 0.37 | 0.56 | 0.56 | 0.37 | 0.56 | 0.56 |
| 3 | 1½ | 3—0 | 0—4½ | 0—4½ | 0—5 | 0.38 | 0.54 | 0.57 | 0.40 | 0.54 | 0.59 |
| 3 | 2 | 3—0 | 0—4½ | 0—4½ | 0—5 | 0.38 | 0.55 | 0.57 | 0.40 | 0.55 | 0.59 |
| 3 | 2½ | 3—0 | 0—5 | 0—5 | 0—5 | 0.38 | 0.56 | 0.57 | 0.40 | 0.56 | 0.59 |
| 3 | 3 | 3—0 | 0—5 | 0—5 | 0—5 | 0.38 | 0.57 | 0.57 | 0.40 | 0.59 | 0.59 |
| 4 | 1½ | 3—0 | 0—4½ | 0—4½ | 0—6 | 0.39 | 0.54 | 0.58 | 0.46 | 0.54 | 0.65 |
| 4 | 2 | 3—0 | 0—4½ | 0—4½ | 0—6 | 0.39 | 0.55 | 0.58 | 0.46 | 0.55 | 0.65 |
| 4 | 2½ | 3—0 | 0—5 | 0—5 | 0—6 | 0.39 | 0.56 | 0.58 | 0.46 | 0.56 | 0.65 |
| 4 | 3 | 3—0 | 0—5 | 0—5 | 0—6 | 0.39 | 0.57 | 0.58 | 0.46 | 0.59 | 0.65 |
| 4 | 4 | 3—0 | 0—6 | 0—6 | 0—6 | 0.39 | 0.58 | 0.58 | 0.46 | 0.65 | 0.65 |
| 5 | 2 | 3—0 | 0—5 | 0—5 | 0—6 | 0.41 | 0.55 | 0.60 | 0.52 | 0.55 | 0.71 |
| 5 | 2½ | 3—0 | 0—5 | 0—5 | 0—6 | 0.41 | 0.56 | 0.60 | 0.52 | 0.56 | 0.71 |
| 5 | 3 | 3—0 | 0—5 | 0—5 | 0—6 | 0.41 | 0.57 | 0.60 | 0.52 | 0.59 | 0.71 |
| 5 | 4 | 3—0 | 0—6 | 0—6 | 0—6 | 0.41 | 0.58 | 0.60 | 0.52 | 0.65 | 0.71 |
| 5 | 5 | 3—0 | 0—7 | 0—7 | 0—7 | 0.41 | 0.60 | 0.60 | 0.52 | 0.71 | 0.71 |
| 6 | 2 | 3—0 | 0—5 | 0—5 | 0—7 | 0.43 | 0.55 | 0.62 | 0.57 | 0.55 | 0.76 |
| 6 | 2½ | 3—0 | 0—5 | 0—5 | 0—7 | 0.43 | 0.56 | 0.62 | 0.57 | 0.56 | 0.76 |
| 6 | 3 | 3—0 | 0—6 | 0—6 | 0—7 | 0.43 | 0.57 | 0.62 | 0.57 | 0.59 | 0.76 |
| 6 | 4 | 3—0 | 0—6 | 0—6 | 0—7 | 0.43 | 0.58 | 0.62 | 0.57 | 0.65 | 0.76 |
| 6 | 5 | 3—0 | 0—7 | 0—7 | 0—7 | 0.43 | 0.60 | 0.62 | 0.57 | 0.71 | 0.76 |
| 6 | 6 | 3—0 | 0—7 | 0—7 | 0—7 | 0.43 | 0.62 | 0.62 | 0.62 | 0.76 | 0.76 |
| 7 | 2½ | 3—0 | 0—6 | 0—6 | 0—7 | 0.45 | 0.56 | 0.64 | 0.61 | 0.56 | 0.80 |
| 7 | 3 | 3—0 | 0—6 | 0—6 | 0—7 | 0.45 | 0.57 | 0.64 | 0.61 | 0.59 | 0.80 |
| 7 | 4 | 3—0 | 0—6 | 0—6 | 0—7 | 0.45 | 0.58 | 0.64 | 0.61 | 0.65 | 0.80 |
| 7 | 5 | 3—0 | 0—7 | 0—7 | 0—8 | 0.45 | 0.60 | 0.64 | 0.61 | 0.71 | 0.80 |
| 7 | 6 | 3—0 | 0—7 | 0—7 | 0—8 | 0.45 | 0.62 | 0.64 | 0.61 | 0.76 | 0.80 |
| 7 | 7 | 3—0 | 0—8 | 0—8 | 0—8 | 0.45 | 0.64 | 0.64 | 0.61 | 0.80 | 0.80 |
| 8 | 3 | 3—6 | 0—6 | 0—6 | 0—8 | 0.47 | 0.57 | 0.66 | 0.65 | 0.59 | 0.84 |
| 8 | 4 | 3—6 | 0—6 | 0—6 | 0—8 | 0.47 | 0.58 | 0.66 | 0.65 | 0.65 | 0.84 |
| 8 | 5 | 3—6 | 0—7 | 0—7 | 0—8 | 0.47 | 0.60 | 0.66 | 0.65 | 0.71 | 0.84 |
| 8 | 6 | 3—6 | 0—7 | 0—7 | 0—8 | 0.47 | 0.62 | 0.66 | 0.65 | 0.76 | 0.84 |
| 8 | 7 | 3—6 | 0—8 | 0—8 | 0—8 | 0.47 | 0.64 | 0.66 | 0.65 | 0.80 | 0.84 |
| 8 | 8 | 3—6 | 0—8 | 0—8 | 0—8 | 0.47 | 0.66 | 0.66 | 0.65 | 0.84 | 0.84 |
| 9 | 3 | 3—6 | 0—6 | 0—6 | 0—8 | 0.49 | 0.57 | 0.68 | 0.69 | 0.59 | 0.88 |
| 9 | 4 | 3—6 | 0—6 | 0—6 | 0—9 | 0.49 | 0.58 | 0.68 | 0.69 | 0.65 | 0.88 |
| 9 | 5 | 3—6 | 0—7 | 0—7 | 0—9 | 0.49 | 0.60 | 0.68 | 0.69 | 0.71 | 0.88 |
| 9 | 6 | 3—6 | 0—7 | 0—7 | 0—9 | 0.49 | 0.62 | 0.68 | 0.69 | 0.76 | 0.89 |
| 9 | 7 | 3—6 | 0—8 | 0—8 | 0—9 | 0.49 | 0.64 | 0.68 | 0.69 | 0.80 | 0.88 |
| 9 | 8 | 3—6 | 0—8 | 0—8 | 0—9 | 0.49 | 0.66 | 0.68 | 0.69 | 0.88 | 0.88 |
| 9 | 9 | 3—6 | 0—9 | 0—9 | 0—9 | 0.49 | 0.68 | 0.68 | 0.69 | 0.88 | 0.88 |
| 10 | 3 | 3—6 | 0—6 | 0—6 | 0—9 | 0.52 | 0.57 | 0.71 | 0.73 | 0.59 | 0.92 |
| 10 | 4 | 3—6 | 0—6 | 0—6 | 0—9 | 0.52 | 0.58 | 0.71 | 0.73 | 0.65 | 0.92 |

**Table No. T11—Contd.**

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Nom. Int. Dia | | E | F | F1 | G | Classes A and B | | | Classes C and D | | |
| | | | | | | Thickness | | | Thickness | | |
| D1 | D2 | | | | | T1 | T2 | T3 | T1 | T2 | T3 |
| in. | in. | ft. in. | ft. in. | ft. in. | ft. in. | in. | in. | in. | in. | in. | in. |
| 10 | 5 | 3—6 | 0—7 | 0—7 | 0—9 | 0.52 | 0.60 | 0.71 | 0.73 | 0.71 | 0.92 |
| 10 | 6 | 3—6 | 0—7 | 0—7 | 0—9 | 0.52 | 0.62 | 0.71 | 0.73 | 0.76 | 0.92 |
| 10 | 7 | 3—6 | 0—8 | 0—8 | 0—9 | 0.52 | 0.64 | 0.71 | 0.73 | 0.80 | 0.92 |
| 10 | 8 | 3—6 | 0—9 | 0—9 | 0—9 | 0.52 | 0.66 | 0.71 | 0.73 | 0.84 | 0.92 |
| 10 | 9 | 3—6 | 0—9 | 0—9 | 0—10 | 0.52 | 0.68 | 0.71 | 0.73 | 0.88 | 0.92 |
| 10 | 10 | 3—6 | 0—10 | 0—10 | 0—10 | 0.52 | 0.71 | 0.73 | 0.73 | 0.92 | 0.92 |
| 12 | 3 | 3—6 | 0—6 | 0—6 | 0—10 | 0.57 | 0.57 | 0.76 | 0.80 | 0.59 | 0.99 |
| 12 | 4 | 3—6 | 0—7 | 0—7 | 0—10 | 0.57 | 0.58 | 0.76 | 0.80 | 0.65 | 0.99 |
| 12 | 5 | 3—6 | 0—7 | 0—7 | 0—10 | 0.57 | 0.60 | 0.76 | 0.80 | 0.71 | 0.99 |
| 12 | 6 | 3—6 | 0—8 | 0—8 | 0—10 | 0.57 | 0.62 | 0.76 | 0.80 | 0.76 | 0.99 |
| 12 | 7 | 3—6 | 0—8 | 0—8 | 0—11 | 0.57 | 0.64 | 0.76 | 0.80 | 0.80 | 0.99 |
| 12 | 8 | 3—6 | 0—9 | 0—9 | 0—11 | 0.57 | 0.66 | 0.76 | 0.80 | 0.84 | 0.99 |
| 12 | 9 | 3—6 | 0—9 | 0—9 | 0—11 | 0.57 | 0.68 | 0.76 | 0.80 | 0.88 | 0.99 |
| 12 | 10 | 3—6 | 0—10 | 0—10 | 0—11 | 0.57 | 0.71 | 0.76 | 0.80 | 0.92 | 0.99 |
| 12 | 12 | 3—6 | 0—11 | 0—11 | 0—11 | 0.57 | 0.76 | 0.76 | 0.80 | 0.99 | 0.99 |

## Table No. (T12 14.18)

### Dimensions of Standard Titles

**Dimensions.**—The thickness T1 and T2 of class A, B tapers are the same as given in Table No. (T1 13.1) for Class B straight pipes. The thickness T1 and T2 of Class C, D tapers are the same as given in Table No. (T1 13.2) for Class D straight pipes.

Dimension B=Dimension G in Table No. (T1 13.16)

Dimension C=(6 in. for sizes upto and including 24 in.

9 in. for sizes over 24 in.)

| Nominal Internal diameter | | F | S | | X* |
|---|---|---|---|---|---|
| D1 | D2 | | Types 14+24 | Types 1B+2B | |
| in. | in. | ft. in. | ft. in. | ft. in. | ft. in. |
| 2 | 1½ | 2—0 | 1—3 | 1—3 | 0—3 |
| 2½ | 2 | 2—0 | 1—3 | 1—3 | 0—3 |
| 2½ | 1½ | 2—0 | 1—3 | 1—3 | 0—6 |
| 3 | 2½ | 2—0 | 1—2½ | 1—3 | 0—3 |
| 3 | 2 | 2—0 | 1—2½ | 1—3 | 0—6 |
| 3 | 1½ | 2—0 | 1—2½ | 1—3 | 0—9 |
| 4 | 3 | 2—0 | 1—2½ | 1—2½ | 0—6 |
| 4 | 2½ | 2—0 | 1—2½ | 1—3 | 0—9 |
| 4 | 2 | 2—0 | 1—2½ | 1—3 | 1—0 |
| 5 | 4 | 2—6 | 1—8½ | 1—8½ | 0—6 |
| 5 | 3 | 2—6 | 1—8½ | 1—8½ | 1—0 |
| 5 | 2½ | 2—6 | 1—8½ | 1—9 | 1—3 |
| 6 | 5 | 3—0 | 2—2½ | 2—2½ | 0—6 |
| 6 | 4 | 3—0 | 2—2½ | 2—2½ | 1—0 |
| 6 | 3 | 3—0 | 2—2½ | 2—2½ | 1—6 |
| 7 | 6 | 3—0 | 2—2½ | 2—2½ | 0—5 |
| 7 | 5 | 3—0 | 2—2½ | 2—2½ | 1—0 |
| 7 | 4 | 3—0 | 2—2½ | 2—2½ | 1—6 |
| 7 | 8 | 3—0 | 2—2½ | 2—2½ | 2—0 |
| 8 | 7 | 3—0 | 2—2 | 2—2½ | 0—6 |
| 8 | 6 | 3—0 | 2—2 | 2—2½ | 1—0 |
| 8 | 5 | 3—0 | 2—2 | 2—2½ | 1—6 |
| 8 | | 3—0 | 2—2 | 2—2½ | 2—2 |
| 9 | 8 | 3—0 | 2—2 | 2—2 | 0—6 |
| 9 | | 3—0 | 2—2 | 2—½ | 1—0 |
| 9 | 6 | 3—0 | 2—2 | 2—2½ | 1—6 |
| 9 | 5 | 3—0 | 2—2 | 2—2½ | 2—0 |
| 10 | 9 | 3—0 | 2—2 | 2—2 | 0—6 |
| 10 | 8 | 3—0 | 2—2 | 2—2 | 1—0 |
| 10 | 7 | 3—0 | 2—2 | 2—2½ | 1—6 |
| 10 | 8 | 3—0 | 2—2 | 2—2½ | 2—0 |
| 10 | 8 | 3—6 | 2—8 | 2—8½ | 2—6 |
| 12 | 10 | 3—0 | 2—2 | 2—2 | 1—0 |
| 12 | 9 | 3—0 | 2—2 | 2—2 | 1—6 |
| 12 | 8 | 3—0 | 2—2 | 2—2 | 2—0 |
| 12 | 7 | 3—0 | 2—8 | 2—8½ | 2—6 |
| 12 | 6 | 4—0 | 3—2 | 2—2½ | 3—0 |

*Dimensions in this column are lengths of tappered portion of diametrical reduction is truly 1 inch for each 6 inches of lengths.

## Table No. (T13 14.18)

### Dimensions of standard 45° angle Branches

| 1 | | 2 | | 3 | | 4 | | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nominal internal diameter | | | | | | | | | | Classes A and B Thickness | | | Classes C and D Thickness | | |
| D1 | D2 | | | | | | | | | $t_1$ | $t_2$ | $t_3$ | $t_1$ | $t_2$ | $t_3$ |
| in. | in. | ft. | in. | ft. | in. | ft. | in. | ft. | in. | in. | in. | in. | in. | in. | in. |
| 1½ | 1⅓ | 2 | 0 | 0 | 8 | 0 | 10 | 0 | 8 | 0.35 | 0.54 | 0.54 | 0.35 | 0.54 | 0.54 |
| 2 | 1⅔ | 2 | 0 | 0 | 8¼ | 0 | 10 | 0 | 8 | 0.36 | 0.54 | 0.55 | 0.36 | 0.54 | 0.55 |
| 2 | 2 | 2 | 0 | 0 | 8¾ | 0 | 11 | 0 | 8¾ | 0.36 | 0.55 | 0.55 | 0.36 | 0.55 | 0.55 |
| 2½ | 1½ | 2 | 0 | 0 | 8¾ | 0 | 10¼ | 0 | 8¾ | 0.37 | 0.54 | 0.56 | 0.37 | 0.54 | 0.56 |
| 2½ | 2 | 2 | 0 | 0 | 9½ | 0 | 11 | 0 | 9 | 0.37 | 0.55 | 0.56 | 0 37 | 0.55 | 0.56 |
| 2½ | 2½ | 2 | 0 | 0 | 9¾ | 0 | 12 | 0 | 9¾ | 0.37 | 0.56 | 0.56 | 0.37 | 0.56 | 0.56 |
| 3 | 1⅔ | 3 | 0 | 0 | 9 | 0 | 10¾ | 0 | 9 | 0.38 | 0.54 | 0.57 | 0.40 | 0.54 | 0.59 |
| 3 | 2 | 3 | 0 | — | 9⅝ | 0 | 11 | 0 | 9 | 0.38 | 0.55 | 0.57 | 0.40 | 0.55 | 0.59 |
| 3 | 2½ | 3 | 0 | — | 10 | 1 | 0 | 0 | 10 | 0.38 | 0.56 | 0.57 | 0.40 | 0.56 | 0.59 |
| 3 | 3 | 3 | 0 | — | 10 | 1 | 1 | 0 | 10 | 0.38 | 0.57 | 0.57 | 0.40 | 0.59 | 0.59 |
| 4 | 1½ | 3 | 0 | 0 | 10 | 0 | 10¾ | 0 | 10 | 0.39 | 0.54 | 0.58 | 0.46 | 0.54 | 0.65 |
| 4 | 2 | 3 | 0 | 0 | 10½ | 0 | 11 | 0 | 10¼ | 0.39 | 0.55 | 0.58 | 0.46 | 0.55 | 0.65 |
| 4 | 2½ | 3 | 0 | 0 | 11 | 1 | 1 | 0 | 11 | 0.39 | 0.56 | 0.58 | 0.46 | 0.56 | 0.65 |
| 4 | 3 | 3 | 0 | 0 | 11 | 1 | 1 | 0 | 11 | 0.39 | 0.57 | 0.58 | 0.46 | 0.59 | 0.65 |
| 4 | 4 | 3 | 0 | 1 | 0 | 1 | 2 | 1 | 0 | 0.39 | 0.58 | 0.58 | 0.46 | 0.56 | 0.65 |
| 5 | 2 | 3 | 0 | 0 | 11¾ | 1 | 0 | 0 | 11 | 0.41 | 0.55 | 0.60 | 0.52 | 0.55 | 0.71 |
| 5 | 2½ | 3 | 0 | 1 | 0 | 1 | 1 | 0 | 11¾ | 0.41 | 0.56 | 0.60 | 0.52 | 0.56 | 0.71 |
| 5 | 3 | 4 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0.41 | 0.57 | 0.60 | 0.52 | 0.59 | 0.71 |
| 5 | 4 | 3 | 0 | 1 | 0 | 1 | 2 | 1 | 0 | 0.41 | 0.58 | 0.60 | 0.52 | 0.65 | 0.17 |
| 5 | 5 | 3 | 0 | 1 | 1 | 1 | 4 | 1 | 1 | 0.41 | 0.60 | 0.60 | 0.52 | 0.71 | 0.17 |
| 5 | 2 | 3 | 6 | 0 | 11 | 1 | 0 | 0 | 11 | 0.43 | 0.65 | 0.62 | 0.57 | 0.55 | 0.76 |
| 6 | 2½ | 3 | 6 | 0 | 11 | 1 | 1 | 1 | ¼ | 0.43 | 0.56 | 0.62 | 0.57 | 0.65 | 0.76 |
| 6 | 3 | 3 | 6 | 1 | 0 | 1 | 1 | 1 | 1 | 0.43 | 0.57 | 0.62 | 0.57 | 0.59 | 0.76 |
| 6 | 4 | 3 | 6 | 1 | 1 | 1 | 3 | 1 | 1 | 0.43 | 0.58 | 0.62 | 0.57 | 0.65 | 0.76 |
| 6 | 5 | 3 | 6 | 1 | 2 | 1 | 4 | 1 | 2 | 0.43 | 0.60 | 0.62 | 0.57 | 0.71 | 0.76 |
| 6 | 6 | 3 | 6 | 1 | 3 | 1 | 6 | 1 | 3 | 0.43 | 0.62 | 0.62 | 0.51 | 0.76 | 0.76 |
| 7 | 2½ | 3 | 6 | 1 | ¼ | 1 | 1 | 1 | 0 | 0.45 | 0.56 | 0.64 | 0.61 | 0.56 | 0.80 |
| 7 | 3 | 3 | 6 | 1 | 1 | 1 | 1 | 1 | 1 | 0.45 | 0.57 | 0.64 | 0.61 | 0.59 | 0.80 |
| 7 | 4 | 3 | 6 | 1 | 2 | 1 | 3 | 1 | 2 | 0.45 | 0.58 | 0.64 | 0.61 | 0.65 | 0.80 |
| 7 | 5 | 3 | 6 | 1 | 2 | 1 | 4 | 1 | 3 | 0.45 | 0.60 | 0.64 | 0.61 | 0.71 | 0.80 |
| 7 | 6 | 3 | 6 | 1 | 3 | 1 | 6 | 1 | 3 | 0.45 | 0.62 | 0.64 | 0.61 | 0.76 | 0.80 |
| 7 | 7 | 3 | 6 | 1 | 4 | 1 | 7 | 1 | 4 | 0.45 | 0.64 | 0.64 | 0.61 | 0.80 | 0.80 |
| 7 | 3 | 3 | 6 | 1 | 1 | 1 | 1 | 1 | 2 | 0.47 | 0.57 | 0.66 | 0.65 | 0.59 | 0.84 |
| 8 | 4 | 3 | 6 | 1 | 2 | 1 | 3 | 1 | 3 | 0.47 | 0.58 | 0.66 | 0.65 | 0.65 | 0.84 |
| 8 | 5 | 3 | 6 | 1 | 3 | 1 | 4 | 1 | 3 | 0.43 | 0.60 | 0.66 | 0.65 | 0.71 | 0.84 |
| 8 | 6 | 3 | 6 | 1 | 4 | 1 | 6 | 1 | 4 | 0.47 | 0.62 | 0.66 | 0.65 | 0.71 | 0.84 |
| 8 | 7 | 3 | 6 | 1 | 5 | 1 | 7 | 1 | 5 | 0.47 | 0.64 | 0.66 | 0.65 | 0.84 | 0.84 |
| 8 | 8 | 3 | 6 | 1 | 5 | 1 | 9 | 1 | 5 | 0.47 | 0.66 | 0.66 | 0.65 | 0.84 | 0.84 |
| 9 | 3 | 3 | 6 | 1 | 2 | 1 | 1 | 1 | 3 | 0.49 | 0.57 | 0.68 | 0.69 | 0.59 | 0.88 |
| 9 | 4 | 3 | 6 | 1 | 3 | 1 | 8 | 1 | 4 | 0.49 | 0.58 | 0.68 | 0.69 | 0.65 | 0.88 |
| 9 | 5 | 3 | 6 | 1 | 4 | 1 | 4 | 1 | 4 | 0.49 | 0.60 | 0.68 | 0.69 | 0.71 | 0.88 |
| 9 | 6 | 3 | 6 | 1 | 4 | 1 | 6 | 1 | 5 | 0.49 | 0.62 | 0.68 | 0.69 | 0.76 | 0.88 |
| 9 | 7 | 3 | 6 | 1 | 5 | 1 | 7 | 1 | 5 | 0.49 | 0.64 | 0.68 | 0.69 | 0.80 | 0.88 |
| 9 | 8 | 3 | 6 | 1 | 6 | 1 | 9 | 1 | 6 | 0.49 | 0.66 | 0.68 | 0.69 | 0.84 | 0.88 |
| 9 | 9 | 3 | 6 | 1 | 7 | 1 | 10 | 1 | 7 | 0.49 | 0.68 | 0.68 | 0.69 | 0.88 | 0.88 |
| 10 | 3 | 4 | 0 | 1 | 3 | 1 | 1 | 1 | 4 | 0.52 | 0.57 | 0.71 | 0.73 | 0.59 | 0.92 |
| 10 | 4 | 4 | 0 | 1 | 3 | 1 | 3 | 1 | 4 | 0.52 | 0.58 | 0.71 | 0.73 | 0.65 | 0.92 |
| 10 | 5 | 4 | 0 | 1 | 4 | 1 | 4 | 1 | 5 | 0.52 | 0.60 | 0.71 | 0.73 | 0.71 | 0.92 |
| 10 | 6 | 4 | 0 | 1 | 5 | 1 | 6 | 1 | 6 | 0.52 | 0.62 | 0.71 | 0.73 | 0.76 | 0.92 |
| 10 | 7 | 4 | 0 | 1 | 6 | 1 | 7 | 1 | 6 | 0.52 | 0.64 | 0.71 | 0.73 | 0.80 | 0.92 |
| 10 | 8 | 4 | 0 | 1 | 6 | 1 | 9 | 1 | 7 | 0.52 | 0.66 | 0.71 | 0.73 | 0.84 | 0.92 |
| 10 | 9 | 4 | 0 | 1 | 7 | 1 | 11 | 1 | 7 | 0.52 | 0.68 | 0.71 | 0.73 | 0.88 | 0.92 |
| 10 | 10 | 4 | 0 | 1 | 8 | 2 | 0 | 1 | 8 | 0.52 | 0.71 | 0.71 | 0.73 | 0.92 | 0.92 |
| 12 | 3 | 4 | 0 | 1 | 4 | 1 | 2 | 1 | 5 | 0.57 | 0.57 | 0.76 | 0.80 | 0.59 | 0.99 |
| 12 | 4 | 4 | 0 | 1 | 5 | 1 | 3 | 1 | 6 | 0.57 | 0.58 | 0.76 | 0.80 | 0.65 | 0.99 |
| 12 | 5 | 4 | 0 | 1 | 6 | 1 | 5 | 1 | 7 | 0.57 | 0.60 | 0.76 | 0.80 | 0.71 | 0.99 |
| 12 | 6 | 4 | 0 | 1 | 6 | 1 | 6 | 1 | 7 | 0.57 | 0.62 | 0.76 | 0.80 | 0.76 | 0.99 |
| 12 | 7 | 4 | 0 | 1 | 7 | 1 | 8 | 1 | 8 | 0.57 | 0.64 | 0.76 | 0.80 | 0.80 | 0.99 |
| 12 | 8 | 4 | 0 | 1 | 8 | 1 | 9 | 1 | 8 | 0.57 | 0.66 | 0.76 | 0.80 | 0.84 | 0.99 |
| 12 | 9 | 4 | 0 | 1 | 9 | 1 | 11 | 1 | 9 | 0.57 | 0.68 | 0.76 | 0.80 | 0.88 | 0.99 |
| 12 | 10 | 4 | 0 | 1 | 9 | 2 | 0 | 1 | 10 | 0.57 | 0.71 | 0.76 | 0.80 | 0.92 | 0.99 |
| 12 | 12 | 4 | 0 | 1 | 11 | 2 | 4 | 1 | 11 | 0.57 | 0.76 | 0.76 | 0.80 | 0.99 | 0.99 |

Table No. (T14 14.18)

Dimensions of Standard Crosses

| 1 | 2 | 3 | | 4 | | 5 | | 6 | | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nominal Internal Dia | | E | | F | | F1 | | G | | Classes A and B Thickness | | | Classes C and D Thickness | | |
| $D_1$ | $D_2$ | | | | | | | | | $t_1$ | $t_2$ | $t_3$ | $t_1$ | $t_2$ | $t_3$ |
| in. | in. | ft. | in. | ft. | in. | ft. | in. | ft. | in. | in. | in. | in. | in. | in. | in. |
| 1¼ | 1¼ | 2 | 0 | 0 | 4¼ | 0 | 4¼ | 0 | 4½ | 0.50 | 0.54 | 0.54 | 0.35 | 0.54 | 0.54 |
| 2 | 1¼ | 2 | 0 | 0 | 4½ | 0 | 4½ | 0 | 4½ | 0.36 | 0.54 | 0.55 | 0.36 | 0.54 | 0.55 |
| 2 | 2 | 2 | 0 | 0 | 4½ | 0 | 4½ | 0 | 4½ | 0.36 | 0.55 | 0.55 | 0.36 | 0.55 | 0.55 |
| 2½ | 1¼ | 2 | 0 | 0 | 4½ | 0 | 4½ | 0 | 5 | 0.37 | 0.54 | 0.56 | 0.56 | 0.37 | 0.56 |
| 2½ | 2 | 2 | 0 | 0 | 4½ | 0 | 4½ | 0 | 5 | 0.37 | 0.55 | 0.56 | 0.37 | 0.55 | 0.56 |
| 2½ | 2½ | 2 | 0 | 0 | 5 | 0 | 5 | 0 | 5 | 0.37 | 0.56 | 0.56 | 0.37 | 0.56 | 0.56 |
| 3 | 1¼ | 3 | 0 | 0 | 4½ | 0 | 4½ | 0 | 5 | 0.36 | 0.54 | 0.57 | 0.40 | 0.54 | 0.59 |
| 3 | 2 | 3 | 0 | 0 | 4½ | 0 | 4½ | 0 | 5 | 0.36 | 0.55 | 0.55 | 0.40 | 0.55 | 0.59 |
| 3 | 2½ | 3 | 0 | 0 | 5 | 0 | 5 | 0 | 5 | 0.38 | 0.56 | 0.57 | 0.59 | 0.56 | 0.59 |
| 3 | 3 | 3 | 0 | 0 | 5 | 0 | 5 | 0 | 5 | 0.38 | 0.57 | 0.57 | 0.40 | 0.59 | 0.59 |
| 4 | 1¼ | 3 | 0 | 0 | 4½ | 0 | 4½ | 0 | 6 | 0.39 | 0.54 | 0.58 | 0.46 | 0.54 | 0.65 |
| 4 | 2 | 3 | 0 | 0 | 4½ | 0 | 4½ | 0 | 6 | 0.39 | 0.55 | 0.58 | 0.46 | 0.55 | 0.65 |
| 4 | 2½ | 3 | 0 | 0 | 5 | 0 | 5 | 0 | 6 | 0.39 | 0.56 | 0.58 | 0.46 | 0.56 | 0.65 |
| 4 | 3 | 3 | 0 | 0 | 5 | 0 | 6 | 0 | 6 | 0.39 | 0.57 | 0.58 | 0.46 | 0.59 | 0.65 |
| 4 | 4 | 3 | 0 | 0 | 6 | 0 | 6 | 0 | 6 | 0.39 | 0.58 | 0.58 | 0.46 | 0.55 | 0.65 |
| 5 | 2 | 3 | 0 | 0 | 5 | 0 | 5 | 0 | 6 | 0.41 | 0.55 | 0.60 | 0.52 | 0.55 | 0.71 |
| 5 | 2½ | 3 | 0 | 0 | 5 | 0 | 5 | 0 | 6 | 0.41 | 0.55 | 0.60 | 0.52 | 0.56 | 0.71 |
| 5 | 3 | 3 | 0 | 0 | 5 | 0 | 5 | 0 | 6 | 0.41 | 0.60 | 0.60 | 0.52 | 0.59 | 0.71 |
| 5 | 4 | 3 | 0 | 0 | 6 | 0 | 6 | 0 | 6 | 0.41 | 0.58 | 0.60 | 0.52 | 0.65 | 0.71 |
| 5 | 5 | 3 | 0 | 0 | 7 | 0 | 7 | 0 | 7 | 0.41 | 0.60 | 0.60 | 0.52 | 0.71 | 0.71 |
| 10 | 3 | 3 | 6 | 0 | 6 | 0 | 6 | 0 | 9 | 0.52 | 0.57 | 0.57 | 0.73 | 0.59 | 0.92 |
| 10 | 4 | 3 | 6 | 0 | 6 | 0 | 6 | 0 | 9 | 0.52 | 0.58 | 0.71 | 0.73 | 0.65 | 0.92 |
| 10 | 5 | 3 | 6 | 0 | 7 | 0 | 7 | 0 | 9 | 0.52 | 0.60 | 0.71 | 0.73 | 0.71 | 0.92 |
| 10 | 6 | 3 | 6 | 0 | 7 | 0 | 7 | 0 | 9 | 0.52 | 0.62 | 0.71 | 0.73 | 0.76 | 0.92 |
| 10 | 7 | 3 | 6 | 0 | 8 | 0 | 8 | 0 | 9 | 0.52 | 0.64 | 0.71 | 0.73 | 0.80 | 0.92 |
| 10 | 8 | 3 | 6 | 0 | 9 | 0 | 9 | 0 | 9 | 0.52 | 0.66 | 0.71 | 0.72 | 0.84 | 0.92 |
| 10 | 9 | 3 | 6 | 0 | 9 | 0 | 9 | 0 | 10 | 0.52 | 0.63 | 0.71 | 0.73 | 0.88 | 0.92 |
| 10 | 10 | 3 | 6 | 0 | 10 | 0 | 10 | 0 | 10 | 0.52 | 0.71 | 0.71 | 0.73 | | |
| 12 | 3 | 3 | 6 | 0 | 6 | 0 | 6 | 0 | 10 | 0.57 | 0.57 | 0.76 | 0.80 | 0.59 | 0.99 |
| 12 | 4 | 3 | 6 | 0 | 7 | 0 | 7 | 0 | 10 | 0.57 | 0.58 | 0.76 | 0.80 | 0.65 | 0.99 |
| 12 | 5 | 3 | 6 | 0 | 7 | 0 | 7 | 0 | 10 | 0.57 | 0.60 | 0.76 | 0.80 | 0.71 | 0.99 |
| 12 | 6 | 2 | 6 | 0 | 8 | 0 | 8 | 0 | 10 | 0.57 | 0.62 | 0.76 | 0.80 | 0.76 | 0.99 |
| 12 | 7 | 3 | 6 | 0 | 8 | 0 | 8 | 0 | 11 | 0.57 | 0.64 | 0.76 | 0.80 | 0.80 | 0.99 |
| 12 | 8 | 3 | 6 | 0 | 9 | 0 | 9 | 0 | 11 | 0.57 | 0.64 | 0.76 | 0.80 | 0.84 | 0.99 |
| 12 | 9 | 3 | 6 | 0 | 9 | 0 | 9 | 0 | 11 | 0.57 | 0.68 | 0.76 | 0.80 | 0.88 | 0.99 |
| 12 | 10 | 3 | 6 | 0 | 10 | 0 | 10 | 0 | 11 | 0.57 | 0.71 | 0.76 | 0.80 | 0.92 | 0.99 |
| 12 | 12 | 3 | 6 | 0 | 11 | 0 | 11 | 0 | 11 | 0.57 | 0.76 | 0.76 | 0.80 | 0.99 | 0.99 |

**Table No. (T14 14.18)**

**Dimensions of standard flanged, spigotted and socket tail pieces**

| Nom Int. diameter | | | Thickness | |
|---|---|---|---|---|
| D | A | B | Classes A & B | Classes C & D |
| in. | in. | in. | in. | in. |
| 1½ | 4 | 16 | 0.35 | 0.35 |
| 2 | 4 | 16 | 0.36 | 0.36 |
| 2½ | 5 | 16 | 0.37 | 0.37 |
| 3 | 6 | 18 | 0.38 | 0.40 |
| 4 | 6 | 18 | 0.39 | 0.46 |
| 5 | 6 | 18 | 0.41 | 0.52 |
| 6 | 6 | 18 | 0.43 | 0.57 |
| 7 | 6 | 18 | 0.45 | 0.61 |
| 8 | 6 | 18 | 0.47 | 0.65 |
| 9 | 6 | 21 | 0.49 | 0.69 |
| 10 | 7 | 21 | 0.52 | 0.73 |
| 12 | 7 | 21 | 0.57 | 0.80 |

**Table No. (T15 14.18)**

**Dimensions of standard plugs**

| Int. dia. | A | B | K | Classes A & B Thickness | | | Classes C & D Thickness | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | $t_1$ | $t_2$ | $t_3$ | $t_1$ | $t_2$ | $t_3$ |
| in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| 1½ | 5.0 | 2.58 | 0.63 | 0.35 | 0.54 | 0.36 | 0.35 | 0.54 | 0.36 |
| 2 | 5.0 | 3.10 | 0.63 | 0.36 | 0.55 | 0.40 | 0.36 | 0.55 | 0.40 |
| 2½ | 5.0 | 3.62 | 0.63 | 0.37 | 0.56 | 0.64 | 0.37 | 0.56 | 0.44 |
| 3 | 5.5 | 4.14 | 0.69 | 0.38 | 0.57 | 0.48 | 0.40 | 0.59 | 0.48 |
| 4 | 5.5 | 5.18 | 0.69 | 0.39 | 0.58 | 0.56 | 0.46 | 0.65 | 0.56 |
| 5 | 5.5 | 6.28 | 0.69 | 0.41 | 0.60 | 0.61 | 0.52 | 0.71 | 0.61 |
| 6 | 5.51 | 7.36 | 0.75 | 0.43 | 0.62 | 0.66 | 0.57 | 0.76 | 0.66 |
| 7 | 5.5 | 8.44 | 0.75 | 0.45 | 0.64 | 0.71 | 0.61 | 0.80 | 0.71 |
| 8 | 6.0 | 9.52 | 0.75 | 0.47 | 0.66 | 0.75 | 0.65 | 0.84 | 0.75 |
| 9 | 6.0 | 10.58 | 0.75 | 0.49 | 0.68 | 0.79 | 0.69 | 0.88 | 0.79 |
| 10 | 6.0 | 11.64 | 0.75 | 0.52 | 0.71 | 0.82 | 0.73 | 0.92 | 0.82 |
| 12 | 6.0 | 13.52 | 0.75 | 0.57 | 0.76 | 0.89 | — | — | — |

Note.—The use of plugs with classes C and D pipes over 10 in. dia. is not recommended without some additional means of securing them other than that which is obtained by caulked lead and yarn joints.

**Table No. (T16 14.18)**

**Dimensions of standard caps**

| Nom. Int. dia | A | B | Classes A & B | | | Classes C & D | | |
|---|---|---|---|---|---|---|---|---|
| | | | C | D | M | C | D | M |
| in. | in. | in. | in. | in. | in. | in. | in. | in. |
| 1½ | 3 | 2.96 | 0.95 | 1.20 | 0.67 | 0.95 | 1.20 | 0.67 |
| 2 | 3 | 3.48 | 0.97 | 1.22 | 0.68 | 0.97 | 1.22 | 0.68 |
| 2½ | 3 | 4.00 | 1.00 | 1.25 | 0.70 | 1.00 | 1.25 | 0.70 |
| 3 | 3.5 | 4.52 | 1.04 | 1.29 | 0.73 | 1.04 | 1.29 | 0.73 |
| 4 | 3.5 | 5.56 | 1.09 | 1.34 | 0.76 | 1.09 | 1.34 | 0.76 |
| 5 | 3.5 | 6.66 | 1.11 | 1.36 | 0.78 | 1.11 | 1.36 | 0.78 |
| 6 | 3.5 | 7.74 | 1.15 | 1.40 | 0.81 | 1.15 | 1.40 | 0.81 |
| 7 | 3.5 | 7.74 | 1.18 | 1.43 | 0.83 | 1.18 | 1.43 | 0.83 |
| 8 | 4 | 9.90 | 1.24 | 1.50 | 0.86 | 1.24 | 1.50 | 0.86 |
| 9 | 4 | 10.96 | 1.26 | 1.51 | 0.88 | 1.26 | 1.51 | 0.88 |
| 10 | 4 | 12.02 | 1.29 | 1.54 | 0.90 | 1.29 | 1.54 | 0.90 |
| 12 | 4 | 13.90 | 1.40 | 1.65 | 0.98 | — | — | — |

Note.—Internal grooving of caps shall be the same as for sockets of Standard st pipes of corresponding nominal internal dia (Table 4). Caps for classes A and B pipes over 30 in. nominal dia may be ribbed and strengthened if desired.

The use of caps with class C and D over 10 in. dia is not recommended without some additional means of securing them other than that which is obtained by chaulked lead and yarn joints.

# Strainer

## DEFINITION

By strainer or well screen is meant the pipe with holes or slots from which water is drawn from ground acquifers. The bored or drilled well, where strainers are employed is called the tubewell.

## TYPES OF STRAINER

### 1. Iron Strainer

Strainer made of iron pipes with slits cut or punched were tried but due to rusting and choking of slits were soon replaced by strainers made of copper or brass. Copper was found too soft and brass strainer was adopted as the most suitable.

### 2. Tej Strainer

This is a brass strainer named as Tej strainer after the name of the manufacturing firm and it gave about 1 gallon per minute per inch diameter of strainer. This type of brass strainer with slits was perfected as early as 1910-12 and are being made in sizes of 3", 5", 7", 9" and 10" and boring were made nearly one inch wider than the strainer selected/designed. Thus 4" boring maximum 3" strainer would yield upto 600 gallons, 6" boring maximum 5" strainer would yield upto 20,000 gallons per hour, 8" boring maximum 7" strainer would yield upto 50,000 gallons per hour.

### 3. Ashford or Sarup Bensi Strainer

At the same time Ashford thought of using a brass wire string wound around a brass pipe. Big cut about 4" × 1" were made in the pipe and its outer surface was threaded. In the grooves a brass wire with one flat face was wound. It was soldered at two points on the pipe. The distance between the two pipes was adjusted according to the grain of the sand formation where it was to be installed. It was later on taken up by a manufacturing firm and was generally named as Sarup Bensi Strainer. This brass strainer with slits however continued to be commonly used till recent times for domestic, Irrigation and Agricultural purposes.

### 4. Haigh Strainer

In 1945, a change had to be introduced on account of the non-avalability of brass metal. Wooden strainers were devised by Mr. Haigh. This type of strainer was used throughout the depth of the bore irrespective of the existence of clay or fine sand bands in the formation. The top iron pipe of the tubewell was also replaced by cement concrete. Thus a tubewell was devised for the first time to which all the materials used were innert to chemical and physical action of the water but choking has been observed even in innert strainers like that of wood.

### 5. Ghafoor Strainer

In 1953 Mr. Ghafoor came forward with an idea of his own and devised a gravel packed strainer. This strainer consisted of coated iron flanges to which 3-4 equally spaced stiffners were welded. The length of a piece was four to six feet so that the iron flanges were kept at these distances circular ring of iron flat were also jointed to the stiffners to give extra strength. These were placed usually 2' apart. The segment between each pair of stiffner was covered by 1/4" dia iron bars. The outside area of the bar was filled with porous concrete which consisted of gravel 3/16" to 1/16" size held together by 3 to 5% cement. The thickness of porous concrete, ranged between 2", 2½" to all-round. In some strainers the concrete was laid in layer, the first layer is 1/16" to 3/16". The outer side was protected by a stout wire gauze.

**6. Stainless Steel Strainer**

The latest proposals partly based upon the experience of wide slits iron strainers is to revert to wire type strainers but the wire wound strainer will be of stainless steel instead of brass which is non-corrosion metal. This will be a new experiment in the country as no country has used a stainless steel strainer so for.

**7. Coir Strainer**

From the year 1955 onward the use of coir string strainer is being advocated and commonly used by the individuals. This string is resistant to salts and does not deteriorate when kept in saturated soil. It is very cheap and has proved useful where the sand is fine and water is highly saline.

**8. Cement Asbestos Strainer**

In a quest to devise cheap and durable strainer the research work is in progress on the behaviour of cement Asbestos strainers.

**9. Plastic Strainers**

Experimental tubewells are being installed by the various research institutions with plastic strainers and will be tested finally before advocating their use.

**10. Johnson Well Screen**

This strainer is made by welding rings of mild steel bars with vertical ribs of the same type. The rings are of triangular shape to reduce entrance losses.

## SPECIFICATION

**1. Material.**

The material of the strainer shall be as specified

**2. Size of Slits or Holes.**

The size of slits or holes shall be as specified or directed in writing by the Engineer-in-charge.

**3. Diameter and Thickness.**

By diameter shall be meant the internal diameter in the case of strainers made of sheet metal, the thickness be as specified. In the case of strainers made from wire, the gauge or thickness be as specified.

**4. Joints.**

The Joints shall be socket and spigot, or separate socket collar with threading. The socket shall be of the same thickness as the strainers.

**5. Measurements.**

Measurement shall be in feet measured from end to end of strainer. The unit of measurement shall be one foot.

**6. Rate.**

The rate shall be for supply of strainer at the site as specified in the contract and shall include cost, of socket, spiders and all incidental charges, taxes, etc.

# CHAPTER XV

## MISCELLANEOUS

## ASBESTOS CEMENT SHEETS

### INTRODUCTION

Asbestos Cement products are made by a combination of Portland Cement with asbestos fibres. These are usually fragile and easily breakable by expansion and contraction, by shock and by strong wind. The fibres act as a sort of reinforcement and their products are stronger and more resilient than pure eement sheets. These are available in flat, as well as corrugated form.

### SPECIFICATIONS

#### No. 15.1 Flat Asbestos Cement Sheets

**Quality**

1. Flat sheets shall be rectangular, have a plain surface on one side and shall have neatly trimmed edges.

**Tolerance**

2. The linear dimensions of Flat sheets shall not vary in dimension from those specified by more than 0.25%. They shall be tested for thickness by stacking 20 sheets together and the difference between actual height and the theoretical height shall not exceed 10%.

**Breaking Strength**

3. The average breaking load of 5 square specimens 10" × 10" cut from flat sheets, when tested wet over a 9" span shall not be less than the values given below:—

| Type | Thickness | Tested with the fibres running parallel to the bearers (lbs.) | Tested with the fibres running at right angles to the bearers (lbs.) |
|---|---|---|---|
| Flat Sheets | 3/32" | 34 | 48 |
| | 3/16" | 49 | 69 |
| | 1/ 4" | 88 | 123 |
| | 5/16" | 137 | 192 |
| | 3/ 8" | 196 | 276 |

4. If the breaking strength of any specimen is less than 70% of the average breaking strength of six specimens tested, a further six specimens shall be tested and the results combined with those of the previous 5 results, the lowest result having been eliminated. The breaking strength of any one of 11 specimens shall not be less than 70% of the average breaking strength of the specimens.

**Colours**

5. Pigments that are embodied in the asbestos cement for colouring purposes shall be of permanent colour. They shall not contain substances deleteriously affecting cement, such as lead oxide. The proportions of water soluble chloride and of water soluble sulphates together shall not exceed 2.5 per cent by weight of pigment.

**Quality**

6. The finished product shall be free from visible defects and shall have been manufactured for at least 4 weeks before use.

**Measurement**

7. Flat sheets shall be measured in square feet. The unit of measurement shall be 100 sq. ft.

**Rate**

8. Unit rate shall include furnishing plain asbestos sheets conforming to above specifications at Site of Work as defined in the Conditions of Contract.

## SPECIFICATIONS

### No. 15.2. Corrugated Asbestos Cement Sheets

**Classification**

1. Corrugated sheets shall be classified according to the size and form of the corrugation as follows:—

| Type of Sheet | Depth of Corrugation | Centres of Corrugations |
|---|---|---|
| Small section | Under 2″ | 2½″ and 3″. |
| Large section | 2″ and over | 5½″ and 6″. |
| Alternate Flat and corrugated section | 2″ and over | 13⅓″ usually |

**Tolerance**

2. The sheets shall be corrugated in a true and regular manner. The corrugated sheets shall not vary from the standard dimension of length and width by more than 0.25%.

**Breaking Strength**

3. When tested wet the average breaking load of 3 specimens shall not be less than the values given in the following table:—

| Class of Sheet | Span at which tested | | Minimum width of sheet tested | | Minimum average breaking load per inch width of specimens tested. |
|---|---|---|---|---|---|
| | ft. | in. | ft. | in. | lbs. |
| Small section | 2 | 6 | 2 | 0 | 12 |
| Large section | 3 | 6 | 3 | 0 | 26 |
| Alternate flat and corrugated section | 3 | 6 | 3 | 6 | 26 |

If the breaking strength of a specimen is less than 70% of the average breaking strength of the 3 specimens tested, a further 3 specimens shall be tested and the results combined with the result of the previous two tests, the lowest result having been eliminated. The lowest breaking strength of any one of the 3 specimens shall not be less than 70 per cent of the average breaking strength of the specimens.

**Colour**

4. Pigments that are embodied in the asbestos cement for colouring purposes shall be of permanent colour. They shall not contain substances deleteriously affecting cement, such as lead oxide. The proportions of water soluble chloride and of water soluble sulphates together shall not exceed 2.5 per cent by weight of pigment.

**Quality**

5. The finished product shall be free from visible defects and shall have been manufactured for at least four weeks before use.

**Measurement**

6. Corrugated asbestos sheets shall be measured in Square Feet. The unit of measurement shall be 100 sq. ft.

**Rate**

7. The unit rate shall include furnishing corrugated asbestos cement sheets conforming to above specifications at Site of Work, as defined in the Conditions of Contract.

## SPECIFICATIONS

### No. 15.3 Ballies

**Quality**

1. Ballies shall be of good quality timber properly seasoned, of mature growth, uniform in texture, straight in fibre, free from sapwood and live or dead knots and shall be procured from an approved source.

**Taper**

2. In circumference Ballies shall not have a taper of more than 1 inch in 4 feet.

**Classification**

3. Ballies shall be classified according to length and girth at both ends.

**Measurement**

4. Ballies shall be measured in number. The unit of measurement shall be each bally.

**Rate**

5. The unit rate shall include furnishing ballies conforming to above specifications at Site of Work, to be defined in the Conditions of Contract.

## SPECIFICATIONS

### No. 15.4. Bamboos

**Quality**

1. Bamboo shall be of mature growth, free from splits, weevil rot, borehole and other defects and shall be procured from an approved source. Bamboos of 8 inch girth and over shall be semi-solid (fibre content not less than 75 per cent of cross sectional area).

**Classification**

2. Bamboo shall be classified according to length and girth at both ends.

**Measurement**

3. Bamboo shall be measured in number. The unit of measurement shall be each bamboo.

**Rate**

4. Unit rate shall include furnishing bamboo conforming to above specifications at Site of Work, to be defined in the Conditions of Contract.

## SPECIFICATIONS

### No. 15.5. Water Proof Building Paper

**Quality**

1. Waterproof building or insulating paper shall be of an approved manufacture, stout, strong and thoroughly impregnated with waterproof composition and supplied in roll of standard widths.

**Classification**

2. Building paper shall be classified according to the number of plies or laminations.

**Measurement**

3. Building paper shall be measured in square feet. The unit of measurement shall be 100 square feet.

**Rate**

4. The unit rate shall include furnishing building paper conforming to above specifications at Site Work to be defined in the Conditions of Contract.

## SPECIFICATIONS

### No. 15.6. Flat Sheets

**Quality**

1 (i). Flat steel sheets shall be made of tough mild steel, well annealed, even in temper and thickness, free from holes, cracks, blisters and other defects.

(ii). The sheets shall be perfectly rectangular and the weight of any ten sheets to be within 7½ per cent margin of the weights given in (2) below.

**Weight**

2. The weight and thickness of sheets before galvanizing shall be as follows:—

(a) No. 24 B.-G. to be .02476 inch thick and to weigh 1.01 lbs. per square foot.
(b) No. 22 B.-G. to be .03125 inch thick and to weigh 1.27 lbs. per square foot.
(c) No. 20 B.-G. to be .0392 inch thick and weigh 1.59 lbs. per square foot.

The allowance for increase in weight by galvanising shall be 2 oz. per square foot.

**Galvanizing**

3. Galvanized steel sheets shall be thoroughly and evenly coated with zinc and shall be free from stains, bare spots and other defects.

**Painting**

4. When not galvanized all sheets shall be coated immediately after manufacture with one coat of oil-paint applied by dipping or brushing over the whole of the surface of each sheet.

**Dimensions**

5. The sheets shall be of standard dimensions. The diagonal distance between opposite corner of sheets shall not differ by more than 3/4 inch.

**Measurement**

6. Sheets shall be measured by weight. The unit of measurement shall be one cwt.

**Rate**

7. The unit rate shall include furnishing flat steel sheets conforming to above specifications at Site of Work, to be defined in the Conditions of Contract.

## SPECIFICATIONS

### No. 15.7 Corrugated Steel Sheets

**Quality**

1. Corrugated steel sheets shall be made of tough mild steel, well annealed, even in temper and thickness, free from holes, cracks, blisters and other defects.

2. Corrugated steel sheets shall be perfectly rectangular, the corrugations parallel with the sides and regular in curve, pitch and depth, and the weight of any ten sheets to be within 7½ per cent margin of the weights given in (3) below.

**Weight**

3. The weight and thickness of corrugated steel sheets before galvanizing shall be as follows:—

(a) No. 24 B.-G. to be .02476 inch thick and to weigh 1.01 lbs. per square foot of girthed surface.

(b) No. 22 B.-G. to be .03125 inch thick and to weigh 1.27 lbs. per square foot of girthed surface.

(c) No. 20 B.-G. to be .0392 in. thick and to weigh 1.59 lbs. per square foot of girthed surface. The allowance for increase in weight by galvanizing shall be 2 ozs., per square foot of girthed surface which weight includes both sides.

**Galvanizing**

4. Galvanized corrugated steel sheets shall be thoroughly and evenly coated with zinc, and to be free from stains, bare spots and other defects.

**Paint**

5. When not galvanized, all corrugated steel sheets shall be coated immediately after manufacture with one coat of oil paint applied by dipping or brushing over the whole of the surface of each sheet.

**Corrugations**

6. Unless otherwise specifically ordered the corrugations shall be of standard pattern—3 inches pitch and 3/4 inch deep. The widths shall be as under:—

| | |
|---|---|
| 1.8/3 Corrugations | 2 ft. 2 ins. measured straight and<br>2 ft. 6 ins. measured along the girth |
| 2. 10/3 Corrugations | 2 ft. 8 ins. measured straight and<br>3 ft. measured along the girth. |

**Tolerance**

7. The diagonal distances between opposite corners of any sheet shall not differ by more than 3/4 inch.

**Measurement**

8. Corrugated sheets shall be measured by weight. The unit of measurement shall be one cwt.

**Rates**

9. The unit rate shall include furnishing corrugated steel sheets conforming to above specifications at Site of Work, to be defined in the Conditions of Contract.

## FIRE BRICKS

## INTRODUCTION

**Use**

Fire bricks are used for lining furnaces, boilers, combustion chambers, chimney flues and at places where high temperature is developed.

## COMPOSITION

They are manufactured from fire clay or refractory clay burnt at a high temperature (not less than 2500° F.) for 12 to 14 days in special kilns. They are generally of white or yellowish white colour and close in texture. The dimensions are same as of an ordinary brick.

## SPECIFICATIONS

### No. 15.8. Fire Brick

**Manufacture**

1. Fire brick shall be manufactured from fire clay or refractory clay burnt at a high temperature (not less than 2500 °F).

**Quality**

2. Fire brick shall contain no holes or flaws and the surface shall be free from windings.

**Size**

3. Fire bricks shall be of regular and uniform size.

**Test**

4. A test piece when heated to a temperature of 2462°F shall not show more than one per cent linear expansion and when heated to a temperature of 2876°F. shall show no sign of fusion. They shall not absorb more than 10 per cent of water by weight after an immersion for one hour.

**Measurement**

5. The measurement of fire bricks shall be in numbers. The unit of measurement shall be one thousand bricks.

**Rate**

6. The unit rate shall include furnishing fire brick, conforming to above specifications, sorting and stacking at Site of Work, to be defined in the Conditions of Contract.

## SPECIFICATIONS

### No. 15.9. Matting

**Quality**

1. Matting shall be of the best available quality.

| Type | Details |
|---|---|
| Bamboo | Split bamboo (durma, etc.) woven as closely as possible. |
| Flat leaf | Close woven from strips of any approved palm leaf (khajur, mazri, etc.) or from reeds beaten flat leaves (hogla, etc.) |
| Reed | Any approved kinds of reed (pattal, sarkanda, etc.) bound or laced tightly together with strings as ordered. |

**Measurement**

2. Matting shall be measured in square feet. The unit of measurement shall be 100 square feet.

**Rates**

3. The unit rate shall include furnishing matting conforming to above specifications at Site of Work, to be defined in the Conditions of Contract.

## GLASS

### INTRODUCTION

Glass is an amorphous mixture of silicates of metals possessing the properties of hardness, brittleness and transparency. But modern Glass can be made so soft that it can be bent easily and nailed through very conveniently. Glass has roughly the following composition.

| Constituents | Soda, lime glass, window plate glass, or ordinary glass | Lead glass, high glass glassware, cut glass and special glass |
|---|---|---|
| Silica | 70 to 76% | 50% |
| Lime | 10 to 13% | — |
| Soda | 10 to 13% | — |
| Potash | — | 17% |
| Red Lead | — | 33% |
| Alumina | 2 to 4% | — |

## MANUFACTURE OF GLASS

The raw materials mentioned above are ground and sieved. They are then mixed in specified proportion and melted in a furnace termed as a "Tank Furnace". Raw materials are fed into it at one end and moulten glass liquid is drawn out from the other end. Glass materials are prepared from this hot and viscous glass fluid by fibrication which comprises the following processes:—

(a) **Blowing.** The blow pipe is dipped in the liquid glass to take out a small quantity of moulten mass. It is then blown through to form a bulb and then a hollow cylinder which is subsequently cut and spread out to form a thin plate. The process of blowing could be done by a single blow pipe by an individual or through a series of blow pipes working automatically with the aid of a compressed air cyliner.

(b) **Flat Drawing and Rolling.** The viscous fluid is drawn in the form of plate by making an iron bar move sidewise through it. It brings with it a thin film of glass. Sheet glass could also be prepared by the process of rolling. A continuous sheet is formed and the required size could be cut out from it. Rolled Glass is more plain and has a more even surface than the drawn glass.

## TYPES OF GLASSES

1. **Polished plate glass.** It is a transparent glass, the two surfaces of which have been ground, smoothed and polished so that they are flat and parallel allowing clear, undistorted vision and reflection. It is available in three grades, namely:—

(1) Glazing Glass for general glazing purposes (2) Selected glazing quality for better glass work; also for mirrors and bevelling and (3) Silver quality; for high grade mirrors and for all purposes where a super fine glass is required. Various colours of polished plate glass availble are (1) Pink (2) Amber (3) Green (4) Blue and (5) Champagne. Polished plate glass may be processed to provide varying degrees of obscuration and light diffusion. Sandblast, acid or emery may be employed for this purpose. It is commonly used for public, commercial and domestic buildings, hospitals, schools, office blocks, shop windows, show cases, etc. Its high quality enhances the exterior appearance of buildings. It is usually available in 1/4 inch thickness and in varying dimensions starting from $8 \times 10$ inches, up to $60 \times 100$ inches.

2. **Sheet glass (flat drawn).** Sheet glass is another variety of transparent glasses. It has a fine finished surface and as the two surfaces are never perfectly flat and parallel there is always a certain degree of distortion of vision and reflection. It is usually available in two qualities, namely (1) ordinary glazing quality, suitable for general glazing purposes and (2) selected glazing quality, for work requiring a selected sheet glass above the ordinary glazing quality. It is usually avilable in the following weights and dimensions:—

| Thickness | Possible Variation in Weight per sq. foot | Usual size |
|---|---|---|
| (a) 24 ozs. approximate 1/10 inch | $22\frac{1}{2}$—$25\frac{1}{4}$ ozs. | 66" × 44" |
| (b) 26 ozs. approximate 1/8 inch | 26—$28\frac{3}{4}$ ozs. | 66" × 44" |
| (c) 32 ozs. approximate 5/32 inch | $31\frac{3}{4}$—$35\frac{1}{4}$ ozs. | 66" × 44" |

24 ozs. sheet glass is the minimum thickness normally used for glazing. A still thinner glass, 18 oz.

is available, but is not recommended for ordinary glazing purposes. It is commonly used in houses, factories, horticultural purposes, etc. where clear undistorted vision is not required.

3. **Rolled Glasses.** There is a wide range of rolled glasses. A few of them are mentioned here.

(a) **Figured Rolled Glasses.** It is a translucent glass, one surface of which has a texture or pattern; thus producing a varying degree of diffusion and obscuration. They are usually available in 1/8 in. thickness and have an approximate weight of 1½ lbs. per square foot. It is usually employed for glazing where partial or total privacy is required, for instance—bathroom, etc., in domestic buildings, for office partitions and factories where good lighting without glare is required.

(b) **Cathedral Rolled Glasses.** This is another variety of translucent glass and is recommended for all types of glazing where direct vision is not desired and obscuration is not essential but where high light transmission is necessary. Typical uses are in partitions, in offices and in warehouses, and for external glazing in rooms or offices where occupants do not wish to be overlooked and yet desire maximum light transmission.

| Thickness | Approximate Weight per Sq: Foot | Size |
|---|---|---|
| 3/16″ | 2 lbs. 10 oz. | 146″ × 48″ |
| 1/4″ | 3 lbs. 7 oz. | 146″ × 48″ |
| 3/8″ | 5 lbs. 1 oz. | 146″ × 48″ |

(c) It is commonly used for sky-lights and roofings and for vertical windows in factories, warehouses, etc., where direct vision is not required.

(d) **Plain Rolled Glass.** A translucent rolled glass one surface of which bears a pattern consisting of narrow parallel ribs (approximately 19 to the inch). These ribs promote a considerable amount of diffusion in a direction perpendicular to the ribs and reduce direct glare from the sun. It is usually available in 1/8 inch thickness weighs about 1 lb. 13 oz. per sq. foot and has an overall dimension of 120″ × 48″. It is commonly employed as a substitute for "Rough Cast" in order to promote diffusion and reduce glare from direct sun shine.

(e) **Fleeted and feathered glass.** A rolled translucent glass on one side of which is impressed a pattern consisting of broad parallel flutes or wide feathered ribs approximately 3 to the inch. It is available in 1/4 inch thickness weighs about 3½ lbs. per sq. foot and has an overall dimension of 120″ × 48″. It is commonly employed for wash boards and for decorative and illuminating purposes.

(f) **Luminating glass.** A rolled translucent glass on one side of which is impressed a pattern consisting of parallel reeds approximately 6 to the inch. It is usually available in 1/8 inch thickness weighs about 1 lb. 10 oz. per square foot and has an overall size of 120″ × 48″. It is used for decorative and illuminating purposes.

4. **Wired Glass.** A glass with a wiremesh (square or hexagonal) embedded in it during the process of rolling. It is valuable for safety purposes and has an efficient fire retardegative. It is commonly employed for glazing roof lights and lantern lights also for the vertical windows in warehouses, factories, workshops, etc. where maximum protection is needed against shocks.

5. **Armour-plate glass.** It is made by subjecting ordinary polished plate glass to a process of heating and sudden cooling, which results in a glass of greatly increased mechanical strength and much

more resistance to impact and to large and sudden changes in temperature. When broken it disintegrates into small pieces which do not have the dangerous cutting edges of ordinary glass. It is available in wide range of dimensions. It is commonly employed for purposes where a strong, heat resisting glass is required; for example shelves, tabletops, cookers, doors, display signs, electric fire, flood lighting, hospital lockers, screens, windows for mental hospitals, shops and shop fronts, trolley tops, ship's side scuttles and port lights, and in many industrial applications.

6. **Armour Light Glass.** This glass is obtained by a development of the armour plate glass whereby blown or pressed glass can be toughened. The degree to which an article can be toughened depends on the shape and thickness of the glass. It is commonly employed where resistance to impact or thermal shock is necessary; for example, for roof and pavement lenses, high voltage insulation well glasses, bulk head glasses and globes, etc.

7. **Light Refracting Glass.** This is rolled glass one surface of which consists of parallel prisms which reflect the light passing through them according to the angle of the prisms. It is also named as prismic glass. It is usually available in 1/4" thickness, weighs about 3 lbs. per sq. ft. and has an overall dimension of 100"×48". It is commonly employed for glazing windows overshadowed by adjacent buildings.

8. **Anti-fly Glass.** An amber-tinted glass designed as an effective deterrent against house flies and is valuable for use in windows of buildings connected with storage of food. Usually it is available in 1/8 inch thickness.

9. **Anti-Gun Glass.** A high quality polished plate glass which absorbs heat without reducing unduly the light transmission. It has a light greenish tint. The light transmission factor for sun light is of the order of 72 to 80 per cent and where the glass is exposed to solar radiation about 40 to 50 per cent of the total radiation is transmitted. It is used for glazing of offices, schools, hospitals, factories, airports and control towers, etc., and in all instances where climatic or other local conditions demand the use of a glass with these special characteristics

10. **Calorex.** It is a heat absorbing glass in rolled, polished or clear sheet form and absorbs about 80 per cent of solar infra-red rays. It permits the passage of about 60 per cent of visible light and has a soft greenish tint. It is employed in situations where a reduction of the transmission of the sun's radiant heat is required without undue loss of light.

11. **Coloured Sheet Glasses.** These are of two types, flashed and part coloured glass. The flashed glass are those in which, during manufacture, a thin layer of a coloured metal is imposed upon a clear sheet base metal. Part coloured glasses are those in which the colour is introduced by dyeing the glass in the mass. They are available in self colours, black, white, green, cream primrose, pearl grey, egg shell, ivory, etc. It is commonly employed for wall lighting in bath rooms, kitchens, corridors, hairdressing saloons, cinema halls, external facing of buildings, operating theatres and table tops, etc.

12. **Pressed Glass.** The term "pressed glass" embraces pavement lights, decorative moulded panels and certain types of glass tiles, etc. The glass liquid is pressed into moulds of requisite dimensions and shape.

13. **Safety and Bulletproof Glass.** Laminated glass, built up of layers of glass between which are cemented layers of a colourless transparent plastic resembling celluloid, is called shatterproof or safety glass. The chief use of glass of this type is in automobiles, but it is also used for sky-lights and in the windows of asylums. Bulletproof glass or bullet resisting glass is a thick safety glass used in banks. Ordinary safety glass is 1/8 to 1/4 inch thick but bulletproof glass has several laminations built up of thicknesses to 2 inches. The thickness most commonly used is 1¼ inches. This glass will not be penetrated by bullets from most firearms which might be used, but 2-inch glass is recommended to resist

shots from a 303 rifle. These types of glass will crack under impact but the plastic layers hold the various pieces of glass together so that it does not shatter.

## WORK ON GLASS

In order to cut various decorative designs on the surface of glass and to give different shades and colours the following processes are employed.

1. **Acid Embossing or Etching.** It is the most common method of working on the surface of glass and owes its existence to the property possessed by hydrofluoric acid of dissolving glass when applied to polish plate glass, the acid dissolves the surface, leaving it comparatively clear; but, by adding an alkali such as ammonia a dense white frosted appearance is obtained. This combination of acid and alkali treatment is known as white acid and by subsequent acid treatment as many as four or five tones can be obtained, each one slightly less obscured than the last. Stippling or stippled acid finishes are obtained by strewing grains of mica evenly over the surface of glass before flooding with acid. The acid is more active where the mica has not settled on the glass and a stippled texture results, the coarseness or fineness of the stipple being determined by the size of the mica grain used. The finishes which constitute acid etching are (1) Single Acid—a design worked on a white acid surface with a further acid process, so that two shades are produced (ii) Double Acid—A design worked on a white acid surface with two further acid processes, so that three shades are produced (iii) Double or Furnish Acid—A design worked on a white acid surface with three or more acid processes, so that four or more shades are produced.

2. **Brilliant Cutting and Edge work.** It is a decorative process used for cutting design on glass surfaces, the design being cut by bringing the glass to bear on a revolving sand-stone wheel, after which it is smoothed and polished. Various standard types of cut that can be worked are: V cut, edge cut, round cut, panel-cut, round punt, oval punt and hollow or finger grip.

3. **Edge work and Bevelling.** These are processes whereby the cut edges of glass are worked to produce various shapes, the most common being arrises edge, flat edge, rounded edge, half round, full round, thumb or bull nose. Bevel, mitre bevel single side, mitre bevel both sides, step bevel and feather edge bevel.

4. **Sandblasting.** Sandblasting comprises of deep sandblast, light sandblast and shaded sandblast. Each process is employed for different purposes as described below:—

Deep sandblasting or grave sandblast bites deeply into the glass and can be used where a design of varying depth is required.

Light sandblast gives a flat obscured effect and is applied to the whole surface of glass or in the form of lines, or in any flat decorative design. It also provides a base for painted lines or sprayed paint finishes.

Shaded sandblast is a process by which a design of delicate graduation can be produced.

5. **Silvering.** Any form of glass may be silvered for decorative purposes, but for mirror it is necessary to use selected quality polish plate. Gunmetal or dull grey silvered mirrors are obtained by depositing a special grey alloy on polished plate glass whereas other forms of tinted mirrors are usually produced by depositing silver on tinted polished plate glass.

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