FOREWORD

India is on the path of rapid development and urbanization. In the process, huge investments are being made in buildings and infrastructure development. It is imperative that all such constructions being done are safe, durable and sustainable. Building materials form the most fundamental contributor to all types of construction activities. Also, as a result of continuous research and development number of new competing building materials and construction technologies are being developed on regular basis.

In order to ensure that all such traditional and new/innovative materials are of requisite quality, it is necessary to lay down their requirements and test methodologies. As the National Standards Body (NSB) of the country, the **Bureau of Indian Standards (BIS)** has developed a comprehensive set of Indian Standard specifications for each of these materials along with their methods of test. These standards are extensively used by building professionals like architects, civil and structural engineers, and building services engineers; construction departments and agencies, constructors, builders and developers; building material manufacturers; testing laboratories; R&D institutions; etc.

It is also important that the students of various technical education institutions, who are our future building professionals, are fully conversant with and trained in these standards, so that they are industry-ready when they pass out of the institutions. It is therefore with great enthusiasm and deep sense of responsibility that BIS brings out this **Reference Handbook on Building Materials**, which is meticulously crafted to promote and integrate Indian Standards with the educational curriculum.

This book is more than a mere compendium of technical information; it is a vital resource designed to bridge the gap between theoretical knowledge and practical application. By emphasizing Indian Standards, it aligns educational institutions with the national framework, fostering a deeper understanding and adherence to these crucial benchmarks among students, educators, and even industry professionals.

As the construction industry stands as a cornerstone of economic growth and societal advancement, this handbook offers the students a comprehensive set of information and framework that helps promote quality, durability, safety and sustainability in construction. This reference book also serves as an invaluable tool for faculty members, offering clear explanations, practical information, and detailed references that will enrich the curriculum and enhance the teaching-learning experience.

It is also to note that BIS operates certification scheme thereby making available the BIS certified building materials with BIS Standard Mark (ISI Mark) for the products conforming to the relevant Indian Standard Specifications. Information about various Indian Standards and BIS Certification, and BIS certified products and their manufacturers can be had from the BIS website: www.bis.gov.in or the **BIS Care App**.

I take this opportunity to thank **Shri Pramod Kumar Tiwari, Director General, BIS** on whose initiative, guidance and inspiration this reference handbook has been brought out. The information contained in this handbook is largely based on Indian Standards. Some photographs have been taken from internet sources only for general illustration purposes, which are duly acknowledged herewith.

CONTENTS

INTRODUCTION

INTRODUCTION

From the earliest times of civilization, construction including building construction has played an important role which continues to occupy a position of prime importance in the development of countries and their infrastructure. One of the pre-requisites of a good construction is availability and selection of right building materials. The quality of building materials along with good workmanship play an important role in ensuring sound, safe, durable and aesthetically pleasing construction of buildings and other structures.

Indian Standards formulated by **Bureau of Indian Standards (BIS)** play an important role in characterizing the building materials by specifying their physical, mechanical and chemical requirements apart from classifying the materials into different classes, types, grades or varieties suitable for various end applications.

Building materials essentially form the embodied energy of the structures and coupled with the operational energy of the built environment, it greatly affects the total energy and thus the sustainability of the built facility. Indian Standards also help in optimizing the embodied energy through facilitating recycling of materials, use of alternative/ non-conventional raw materials, waste utilization and economic design of structures and their elements.

For the purpose of better understanding the entire spectrum of building materials, the same may be classified into various categories and their sub-categories as enlisted alphabetically in **Annex 1**. For complete list of Indian Standards Specifications and Methods of Test under each of these categories/sub-categories, a reference may be made to Part 5 'Building Materials' of the SP 7 : 2016 **'National Building Code of India 2016' (NBC 2016)** published by BIS. For guidance regarding sustainability in built environment, a reference may be made to **Part 11 'Approach to Sustainability'** of NBC 2016.

This publication gives a brief introduction about some of the important building materials and components, and the relevant Indian Standard Specifications and Methods of Test on the same. **For complete and latest details of the provisions of these Indian Standards and for use in the context of any project or contract, a reference may be made to them.** These indigenous Indian Standards are available for free download from the BIS website www.bis.gov.in

CHAPTER I

CEMENT

CHAPTER I

CEMENT

1.1 General

Hydraulic cement, more commonly known as 'cement', is one of the most extensively used basic materials in all civil engineering constructions. Tremendous progress in the civil engineering industry and the exacting demands of engineers for high quality building materials have resulted in the development of a large variety of hydraulic cements, both for general and specialized use in civil engineering constructions.

Hydraulic cement is finely ground material which on addition of requisite quantity of water is capable of hardening both under water and in air by the chemical interaction of its constituents with water, and is also capable of blending together appropriate materials.

Cement is obtained by intimately mixing together a calcareous material such as limestone or chalk, and an argillaceous material (that is, silica, alumina and iron oxide bearing material), for example, clay or shale, burning them at a clinkering temperature of 1400 °C to 1450 °C and grinding the resulting clinker with gypsum (natural or chemical). Since the raw materials consist mainly of lime, silica, alumina and iron oxide, these form the major elements in cement also. Cement may be supplied in bags, drums and in bulk.

Important properties of cement which determine its suitability for different applications are fineness, setting time, soundness and compressive strength.

Indian Standards specifications give requirements with respect to such properties as above and the standard methods of test give the procedure for evaluating the same. These standards thus become important basis for utilization of cements for appropriate applications, such as low strength cement may be suitable for low strength applications such as lean concrete, small elements/structures bearing less loads/forces, small buildings, etc; medium strength cement may be suitable for bigger/medium strength bearing components/structures; and high strength cement may be suitable for high strength components, tall buildings, long span structures, bridges and flyovers. Here, for proper mix design of concrete using appropriate cements, mineral admixtures and chemical admixtures, a reference need to be made to IS 10262:2019 'Concrete mix proportioning – Guidelines (*second revision*)'.

1.2 Specifications

Following are some of the most common types of cements and their Indian Standards

a) *Ordinary Portland Cement* (IS 269:2015)

This is the most common type of cement which is uses for all applications depending on strength requirements. It may be of comprehensive strength classes of 33 grade, 43 grade and 53 grade having compressive strengths as follows:

Grade	*Compressive Strength Requirements*	
	Min	Max
33 Grade	33 MPa	48 MPa
43 Grade	43 MPa	58 MPa
53 MPa	53 MPa	-

b) *Portland Slag Cement* (IS 455:2015)

It is an intimately interground mixture of Portland cement clinker and granulated slag with addition of gypsum and permitted additives or an intimate and uniform blend of ordinary Portland cement and finely ground granulated slag with addition of ground gypsum, if required. The granulated slag constituent is not less than 25 percent and not more than 70 percent by mass of Portland slag cement. This cement has only one class having minimum compressive strength of 33 MPa.

c) *Portland Pozzolana Cement: Fly Ash Based* [IS 1489 (Part 1):2015]

It is an intimately interground mixture of Portland cement clinker/ordinary Portland cement and pozzolana with the possible addition of gypsum or an intimate and uniform blending ordinary Portland cement and fine pozzolana with addition of ground gypsum, if required. The fly ash constituent is not less than 15 percent and not more than 35 percent by mass of Portland pozzolana cement. This cement has only one class having minimum compressive strength of 33 MPa.

d) *White Portland Cement* (IS 8042 : 2015)

It is manufactured by intimately grinding the Portland cement clinker with appropriate proportion of natural or chemical gypsum so as to produce a cement capable of displaying degree of whiteness of minimum 70 percent. The degree of whiteness is measured by noting the reflectivity of the compact cement surface with standard magnesium oxide blocks of certified reflectivity on absolute scale with the help of a suitable apparatus, for example, a reflectometer or reflectance spectrophotometer. This cement has only one class having minimum compressive strength of 33 MPa.

e) *Composite Cement* (IS 16415:2015)

It is manufactured by intimately interground mixture of Portland cement clinker, granulated slag and fly ash with addition of gypsum (natural or chemical) or an intimate and uniform blending of ordinary Portland cement, finely ground granulated slag and fine fly ash with addition of ground gypsum, if required.

FIG. 1 CEMENT

The complete list of Indian Standard Specifications for various types of cements is given below for making further reference to the same:

SI No.	IS Number	Title
1	IS 269:2015	Ordinary Portland cement – Specification (*sixth revision*)
2	IS 455:2015	Portland slag cement – Specification (*fifth revision*)
3	IS 1489 (Part 1):2015	Portland pozzolana cement – Specification: Part 1 Fly ash based (*fourth revision*)
4	IS 1489 (Part 2):2015	Portland pozzolana cement – Specification: Part 2 Calcined clay based (*fourth revision*)
5	IS 3466:1988	Specification for masonry cement (*second revision)*
6	IS 6452:1989	Specification for high alumina cement for structural use (*first revision*)
7	IS 6909:1990	Specification for supersulphated cement (*first revision*)
8	IS 8041:1990	Specification for rapid hardening Portland cement (*second revision)*
9	IS 8042:2015	White Portland cement – Specification (*third revision*)
10	IS 8043:1991	Specification for hydrophobic Portland cement
11	IS 8229:1986	Specification for Oil-well Cement
12	IS 12330:1988	Specification for sulphate resisting Portland cement
13	IS 12600:1989	Specification for low heat Portland cement
14	IS 16415:2015	Composite cement – Specification
15	IS 16993:2018	Microfine ordinary Portland cement – Specification
16	IS 18189:2023	Portland calcined clay limestone cement – Specification

1.3 Test Methods

Testing of cement is the most important component of quality assurance of cement, while tests would vary depending on type of cements, the usual tests carried out on cement are:

a) *Blaines Air Permeability Test* – The test is done for determining the fineness of cement. The method is based on the permeability to flow of air through a bed of cement. The fineness is expressed as specific surface area per gram of cement.

b) *Initial and Final Setting Times* – These are measured by vicat apparatus, with different penetrating attachments. The term 'setting' is used to described the stiffening of cement paste, and the 'initial set' and 'final set' are used to describe arbitrary chosen stages of setting.

c) *Soundness* – The soundness of cement is determined in an accelerated manner by Le-Chatelier apparatus. The test detects unsoundness due to free time only.

Unsoundness due to magnesia present in the raw materials from which cement is manufactured, is determined by autoclave test. This test is sensitive to both free lime and free magnesia. In this test high pressure steam accelerates the hydration of both magnesia and lime. The results of the autoclave test are affected by, in addition to the compounds causing expansion, the C_3A content.

d) *Compressive Strength* – The compressive strength of cement is determined on 1:3 cement-sand mortar cube specimens with standard graded sand, cast and cured under controlled conditions of temperature and humidity. The water content in the mix is determined as (P/4 + 3) percent by mass of cement and sand, where P is percentage of water required for standard consistency. In most cases, it corresponds to a water-cement ratio of 0.37 to 0.42. The comprehensive strength is evaluated at 3, 7 and 28 days curing of cubes.

e) *Chemical Analysis* – The chemical analysis is carried out to determine the oxide composition of cement. The percentage of main compounds in cement (that is, C_3S, C_2S, C_3A and C_4AF) can be calculated from oxide composition. In addition to the main compounds, two of the minor compounds are of interest. They are alkalis – Na_2O and K_2O. Some of the compounds such as MgO and SO_3 are also important from the point of view of limiting these from durability considerations. The insoluble residue determined by treating cement with hydrochloric acid, is a measure of impurities in ordinary Portland cement, largely arising from impurities in gypsum. The loss on ignition shows the extent of carbonation of free and hydration due to the exposure of cement to the atmosphere.

The equipment used for testing such as Blaines air permeability apparatus, pressure gauge in autoclave test, vibration machine, etc are calibrated periodically and specified temperature and humidity conditions are maintained to ensure correctness of results.

The following Indian Standards lay down the test methods for checking the quality of various types of cements:

SI No.	**IS Number**	**Title**
1	IS 4031 (Part 1):1996	Methods of physical tests for hydraulic cement: Part 1 Determination of fineness by dry sieving (*second revision)*
2	IS 4031 (Part 2):1999	Methods of physical tests for hydraulic cement: Part 2 Determination of fineness by Blaine air permeability method (*second revision)*
3	IS 4031 (Part 3):1988	Methods of physical tests for hydraulic cement: Part 3 Determination of soundness (*first revision*)
4	IS 4031 (Part 3):1988	Methods of physical tests for hydraulic cement: Part 3 Determination of consistency of standard cement paste (*first revision*)
5	IS 4031 (Part 5):1988	Methods of physical tests for hydraulic cement: Part 5 Determination of initial and final setting times (*first revision*)

6	IS 4031 (Part 6):1988	Methods of physical tests for hydraulic cement: Part 6 Determination of compressive strength of hydraulic cement other than masonry cement (*first revision*)
7	IS 4031 (Part 7):1988	Methods of physical tests for hydraulic cement: Part 7 Determination of compressive strength of masonry cement (*first revision*)
8	IS 4031 (Part 8):1988	Methods of physical tests for hydraulic cement: Part 8 Determination of transverse and compressive strength of plastic mortar using prism (*first revision*)
9	IS 4031 (Part 9):1988	Methods of physical tests for hydraulic cement: Part 9 Determination of heat of hydration (*first revision*)
10	IS 4031 (Part 10):1988	Methods of physical tests for hydraulic cement: Part 10 Determination of drying shrinkage (*first revision*)
11	IS 4031 (Part 11):1988	Methods of physical tests for hydraulic cement: Part 11 Determination of density (*first revision*)
12	IS 4031 (Part 12):1988	Methods of physical tests for hydraulic cement: Part 12 Determination of air content of hydraulic cement mortar (*first revision*)
13	IS 4031 (Part 13):1988	Methods of physical tests for hydraulic cement: Part 13 Measurement of water retentivity of masonry cement (*first revision*)
14	IS 4031 (Part 14):1989	Hydraulic cement - Methods of physical tests: Part 14 Determination of false set
15	IS 4031 (Part 15):1991	Methods of physical tests for hydraulic cement: Part 15 Determination of fineness by wet sieving
16	IS 4032:1985	Method of chemical analysis of hydraulic cement (*first revision*)

Apart from the above, following are the Indian Standards laying down instrumental methods for speedier testing of cements:

SI No.	**IS Number**	**Title**
1	IS 12423:1988	Method for colorimetric analysis of hydraulic cement
2	IS 12803:1989	Methods of analysis of hydraulic cement by X-ray fluorescence spectrometer
3	IS 12813:1989	Method of analysis of hydraulic cement by atomic absorption spectrophotometer

1.4 Stacking and Storage

Cement is a hygroscopic material and deteriorates fast with exposure to moisture. Cement should be stored at the work site in a building or a shed which is dry, leakproof

and as moisture-proof as possible. The building or shed for storage should have minimum number of windows and close-fitting doors and these should be kept closed as far as possible.

Cement stored and stacked in bags should be kept free from the possibility of any dampness or moisture coming in contact with them. Cement bags should be stacked off the floor on wooden planks in such a way as to keep about 150 mm to 200 mm clear above the floor. The floor may be made of lean cement concrete or two layers of dry bricks laid on well consolidated earth. A space of 600 mm minimum should be left all-round between the exterior walls and the stacks (see Fig. 2).

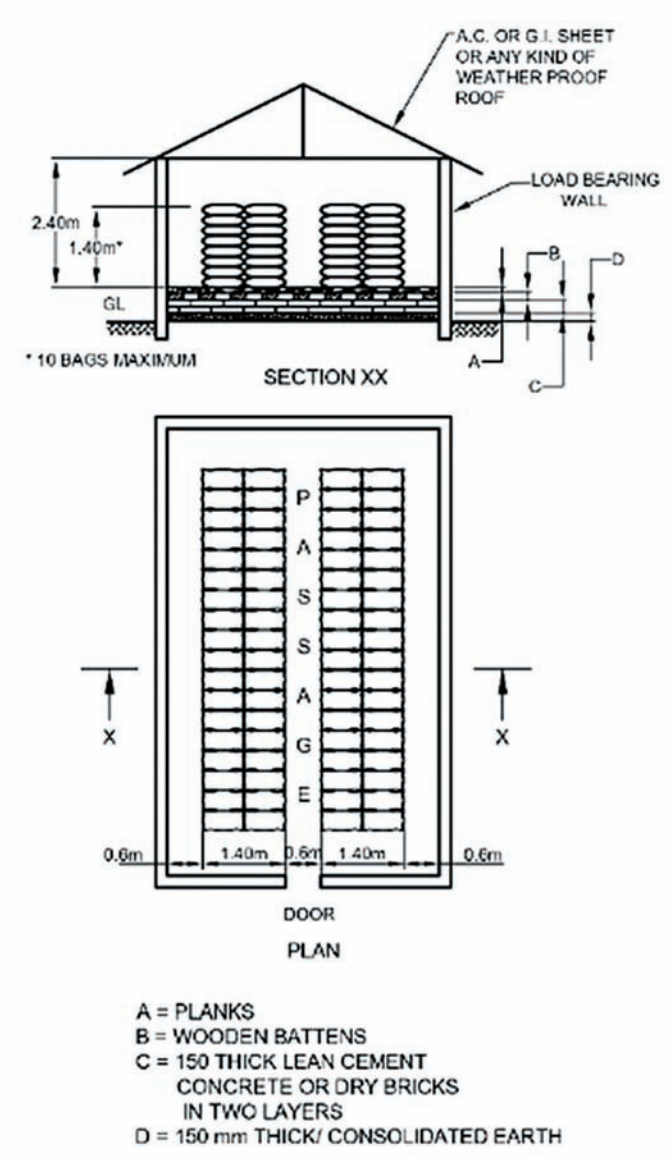


FIG. 2 TYPICAL ARRANGEMENT IN CEMENT GODOWN

For complete details on staking and storage of cement, a reference may be made to IS 4082:1996 'Stacking and storage of construction materials and components at site - Recommendations (*second revision*)'.

CHAPTER II

BRICKS

Chapter II

BRICKS

2.1 General

Bricks are most commonly used building material used as building blocks in construction work particularly in masonry work. Common burnt clay bricks may be hand-made or manufactured using suitable mechanized process. The following Indian Standards provide guidance in this regard:

SI No.	IS Number	Title
1	IS 2117:1991	Guide for manufacture of hand-made common burnt clay building bricks (*third revision*)
2	IS 11650:1991	Guide for manufacture of common burnt clay building bricks by semi-mechanized process (*first revision*)

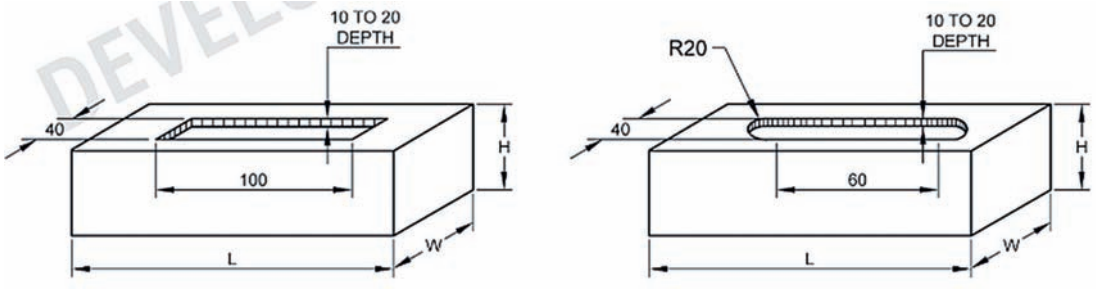
Similarly, for guidance for manufacture of stabilized soil bricks/blocks, a reference may be made to IS 17165:2020 'Manufacture of stabilized soil blocks – Guidelines'.

Bricks may be modular or non-modular in size. The standard modular sizes of bricks are as follows (see Fig. 3A and Fig 3B):

Length (L)mm	Width (B)mm	Height (H)mm
190	90	90
190	90	40

The following non-modular sizes of the bricks may also be used (see Fig. 3A and Fig. 3B):

Length (L)mm	Width (B)mm	Height (H)mm
230	110	70
230	110	30



3A 3B

FIG. 3 SHAPE AND SIZE OF FROGS IN PULVERIZED FUEL ASH-CEMENT BRICKS

Bricks are classified on the basis of average compressive strength mainly into the following classes:

Sl No.	Class Designation	Average 28-Day Wet Compressive Strength, MinN/mm^2
i)	15	15
ii)	12.5	12.5
iii)	10	10
iv)	7.5	7.5
v)	5	5
vi)	3.5	3.5

2.2 Specifications

Based on the material used in the manufacture of bricks and their applications, the bricks may be classified as follows:

a) Burnt Clay Bricks

1) *Common Burnt Clay Solid Bricks* (IS 1077:1992) –The burnt clay building bricks are most commonly used in building and civil engineering construction work, and in these frogs do not exceed 20 percent of the brick volume. These have minimum average comprehensive strength of wide range up to 40 N/mm^2 and maximum average water absorption of 15 percent, but generally available from 3.5 N/mm^2 to 15 N/mm^2. Bricks with more than 40 N/mm^2 are designated as heavy duty bricks.

FIG. 4 COMMON BURNT CLAY SOLID BRICKS

2) *Perforated Bricks* (IS 2222:1991) – In these bricks, the perforations, which may be circular or square or rectangular, pass through the thickness of the brick. The area of each perforation does not exceed 500 mm^2, and total area of perforations is between 35 percent and 45 percent of the total area of the corresponding face of the brick. These bricks are light in weight and provide better thermal insulation as compared to common bricks and are therefore suitable for use in walls and partitions where thermal insulation is an important consideration.

FIG. 5 PERFORATED BRICKS

3) *Hollow Bricks/ Blocks* (IS 3952:2013) – In these bricks, the volume of holes passing through the brick/block is more than 25 percent of the total volume of the brick/ block and the holes shall not be small. The hollows may be at right angle or parallel to the bearing surface These bricks are light in weight and being hollow, impart thermal insulation to the building. These may be of the following types:

Type A — Bricks/blocks with both faces keyed for plastering or rendering;

Type B — Bricks/blocks with both faces smooth and suitable for use without plastering or rendering on either side; and

Type C — Bricks/blocks with one face keyed and one face smooth.

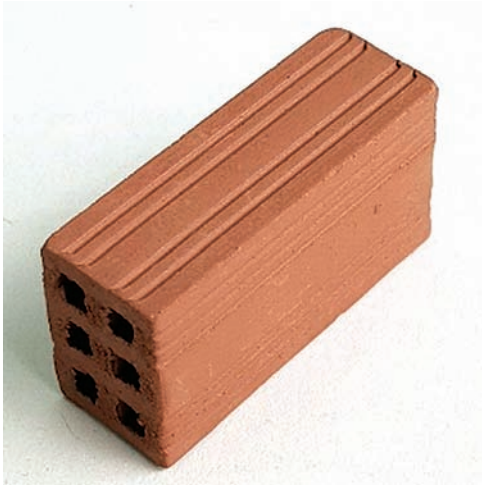


FIG. 6 HOLLOW BRICKS/BLOCKS

4) *Facing Bricks* (IS 2691:2017) – These bricks are made specially for facing purpose, that is, for use in the exposed face of masonry without any further surface protection. Where external plastering or renderings have to be frequently renewed due to corrosive atmosphere and also for high rise buildings where maintenance of exposed bricks walls is expensive, use of facing bricks prove economical. The bricks are so manufactured such that they are free from cracks, flaws and nodules of free lime and have an even texture. These are thoroughly burnt and have plane rectangular faces with parallel sides and sharp straight right-angled edges making them suitable for use for facing purpose.

FIG. 7 FACING BRICKS

5) *Heavy Duty Bricks* (IS 2180:1988) – These bricks are required for masonry in heavy engineering work, such as, bridge structure, industrial foundations and multi-storeyed buildings having high durability and compressive strength and low water absorption of maximum average value of 10 percent. These bricks have compressive strength as follows:

SlNo.	**Class Designation**	**Average 28-Day Wet Compressive Strength N/mm²**
i)	40	40-45
ii)	45	45, *Min*

6) *Sewer Bricks* (IS 4885:1988) – These bricks are intended for use in the lining of walls, roofs and floors of sewers used for the ordinary sanitary (domestic) sewage. As compared to common burnt clay building bricks which has generally lower compressive strength and higher water absorption, these bricks have minimum average comprehensive strength of 17.5 N/mm^2 and water absorption of maximum average water absorption of 10%.

7) *Soling Bricks* (IS 5779:1986) – These bricks are used as soling material for roads. They are different from common building solid bricks. As compared to common burnt clay building bricks which has generally lower compressive strength and higher water absorption, these bricks have less rigidity, minimum average comprehensive strength of 10 N/mm^2 and maximum average water absorption of 20%.

8) *Paving Bricks* (IS 3583:1988) – These bricks are used as a paving material for roads, heavy duty industrial floors, particularly suited to resist heavy wear and tear from steel tyred traffic. The bricks shall be mechanically shaped and not hand moulded. The burning process shall be so controlled that the bricks are thoroughly burnt, annealed, tough and durable so that, when broken, bricks show a uniformly dense structure free from lime, large voids and marked laminations. These bricks have minimum average comprehensive strength of 40 N/mm^2 and maximum average water absorption of 5 percent.

FIG. 8 PAVING BRICKS

9) *Burnt Clay Fly Ash Bricks* (IS 13757:1993) – These bricks promote use of fly ash waste generated from thermal power plants in the manufacture of burnt clay bricks and in the process helps in saving precious top soil of the earth.

b) *Fly Ash Lime Bricks* (IS 12894:2002) – Pulverized fuel ash (such as fly ash) lime bricks are obtained from materials consisting of pulverized fuel ash in major quantity, lime and additive such as gypsum. Pulverized fuel ash-lime bricks are manufactured by intergrinding or blending various raw materials which are then moulded into bricks and subjected to curing cycles at different temperatures and pressures. These bricks also promote use of fly ash waste and thus environment protection.

c) *Fly Ash Cement Bricks* (IS 16720:2018) – These bricks are manufactured by mixing of cement, pulverized fuel ash (fly ash), aggregate and water. Chemical admixtures may be added, if required. These bricks have total pulverized fuel ash (fly ash) content not less than 35 percent of the mass of bricks. These bricks also promote use of fly ash waste and resource optimization, and thus environment protection. These are also tested against the requirement of drying shrinkage.

FIG. 9 FLY ASH CEMENT BRICKS

d) *Calcium Silicate Bricks* (IS 4139:1989) **–** These bricks derive their strength from the formation of calcium silicate hydrates in crystallized form by the reaction of

hydrated lime with active siliceous materials. Such active materials include finely ground sand/siliceous rock and fly ash. The chemical reaction leading to formation of calcium silicate hydrates (and calcium aluminates in case of addition of fly ash) are carried out under autoclaving at elevated temperature and pressure of steam. Coloured calcium silicate bricks can also be made by adding lime fast pigments to the raw mix before pressure casting. These bricks may be used for masonry construction just like burnt clay bricks. Calcium silicate bricks may also be used as facing bricks. These are also tested against the requirement of drying shrinkage.

e) *Acid Resistant Bricks* (IS 4860:1968) – Bricks used for masonry construction, such as flooring subject to acid attack, lining of chambers and towers in chemical units, lining of sewers carrying industrial effluents, etc, to prevent deterioration of the surface by acids. except hydrofluoric acid and perchloric acid, and other chemicals. These bricks are made of raw materials, such as clay or shale of suitable composition with low lime and iron content, felspar, flint or sand, and vitrified at high temperatures in ceramic kilns. These bricks are-designed primarily for use in chemical and allied industries and are normally used with chemical resistant mortars. This standard covers the requirements for bricks intended for use where minimum absorption is required and thermal shock and alkali resistance are not important service factors. The properties and classification of these bricks are as follows:

Sl No.	**Characteristic**	**Requirement for**	
		Class I Bricks	**Class II Bricks**
i)	Water absorption	2%, *Max*	4%, *Max*
ii)	Flexural strength	10 N/m^2, *Min*	70, N/m^2, *Min*
iii)	Compressive strength	70 N/m^2, *Min*	50 N/m^2, *Min*
iv)	Resistance to acid	Not more than 1.5% loss in weight	Not more than 4.0% loss in weight
v)	Resistance to wear	Average wear not more than 2 mm	Nil

f) *Stabilized Soil Bricks* (IS 1725:2023) – These are manufactured from a uniform mixture of suitable soil-aggregate mixture and stabilizers such as ordinary Portland cement or a combination of lime and ordinary Portland cement. The homogeneous mixture of soil-Sand-stabilizer is then compacted into a high-density block at optimum moisture content. These are energy efficient and low carbon emission alternative to burnt clay brick and concrete based blocks. These are available both as bricks as well as in higher sizes of blocks, and are tested for dry density, compressive strength, water absorption (maximum 18%), linear expansion on saturation and weathering (mass loss not more than 3%).

2.3 Test Methods

The following Indian Standards lay down the test methods for checking the quality of various types of bricks:

SI No.	IS Number	Title
1	IS 3495 (Part 1):2019	Burnt clay building bricks — Methods of tests: Part 1 Determination of compressive strength (*fourth revision*)
2	IS 3495 (Part 2):2019	Burnt clay building bricks — Methods of tests: Part 2 Determination of water absorption (*fourth revision*)
3	IS 3495 (Part 3):2019	Burnt clay building bricks — Methods of tests: Part 3 Determination of efflorescence (*fourth revision*)
4	IS 3495 (Part 4):2019	Burnt clay building bricks — Methods of tests: Part 4 Determination of warpage (*fourth revision*)
5	IS 3495 (Part 5):2021	Burnt clay building bricks — Methods of test: Part 5 Determination of initial rate of absorption
6	IS 3495 (Part 6):2022	Burnt clay building bricks — Method of test: Part 6 Determination of modulus of rupture
7	IS 5454:2024	Burnt clay bricks and burnt clay tiles — Methods of sampling (*second revision*)

2.4 Stacking and Storage

Bricks should be stacked in regular tiers as and when they are unloaded to minimize breakage and defacement. These should not be dumped at site. Brick stacks should be placed close to the site of work so that least effort is required to unload and transport the bricks again by loading on pallets or in barrows.

Bricks should be stacked on dry firm ground. For proper inspection of quality and ease in counting, the stacks should be 50 bricks long, 10 bricks high and not more than 4 bricks in width, the bricks being placed on edge, two at a time along the width of the stack. Clear distance between adjacent stacks should not be less than 0.8 m. Bricks of each truck load should be put in one stack.

Bricks of different types, such as, clay bricks, fly ash clay bricks, fly ash lime bricks, fly ash cement bricks and sand lime (calcium silicate) bricks should be stacked separately. Bricks of different classifications from strength consideration and size consideration (such as, conventional and modular) should be stacked separately. Also bricks of different types, such as, solid, hollow and perforated should be stacked separately.

For complete details on staking and storage of bricks, a reference may be made to IS 4082:1996 'Stacking and storage of construction materials and components at site - Recommendations (*second revision*)'.

CHAPTER III

STONES

CHAPTER III

STONES

3.1 General

Dimension stones or building stones are the natural rock material quarried for the purpose of obtaining blocks or slabs that meet specifications as to size (width, length, and thickness) and shape. Stones are available in India in large quantities in different parts of the country. To choose and utilize them for various uses, it is necessary to know their availability and also the strength properties determined according to the standard procedures. Some of the important properties of stones are appearance and colour, strength, density, hardness and toughness, and water absorption. Some of the common uses of building stones are in construction of foundations, masonry walls, columns, arches, lintels, roofs, floors, cladding or facing work of masonry, ballast for railways, for bridges, piers, abutments, retaining walls, dams, etc.

FIG. 10 STONES

The durability of stones depends mainly upon its physical structure and chemical composition. The deterioration takes place when their inherent properties are changed by the action of various unavoidable external agencies. It is always desirable, therefore, to use a good durable stone in the very first instance. It is therefore important to understand the principal factors which cause decay of stone in buildings and to suggest preventive measures for their least decay. The preventive measures have to be based on the latest practices being followed and applicable to sedimentary rocks, particularly porous stones which are not plastered.

These aspects have to be duly covered in the Indian Standard, IS 8759:2024 'Maintenance and preservation of stone in buildings – Code of practice (*first revision*)'. The standard details the agents of deterioration (such as rain, salts, freeze-thaw, temperature stresses, atmospheric impurities, deterioration in binding material, movement of chemicals and vegetation), assessment procedures for deterioration, and the procedure for preservation and maintenance (including cleaning, treating strains, surface coatings, etc).

3.2 Specifications

Various commonly used stones in India are as follows:

a) *Limestone* (IS 1128:1974) – Limestone slabs and tiles are used in the construction of building floors. Limestone is found more or less in every part of India. There exists considerable variation in size, and quality of the finished product.

FIG. 11 LIMESTONE

b) *Marble* (IS 1130:1969) – Marbles are metamorphic rocks capable of taking polish, formed from the re-crystallization of limestones or dolomitic limestones and are distinguished from limestone by even visibly crystallized nature and non-flaggy stratification.

FIG. 12 MARBLE

c) *Granite* (IS 3316:1974) – Granite is an important structural and ornamental stone and because of its high compressive strength and durability, is extensively used for massive structural works like bridge piers, sea and river walls, dams and monumental buildings, where excessive wear and abrasion is likely to occur. Fine grained variety of granite that takes and preserves high polish and is capable of being carved and employed for ornamental and monumental works and also for inscription purposes. Granite is found in several parts of India with slight variations in the physical properties of the stone depending upon the grain size and the minerals that go into its formation. Based on appearance and commercial

utility, granites may be broadly classified as: (a) Black granites (mostly basic/ ultrabasic igneous rocks having predominantly mafic minerals such as pyroxenes, amphibole, chlorite biotite); (b) Red granites (mostly covers alkali granite); (c) Grey and multi-coloured granite (mostly cover calc-alkali granite); (d) Granite gneisses/metamorphic rocks (includes gneisses, migmatites, etc); and (e) Volcanic rocks (rhyolite, basalts, etc).

FIG. 13 GRANITE

d) *Polished Granite* [IS 14223 (Part 1): 2023] – Granites occurring in several parts of India are widely distributed throughout the rock successions of Precambrian terrain. Pink, red, grey, black and multicoloured granitic gneisses/migmatites in polished form are presently being quarried and exported apart from their huge consumption in the domestic market.

e) *Sandstone* (IS 3622:1977) – Sandstone is extensively found in Assam, West Bengal, Madhya Pradesh, Jammu and Kashmir, Karnataka, Rajasthan, Tamil Nadu and in many other parts of the country and is used in floor construction, floor finish, facing, roofing, etc. Sandstones of certain minimum requirements of strength, compactness, etc, are suitable as slabs and tiles.

FIG. 14 SANDSTONE

f) *Laterite* (IS 3620:1979) - The laterites occur in Andhra Pradesh, Bihar, Kerala, Tamil Nadu, Maharashtra, Karnataka, Assam, Goa, Meghalaya and Orissa and is mainly used as building blocks for construction of masonry in building. The term laterite stone has been applied generally to a group of rocks, which occur as surficial blankets. It is the residual weathering products of certain rocks containing silicates, such as basalt, granite and slates.

FIG. 15 LATERITE BLOCKS

3.3 Test Methods

The following Indian Standards lay down the test methods for checking the quality of stones:

SI No.	IS Number	Title
1	IS 1121 (Part 1):2023	Determination of strength properties of natural building stones - Methods of test: Part 1 Uniaxial compressive strength (*third revision)*
2	IS 1121 (Part 2):2023	Determination of strength properties of natural building stones - Methods of test: Part 2 Transverse strength (*third revision)*
3	IS 1121 (Part 3):2023	Determination of strength properties of natural building stones - Methods of test: Part 3 Indirect tensile strength (*third revision)*
4	IS 1121 (Part 4):2013	Determination of strength properties of natural building stones - Methods of test: Part 4 Shear strength (*second revision)*
5	IS 1121 (Part 5):2023	Determination of strength properties of natural building stones — Methods of test: Part 5 Flexural modulus of elasticity

6	IS 1122:2023	Determination of true specific gravity of natural building stones — Method of test (*second revision*)
7	IS 1123:1975	Method of identification of natural building stones (*first revision*)
8	IS 1124:1974	Method of test for determination of water absorption, apparent specific gravity and porosity of natural building stones (*first revision*)
9	IS 1125:2013	Determination of weathering of natural building stones - Methods of test (*second revision*)
10	IS 1126:2013	Determination of durability of natural building stones - Methods of test (*second revision*)
11	IS 1706:1972	Method for determination of resistance to wear by abrasion of natural building stones (*first revision*)
12	IS 4121:1967	Method of test for determination of water transmission rate by capillary action through natural building stones
13	IS 4122:1967	Method of test for surface softening of natural building stones by exposure to acidic atmospheres
14	IS 4348:1973	Methods of test for determination of permeability of natural building stones (*first revision*)
15	IS 5218:1969	Method of test for toughness of natural building stones

3.4 Stacking and Storage

Stones of different sizes, types and classification should be stored separately. Stones should be stacked on dry firm ground in a regular heap not more than 1 m in height. Cladding stones should be stacked against vertical support on a firm dry ground in tiers, up to a height of 1.2 m. A distance of about 0.8 m should be kept between two adjacent stacks.

For complete details on staking and storage of building stones, a reference may be made to IS 4082:1996 'Stacking and storage of construction materials and components at site - Recommendations (*second revision*)'.

CHAPTER IV
AGGREGATES

CHAPTER IV

AGGREGATES

4.1 General

Aggregate is a granular material, generally inert, such as natural sand, manufactured sand (such as copper slag aggregate and bottom ash), gravel, crushed gravel, crushed stone, and manufactured coarse aggregate (such as air-cooled blast furnace slag and steel slag aggregates) which when bound together into a conglomerated mass by a matrix forms concrete or mortar. The aggregates may be classified into fine and coarse aggregate, which may be further sub-classified as follows:

a) *Fine Aggregate* – Aggregate most of which passes 4.75 mm IS Sieve and contains only so much coarser material as permitted in Table 1 below:

Table 1 Fine Aggregates

Sl No.	IS Sieve Designation	Percentage Passing			
		Grading Zone I	Grading Zone II	Grading Zone III	Grading Zone IV
(1)	(2)	(3)	(4)	(5)	(6)
i)	10 mm	100	100	100	100
ii)	4.75 mm	90-100	90-100	90-100	95-100
iii)	2.36 mm	60-95	75-100	85-100	95-100
iv)	1.18 mm	30-70	55-90	75-100	90-100
v)	600 µm	15-34	35-59	60-79	80-100
vi)	300 µm	5-20	8-30	12-40	15-50
vii)	150 µm	0-10	0-10	0-10	0-15

NOTES

1 For crushed stone sands, the permissible limit on 150 µm IS Sieve is increased to 20 percent. This does not affect the 5 percent allowance permitted in 6.3 of IS 383:2016 applying to other sieve sizes.

2 Fine aggregate complying with the requirements of any grading zone in this table is suitable for concrete but the quality of concrete produced will depend upon a number of factors including proportions.

3 As the fine aggregate grading becomes progressively finer, that is, from Grading Zones I to IV, the ratio of fine aggregate to coarse aggregate should be progressively reduced. The most suitable fine to coarse ratio to be used for any particular mix will, however, depend upon the actual grading, particle shape and surface texture of both fine and coarse aggregates.

4 It is recommended that fine aggregate conforming to Grading Zone IV should not be used in reinforced concrete unless tests have been made to ascertain the suitability of proposed mix proportions.

Fine aggregate may further be sub-classified into natural sand, crushed sand, mixed sand and manufactured sand, as follows:

1) *Natural Sand* – Fine aggregate resulting from the natural disintegration of rock and which has been deposited by streams or glacial agencies. This may also be called as uncrushed sand.

2) Crushed Sand

i) *Crushed stone sand* – Fine aggregate produced by crushing hard stone.

ii) C*rushed gravel sand* – Fine aggregate produced by crushing natural gravel.

3) *Mixed Sand* – Fine aggregate produced by blending natural sand and crushed stone sand or crushed gravel sand in suitable proportions.

4) *Manufactured Fine Aggregate (Manufactured Sand)* – Fine aggregate manufactured from other than natural sources, by processing materials, using thermal or other processes such as separation, washing, crushing and scrubbing.

NOTE – Manufactured fine aggregate may be Recycled Concrete Aggregate (RCA).

b) *Coarse Aggregate* – Aggregate most of which is retained on 4.75 mm IS Sieve and containing only so much finer material as is permitted for the various types described in this standard. Coarse aggregates are be supplied in the nominal sizes given in Table 2.

NOTE – Coarse aggregate may be,

a) uncrushed gravel or stone which results from natural disintegration of rock;

b) crushed gravel or stone when it results from crushing of gravel or hard stone; and

c) partially crushed gravel or stone when it is a product of the blending of (a) and (b);

d) manufactured from other than natural sources, by processing materials, using thermal or other processes such as separation, washing, crushing and scrubbing. Manufactured coarse aggregate may be Recycled Concrete Aggregate (RCA) or Recycled Aggregate (RA).

Table 2 Coarse Aggregates

Sl No.	IS Sieve Designation	Percentage Passing for Single-Sized Aggregate of Nominal Size						Percentage Passing for Graded Aggregate of Nominal Size			
		63 mm	40 mm	20 mm	16 mm	12.5 mm	10 mm	40 mm	20 mm	16 mm	12.5 mm
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
i)	80 mm	100	-	-	-	-	-	100	-	-	-
ii)	63 mm	85 to 100	100	-	-	-	-	-	-	-	-
iii)	40 mm	0 to 30	85 to 100	100	-	-	-	90 to 100	100	-	-
iv)	20 mm	0 to 5	0 to 20	85 to 100	100	-	-	30 to 70	90 to 100	100	100
v)	16 mm	-	-	-	85 to 100	100	-	-	-	90 to 100	-
vi)	12.5 mm	-	-	-	-	85 to 100	100	-	-	-	90 to 100
vii)	10 mm	0 to 5	0 to 5	0 to 20	0 to 30	0 to 45	85 to 100	10 to 35	25 to 55	30 to 70	40 to 85
viii)	4.75 mm	-	-	0 to 5	0 to 5	0 to 10	0 to 20	0 to 5	0 to 10	0 to 10	0 to 10
ix)	2.36 mm	-	-	-	-	-	0 to 5	-	-	-	-

FIG. 16 COARSE AGGREGATE

FIG. 17 FINE AGGREGATE

4.2 Specifications

For complete details of the specifications for aggregates for concrete, reference may be made to IS 383:2016 'Coarse and fine aggregate for concrete – Specification (*third revision*)'.

Other Indian Standard specifications for aggregate for different types and applications, are given below for making appropriate reference:

SI No.	IS Number	Title
1	IS 1542:1992	Sand for plaster - Specification (*second revision)*
2	IS 2116:1980	Specification for sand for masonry mortars (*first revision*)
3	IS 6579:1981	Specification for coarse aggregate for water bound macadam
4	IS 9142 (Part 1):2018	Artificial light weight aggregates for concrete — Specification: Part 1 For concrete masonry blocks and for applications other than for structural concrete (*first revision*)
5	IS 9142 (Part 2):2018	Artificial light weight aggregates for concrete — Specification: Part 2 Sintered fly ash coarse aggregate (*first revision*)

The properties and performance of concrete are dependent to a large extent on the characteristics and properties of aggregates themselves, and knowledge of the properties of aggregates is thus important. The various important properties of aggregates are as follows for which the Indian Standard (IS 383) prescribes limiting values to make the aggregates suitable for concrete making:

a) *Mechanical properties*

1) Strength of aggregate – The following tests are performed to evaluate the strength of aggregate:

   i) Crushing strength

ii) Crushing value

iii) Ten percent fines value

2) Hardness and abrasion resistance

b) *Particular shape and texture* – The external characteristics of mineral aggregates in terms of physical shape, texture and surface conditions significantly influence the mobility of the fresh concrete and the bond of aggregates with the mortar phase. These properties are sphericity and roundness. Sphericity is defined as a function of the ratio of the surface area of the particle to its volume whereas roundness measures the relative sharpness or angularity of the edges and corners of a particle. To avoid lengthy descriptions of the aggregate shape, IS 383 lists four groups of aggregates in terms of particle shape, namely rounded, irregular or partly rounded, angular and flaky. Well-rounded particles require less water and less paste volume for a given workability; nevertheless, crushed or uncrushed rounded gravels generally tend to have a stronger aggregate-mortar bond and result in substantially the same compressive strength for a given cement content. The shape and texture of fine aggregate also significantly affect the water requirement of the mix. Elongated and flaky particles, having a high ratio of surface area to volume, lower the workability of the mix and can also affect adversely the durability of concrete since they tend to be oriented in one plane with water and air voids underneath.

c) *Porosity and absorption* - Porosity, permeability and absorption of aggregate influence the bond between aggregate and cement paste, the durability of concrete with regard to the aggressive chemical agencies, resistance to abrasion of concrete, and freezing and thawing. The water absorption properties of aggregates are important in the sense that depending upon the condition in which the aggregates are used that is, saturated, surface dry, dry or bone dry. Porous may become reservoir of free moisture inside the aggregates. Afterwards this moisture may be available for hydration or may actually extract some water used for mixing and the entire water may not be available for perfect workability and subsequent hydration of cement.

d) *Deleterious constituents* – A number of materials may be considered undesirable as constituents in aggregates because of their intrinsic weakness, softness, fineness and other physical characteristics, the presence of which may affect the strength, workability and long-term performance of concrete. Some of these materials are iron pyrites, coal, mica, shale and similar laminated materials, clay, alkali, soft fragments, sea shells, and organic impurities.

e) *Soundness of aggregates* - Aggregate is said to be unsound when it produces excessive volume changes resulting in the deterioration of concrete under certain physical conditions, such as freezing and thawing, thermal changes at temperatures above freezing and alternate wetting and drying.

f) *Alkali-aggregate reaction* – This reaction takes place between the alkalis in the cement and the active siliceous constituents or carbonates of aggregates. Under most conditions, this reaction causes excessive expansion and cracking of concrete. It may also be noted that the concrete code (IS 456) gives various measures in case reactive aggregates are encountered for concrete making.

4.3 Test Methods

The Aggregate are tested using standard test methods, for which reference may be made to the following Indian Standards:

SI No.	IS Number	Title
1	IS 2386 (Part 1):1963	Methods of test for aggregates for concrete: Part 1 Particle size and shape
2	IS 2386 (Part 2):1963	Methods of test for aggregates for concrete: Part 2 Estimation of deleterious materials and organic impurities
3	IS 2386 (Part 3):1963	Methods of test for aggregates for concrete: Part 3 Specific gravity, density, voids, absorption and bulking
4	IS 2386 (Part 4):1963	Methods of test for aggregates for concrete: Part 4 Mechanical properties
5	IS 2386 (Part 5):1963	Methods of test for aggregates for concrete: Part 5 Soundness
6	IS 2386 (Part 6):1963	Methods of test for aggregates for concrete: Part 6 Measuring mortar making properties of fine aggregate
7	IS 2386 (Part 7):1963	Methods of test for aggregates for concrete: Part 7 Alkali aggregate reactivity
8	IS 2386 (Part 8):1963	Methods of test for aggregates for concrete: Part 8 Petrographic examination

4.4 Storage

Aggregates should be stored at site on a hard dry and level patch of ground. If such a surface is not available, a platform of planks or old corrugated iron sheets, or a floor of bricks, or a thin layer of lean concrete should be made so as to prevent contamination with clay, dust, vegetable and other foreign matter.

Stacks of fine and coarse aggregates should be kept in separate stock piles sufficiently removed from each other to prevent the material at the edges of the piles from getting intermixed. On a large job it is desirable to construct dividing walls to give each type of aggregates its own compartment. Fine aggregates should be stacked in a place where loss due to the effect of wind is minimum.

For more details on storage of aggregates, a reference may be made to IS 4082:1996 'Stacking and storage of construction materials and components at site - Recommendations (*second revision*)'.

CHAPTER V
CONCRETE BLOCKS

CHAPTER V

CONCRETE BLOCKS

5.1 Specifications

Concrete blocks are available as hollow and solid concrete blocks, hollow and solid light weight concrete blocks, autoclaved aerated concrete blocks, preformed foamed concrete blocks, and concrete stone masonry blocks. Various commonly used blocks in India are as follows:

a) *Hollow and Solid Concrete Blocks [IS 2185 (Part 1):2005]* – These are concrete masonry units, either hollow (open or closed cavity) or solid, any one of the external dimension of which is greater than the corresponding dimension of a brick, and of such size and mass as to permit it to be handled by one man. A hollow concrete block has one or more large holes or cavities which either pass through the block (open cavity) or do not effectively pass through the block (closed cavity) and having the solid material between 50 and 75 percent of the total volume of the block calculated from the overall dimensions. These blocks afford an opportunity for utilization of appropriate quantity of fly ash to promote sustainability. The hollow blocks in addition performed better thermally and can be gainfully utilized for the purpose.

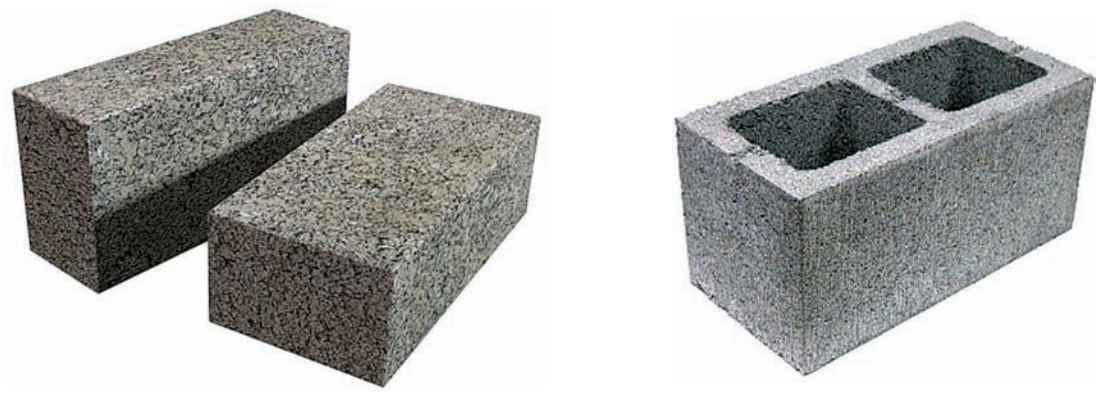


FIG. 18 SOLID AND HOLLOW CONCRETE BLOCKS

b) *Hollow and Solid Lightweight Concrete Blocks [IS 2185 (Part 2):1983]* – These are hollow or solid concrete blocks made using lightweight aggregate such as sintered fly ash aggregate. Hollow concrete blocks are made either with two cores or three cores. Stretchers in the 200, 250 and 300 mm widths should generally have concave ends, each end flange being grooved or plain. All 100 and 150 mm wide units should generally be made with plain ends.

Load bearing lightweight concrete masonry units hollow (open and closed cavity) or solid should conform to the following two grades:

i) *Grade A* - These are used below and above ground level in damp-proof course, in exterior walls that may or may not be treated with a suitable weather-protective coating and for interior walls.

ii) *Grade B*-These are used above ground level in damp-proof course, in exterior walls that are treated with a suitable weather-protective coating and for internal walls.

Non-load bearing lightweight concrete masonry units, hollow (open and closed cavity) or solid should be used in interior walls, partitions, panels and for exterior panel walls in steel or reinforced concrete frame construction when protected from weather by rendering or by some other efficient treatment.

These blocks afford an opportunity for utilization of appropriate quantity of fly ash to promote sustainability through the use of sintered fly ash light weight aggregates.

c) *Autoclaved Cellular (Aerated) Concrete Blocks [IS 2185 (Part 3):1984]* – These are concrete blocks having density up to 1000 kg/m^3. The aerated structure or the cells of the cellular concrete blocks is formed by generation of a gas by chemical action, with the mix, prior to hardening with the aid of suitable chemical foaming agents and mixing devices. The cells in the block should be distributed evenly throughout its volume. Autoclaving is done by steam curing of concrete blocks in an autoclave at ambient temperatures generally between 170 and 215 °C. These blocks afford an opportunity for utilization of large quantity of fly ash to promote sustainability.

FIG. 19 AUTOCLAVED AERATED CONCRETE BLOCKS

d) *Preformed Foam Cellular Concrete Blocks [IS 2185 (Part 4):2008]* – These blocks are produced under ambient conditions using preformed stable foam and having density from 800 kg/m^3 to 1800 kg/m^3; and primarily used for the construction of load bearing and non-load bearing walls. The foam concentrate should be of such chemical composition that is capable of producing stable foam cells in concrete, which can resist the physical and chemical forces imposed during mixing, transporting, pumping, placing and setting of concrete. These blocks afford an opportunity for utilization of large quantity of fly ash to promote sustainability.

e) *Stone Concrete Blocks (12440*:1988) – These are precast cement concrete solid blocks having stone spalls in it (25-30 percent of block volume) and cement concrete with dense stone aggregate and sand. Spalls are broken stone pieces of varying sizes obtained by breaking the natural river boulders or quarry stones. These blocks may be manufactured either at construction site or in factory on a central casting platform using steel moulds with or without surface vibration for

compaction of cement concrete. This enables utilization of waste stone pieces for making concrete blocks thus promoting recycling and sustainability.

5.2 Test Methods

The following Indian Standards lay down the test methods for checking the quality of various types of concrete blocks:

SI No.	IS Number	Title
1	IS 6441 (Part 1):1972	Methods of test for autoclaved cellular concrete products: Part 1 Determination of unit weight or bulk density and moisture content
2	IS 6441 (Part 2):1972	Methods of test for autoclaved cellular concrete products: Part 2 Determination of drying shrinkage
3	IS 6441 (Part 4):1972	Methods of test for autoclaved cellular concrete products: Part 4 Corrosion protection of steel reinforcement in autoclaved cellular concrete
4	IS 6441 (Part 5):1972	Methods of test for autoclaved cellular concrete products: Part 5 Determination of compressive strength
5	IS 6441 (Part 6):1973	Methods of tests for autoclaved cellular concrete products: Part 6 Strength, deformation and cracking of flexural members subject to bending– *S*hort duration loading test
6	IS 6441 (Part 7):1973	Methods of tests for autoclaved cellular concrete products: Part 7 Strength, deformation and cracking of flexural members subject to bending– Sustained loading test
7	IS 6441 (Part 8):1973	Methods of tests for autoclaved cellular concrete products: Part 8 Loading tests for flexural members in diagonal tension
8	IS 6441 (Part 9):1973	Methods of tests for autoclaved cellular concrete products: Part 9 Jointing of autoclaved cellular concrete elements

5.3 Stacking and Storage

Blocks should be unloaded one at a time and stacked in regular tiers to minimize breakage and defacement. These should not be dumped at site. The height of the stack should not be more than 1.2 m. The length of the stack should not be more than 3.0 m, as far as possible and the width should be of two to three blocks. Normally blocks cured for 28 days only should be received at site. In case blocks cured for less than 28 days are received, these should be stacked separately.

For more details on storage of blocks, a reference may be made to IS 4082:1996 'Stacking and storage of construction materials and components at site - Recommendations (*second revision*)'.

CHAPTER VI
BUILDING LIME

CHAPTER VI
BUILDING LIME

6.1 General and Specifications

Lime plays a crucial role in construction due to its versatility and beneficial properties. Traditionally used in the form of lime mortar, it offers superior workability and flexibility compared to modern cement-based alternatives. Lime's ability to absorb and release moisture helps in regulating indoor humidity, contributing to healthier building environments. Additionally, it has a lower carbon footprint than cement, aligning with sustainable construction practices. Lime also facilitates the preservation of historic structures by allowing them to breathe and flex without damage, which is essential for maintaining the integrity of aged buildings. Its use in construction not only enhances durability and adaptability but also supports eco-friendly building practices.

The method of manufacturing building limes and the manner in which they are used in construction work differ from one part of the country to another. For instance, in the south, lime mortar is generally prepared by grinding a mixture of slaked lime and sand in suitable proportions in a bullock mill while in Punjab, lime putty is mixed with sand and the mix used as mortar directly. Besides, defects caused by differences in the method of burning, slaking, storing and using appreciably affect the quality of lime. Building limes are classified as follows:

Class A – Eminently hydraulic lime used for structural purposes.

Class B – Semi-hydraulic lime used for masonry mortars, lime concrete and plaster undercoat.

Class C – Fat lime used for finishing coat in plastering, whitewashing, composite mortars, etc, and with addition of pozzolanic materials for masonry mortar.

Class D – Magnesium dolomitic lime used for finishing coat in plastering, white washing, etc.

Class E – *Kankar* lime used for masonry mortars.

Class F – Siliceous dolomitic lime used for undercoat and finishing coat of plaster.

Lime is available either in hydrated or quick form, except that of Classes A and E which is to be supplied in hydrated form. Applications indicated above are only suggestive.

FIG. 20 LIMESTONE AND LIMESTONE QUARRY

For details, reference may be made to IS 712:1984 'Specification for building limes (*third revision*)'

6.2 Test Methods

The following Indian Standards lay down the test methods for checking the quality of various types of Building Lime:

SI No.	IS Number	Title
1	IS 6932 (Part 1):1973	Methods of tests for building limes: Part 1 Determination of insoluble residue, loss on ignition, insoluble matter, silicone dioxide, ferric and aluminium oxide, calcium oxide and magnesium oxide
2	IS 6932 (Part 2):1973	Methods of tests for building limes: Part 2 Determination of carbon dioxide content
3	IS 6932 (Part 3):1973	Methods of tests for building limes: Part 3 Determination of residue on slaking of quicklime
4	IS 6932 (Part 4):1973	Methods of tests for building limes: Part 4 Determination of fineness of hydrated lime
5	IS 6932 (Part 5):1973	Methods of tests for building limes: Part 5 Determination of unhydrated oxide
6	IS 6932 (Part 6):1973	Methods of tests for building limes: Part 6 Determination of volume yield of quicklime
7	IS 6932 (Part 7):1973	Methods of tests for building limes: Part 7 Determination of compressive and transverse strength
8	IS 6932 (Part 8):1973	Methods of tests for building limes: Part 8 Determination of workability
9	IS 6932 (Part 9):1973	Methods of tests for building limes: Part 9 Determination of soundness
10	IS 6932 (Part 10):1973	Methods of tests for building limes: Part 10 Determination of popping and pitting of hydrated lime
11	IS 6932 (Part 11):1983	Methods of tests for building limes: Part 11 Determination of setting time of hydrated lime
12	IS 1514:1990	Methods of sampling and test for quicklime and hydrated lime

6.3 Storage of lime

6.3.1 *Quicklime Before Slaking*

Quicklime deteriorates rapidly on exposure by taking up moisture and carbon dioxide from atmosphere. It should be slaked as soon as possible before deterioration sets. If unavoidable, it may be stored in compact heaps having only the minimum of exposed

area. The heaps should be stored on a suitable platform and covered by waterproof membrane such as polyethylene to avoid direct contact with rain or being blown away by wind. In case quicklime is stored in a covered shed, a minimum space of 300 mm should be provided all-round the heaps.

6.3.2 *Hydrated Lime*

Hydrated lime is generally supplied in containers such as jute bags lined with polyethylene or HDPE woven bags lined with polyethylene or kraft paper bags. It should be stored in a building to protect the lime from dampness and to minimize warehouse deterioration. The building should be with a concrete floor and having least ventilation to eliminate draughts through the walls and roof. In general, the recommendations given for storing of cement is applicable for hydrated lime. When air movement is reduced to a practical minimum, hydrated lime can be stored for up to three months without appreciable change.

6.3.3 *Slaked Lime*

If the lime is to be used within a few days it may be stored on a platform suitably covered for protection from rain and wind. If it is required to be stored for a longer period not exceeding 2 months it may be kept in a dry and closed godown.

For more details on storage of lime, a reference may be made to IS 4082:1996 'Stacking and storage of construction materials and components at site - Recommendations (*second revision*)'.

CHAPTER VII
TIMBER

CHAPTER VII
TIMBER

7.1 General

Wood is one of the earliest materials used by mankind for building purposes and has continued to attract attention in one form or other in spite of many competitive building materials and their use under highly developed technological considerations. Wood is a biological material from renewable resources, and extensively used in structural design and other engineering fields. It is also used for other applications like panelling and partitioning. Wood in converted form, is known as timber. Timber may be from coniferous trees or non-coniferous trees, which respectively yield soft wood and hard wood suitable for various applications in buildings and other construction works. The following Indian Standards give general information about timber for its better understanding and utilization:

SI No.	IS Number	Title
1	IS 287:1993	Permissible moisture content for timber used for different purposes - Recommendations (*third revision*)
2	IS 707:2011	Timber technology and utilization of wood, bamboo and cane - Glossary of terms (*third revision*)
3	IS 1150:2000	Trade names and abbreviated symbols for timber species (*third revision*)

FIG. 21 SAWN TIMBER AND BALLIES

To ensure durability and requisite performance of timber, the timber should be properly seasoned and preservative treated as per the good practices laid down in the following Indian Standards:

SI No.	IS Number	Title
1	IS 401:2001	Preservation of timber - Code of practice (*fourth revision*)
2	IS 1141:1993	Seasoning of timber - Code of practice (*second revision)*

7.2 Specifications

Timber quality is ensured through its proper gradation into various grades such as Special Grade, Grade 1 and Grade 2 based on limiting various defects, such as cross grains, end splits, knots, sapwood, surface checks, sap stain, wane, borer, centre heart and cup shake. Various important Indian Standard specifications suitable for construction purposes are listed below:

SI No.	IS Number	Title
1	IS 190:1991	Coniferous sawn timber (Baulks and scantlings) - Specification (*fourth revision*)
2	IS 1326:2023	Non-coniferous sawn timber (baulks and scantling) - Specification (*third revision)*
3	IS 3337:1978	Specification for ballies for general purposes (*first revision*)
4	IS 3629:1986	Specification for structural timber in building (*first revision*)

For guidance regarding structural design of timber structures, a reference may be made to IS 883:2016 'Design of structural timber in building - Code of practice (*fifth revision*)'.

7.3 Test Methods

The following Indian Standards lay down the test methods for checking the quality of timber:

SI No.	IS Number	Title
1	IS 1708 (Parts 1 to 18): 1986	Methods of testing of small specimens of timber (*second revision)*: Part 1 Determination of moisture content Part 2 Determination of specific gravity Part 3 Determination of volumetric shrinkage Part 4 Determination of radial and tangential shrinkage and fibre saturation point Part 5 Determination of static bending strength Part 6 Determination of static bending strength Under two point loading Part 7 Determination of impact bending strength

		Part 8	Determination of compressive strength parallel to grain
		Part 9	Determination of compressive strength perpendicular to grain
		Part 10	Determination of hardness under static indentation
		Part 11	Determination of shear strength parallel to grain
		Part 12	Determination of tensile strength parallel to grain
		Part 13	Determination of tensile strength perpendicular to grain
		Part 14	Determination of cleavage strength parallel to grain
		Part 15	Determination of nail and screw holding power
		Part 16	Determination of brittleness by Izod impact
		Part 17	Determination of brittleness by Charpy impact
		Part 18	Determination of torsional strength

7.4 Stacking and Storage

Timber should be stored in stacks upon well treated and even surfaced beams, sleepers or brick pillars so as to be above the ground level by at least 150 mm. The various members should preferably be stored separately in different lengths, and material of equal lengths should be piled together in layers with wooden battens, called crossers, separating one layer from another. The crossers should be sound wood, straight and uniform in thickness. In case where separate crossers are not available smaller sections of the available structural timber may be employed in their place. In any layer, an air space of about 25 mm should be provided between adjacent members. The longer pieces should be placed in the bottom layers and shorter pieces in the top layers but one end of the stack should be in true vertical alignment. The crossers in different layers should be in vertical alignment. The most suitable width and height of a stack are recommended to be about 1.5 m to 2.0 m. Distance between adjacent stacks is recommended to be at least 450 mm. A side view of such a stack is shown in Fig. 15. In case the stacking with the help of battens is not possible, the timber may be close piled in heaps on raised foundations with the precautions specified above.

The stacks should be protected from hot dry winds or direct sun and rain. Heavy weights, such as metal rails or large sections of wood, are recommended to be placed on the top of the stack to prevent distortion or warping of the timber in the stack. In case, timber is to be stored for about a year or more, to prevent end cracking in the material, the ends of all members should be coated with coal tar, aluminium leaf paints (hardened gloss oil), micro crystalline wax or any other suitable material

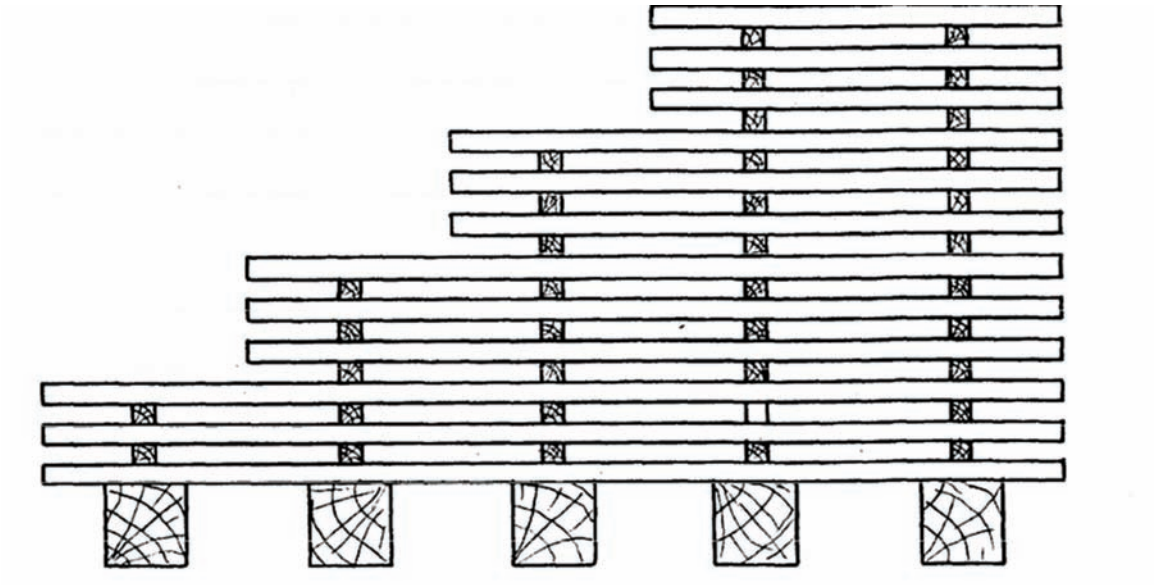


FIG. 22 TYPICAL TIMBER STACK

For more details on storage of timber, a reference may be made to IS 4082:1996 'Stacking and storage of construction materials and components at site - Recommendations (*second revision*)'.

CHAPTER VIII
STRUCTURAL STEEL

CHAPTER VIII
STRUCTURAL STEEL

8.1 General

Considerable steel is used for construction of buildings and other structures. Steel used for structural purposes may be rolled steel sections or built-up steel sections using rolled steel sheets and plates. Various types of sections and shapes are used in construction work.

Steel members have high strength per unit weight. Therefore, a steel member of small section having less self-weight is able to resist heavy loads. Also, it requires less time during construction which is done through welding, bolting or riveting of the steel members. Being light in weight, steel members can be handled and transported easily. For this reason, pre-engineered steel construction has also become quite popular.

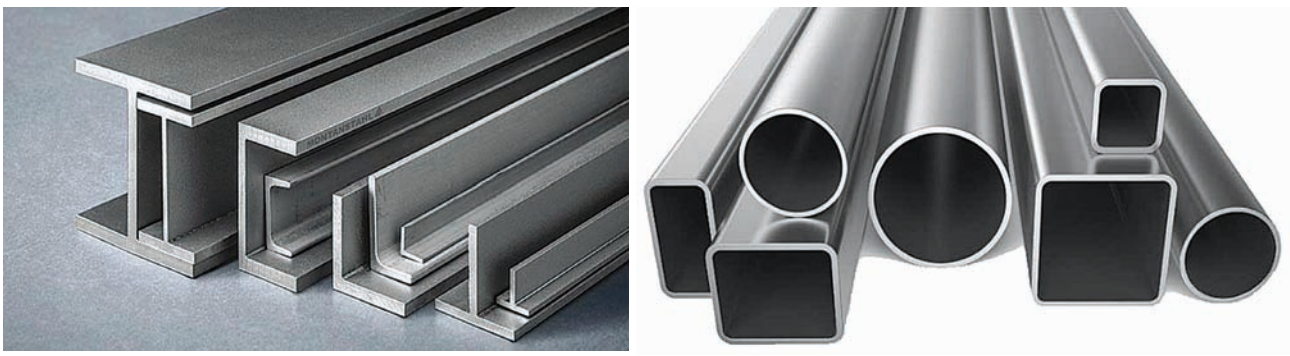


FIG. 23 STRUCTURAL STEEL SECTIONS

8.2 The following Indian Standard specifications have been formulated to lay down the requirements of various structural steel:

SI No.	IS Number	Title
	Structural Steel	
1	IS 2062:2011	Hot rolled medium and high tensile structural steel - Specification (s*eventh revision*)
2	IS 11587:1986	Specification for structural weather resistant steels
3	IS 15103:2002	Fire resistant steel – Specification
4	IS 15962:2012	Structural steels for buildings and structures with improved seismic resistance
5	IS 16732:2019	Galvanized structural steel – Specification
6	IS 1161:2014	Steel tubes for structural purposes - Specification (*fifth revision*)
7	IS 4923:2017	Hollow steel sections for structural use - Specification (*third revision*)

	Structural Steel Sections	
8	IS 808:2021	Hot rolled steel beam, column, channel and angle sections - Dimensions and properties (*fourth revision*)
9	IS 811:1987	Specification for cold formed light gauge structural steel sections (*second revision)*
10	IS 1173:1978	Hot rolled and slit steel tee bars
11	IS 1730:1989	Dimensions for steel plates, sheets strips and flats for general engineering purposes (*second revision*)
12	IS 1732:1989	Steel Bars round and square for structural and general engineering purposes (*second revision*)
13	IS 3954:1991	Hot-rolled steel channel sections for general engineering purposes - Dimensions (*first revision*)
	Sheet Piles	
14	IS 2314 (Part 1): 2023	Steel sheet piling section — Specification: Part 1 Hot rolled sheet pile (*second revision*)
15	IS 2314 (Part 2): 2023	Steel sheet piling section — Specification: Part 2 Cold formed sheet pile (*second revision*)
	Structural Bolts and Rivets	
16	IS 3757:1985	Specification for high strength structural bolts (*second revision*)
17	IS 1148:2009	Steel rivet bars (medium and high tensile) for structural purposes (*fourth revision*)

8.3 Test Methods

The following Indian Standards lay down the test methods for checking the quality of structural steel:

SI No.	**IS Number**	**Title**
1	IS 1608 (Part 1):2022	Metallic materials - Tensile testing - Part 1: Method of test at room temperature
2	IS 1608 (Part 2):2020	Metallic materials - Tensile testing: Part 2 Method of test at elevated temperature (*fourth revision*)
3	IS 1608 (Part 3):2018	Metallic materials - Tensile testing: Part 3 Method of test at low temperature
4	IS 1757(Part 1):2020	Metallic materials — Charpy pendulum impact test: Part 1 Test method (*fourth revision*)
5	IS 1501 (Part 1):2020	Metallic materials — Vickers hardness test: Part 1 Test method (*fifth revision*)

6	IS 1500 (Part 1):2019	Metallic materials - Brinell hardness test: Part 1 Test method (*fifth revision*)
7	IS 1586 (Part 1):2018	Metallic materials - Rockwell hardness test: Part 1 Test method (*fifth revision*)
8		IS 1598:1977 Method for Izod impact test of metals (*first revision*)

8.4 Stacking and Storage

For each classification of steel, separate areas should be earmarked. It is desirable that ends of bars and sections of each class be painted in distinct separate colours.

Structural steel of different classification, sizes and lengths should be stored separately. It should be stored above ground level by at least 150 mm upon platforms, skids or any other suitable supports to avoid distortion of sections. In coastal areas or in case of long storage suitable protective coating of primer paint should be given to prevent scaling and rusting.

For more details on storage of structural steel, a reference may be made to IS 4082:1996 'Stacking and storage of construction materials and components at site - Recommendations (*second revision*)'.

CHAPTER IX
REINFORCING AND PRESTRESSING BARS/WIRES

CHAPTER IX
REINFORCING AND PRESTRESSING BARS/WIRES

9.1 Reinforcing Bars/Wires

9.1.1 *General*

Today, in most of the buildings and other structures, reinforced cement concrete (RCC) is predominantly used as a structural material for their various components. The reinforcing steel used in RCC is usually manufactured through one or combination of processes which may include hot rolling after microalloying, hot rolling followed by controlled cooling (thermo-mechanical treatment or TMT process) and hot rolling followed by cold work.

FIG. 24 REINFORCING BARS

FIG. 25 HOT-DIP ZINC COATED REINFORCING STEEL BARS

FIG. 26 FUSION BONDED EPOXY COATED REINFORCING BARS

Also, now a days non-ferrous reinforcing bars, such as glass fibre reinforced polymer (GFRP) bars are being manufactured for use in appropriate applications in reinforced concrete elements with low-risk (that is, where consequences of failure are less, as judged by the engineer in-charge). Examples of such elements include slab-on-grade (say, pavements and floorings), drainage structures, fences, and manhole covers.

FIG. 27 SOLID ROUND GLASS FIBRE REINFORCED POLYMER (GFRP) BARS

9.1.2 *Specifications*

The following Indian Standard specifications have been formulated to lay down the requirements of various types of reinforcing bars/wires including stainless steel, epoxy coated, glass fibre reinforced bars/wires for concrete reinforcement:

SI No.	IS Number	Title
1	IS 432 (Part 1):1982	Specification for mild steel and medium tensile steel bars and hard-drawn steel wire for concrete reinforcement: Part 1 Mild steel and medium tensile steel bars (*third revision*)
2	IS 432 (Part 2):1982	Specification for mild steel and medium tensile steel bars and hard-drawn steel wire for concrete reinforcement: Part 2 Hard-drawn steel wire (*third revision*)
3	IS 1566:1982	Specification for hard-drawn steel wire fabric for concrete reinforcement (*second revision)*
4	IS 1786:2008	High strength deformed steel bars and wires for concrete reinforcement - Specification (*fourth revision*)
5	IS 12594:1988	Hot-dip zinc coating on structural steel bars for concrete reinforcement – Specification
6	IS 13620:1993	Fusion bonded epoxy coated reinforcing bars - Specification
7	IS 16651:2017	High strength deformed stainless steel bars and wires for concrete reinforcement - Specification
8	IS 18256:2023	Solid round glass fibre reinforced polymer (GFRP) bars for concrete reinforcement — Specification

Steel reinforcement bars/wires as per IS 1786 are the most common reinforcing material used in concrete for reinforced cement concrete (RCC) work. The various grades of steel reinforcing bars specified in the standard are:

Fe 415, Fe 415D, Fe 415S, Fe 500, Fe 500D, Fe 500S, Fe 550, Fe 550D and Fe 600

The standard specifies various physical requirements and also chemical requirements to enable the bars to meet the requisite physical properties. The various physical requirements specified for different grades are:

a) Minimum 0.2 percent proof stress/ yield stress, N/mm^2

b) Maximum 0.2 percent proof stress/ yield stress, N/mm^2

c) TS/YS ratio (ratio of tensile strength to the 0.2 percent proof stress or yield stress of the test piece)

d) Minimum elongation, percent, on gauge length 5.65"A, where A is the cross-sectional area of the test piece

e) Minimum total elongation at maximum force, percent, on gauge length 5.65"A, where A is the cross-sectional area of the test piece

Various methods of reinforcement splicing that are in use include lapping, welding and by mechanical means. Lapping of reinforcement bars using binding wires has been the conventional method and is still widely used in construction projects.

Mechanical means of splicing of reinforcement bars involves joining of two reinforcement bars end to end using a reinforcement coupler and is a relatively new method being adopted in various projects. Mechanical splices may be reliable under conditions of cyclic loading into the inelastic range and may also be advantageous at locations where inelastic yielding may occur. Mechanical splicing of large diameter bars is often advantageous as this results in less congestion during concreting and faster construction. The material of the reinforcement coupler should be compatible with the material of the reinforcement bar to be spliced and as well as with the concrete. The Indian Standard, IS 16172:2023 'Reinforcement couplers for mechanical splices of steel bars in concrete – Specification (*first revision*)' lays down the requirements for reinforcement couplers use for mechanical splicing of steel bars in concrete.

9.1.3 *Test Methods*

The following Indian Standards lay down the test methods for checking the quality of reinforcing bars/wires:

SI No.	**IS Number**	**Title**
1	IS 228 (Parts 1 to 24)	Methods for chemical analysis of steels
2	IS 1608 (Part 1) : 2022	Metallic materials - Tensile testing - Part 1 : Method of test at room temperature
3	IS 2770 (Part 1):1967	Methods of testing bond in reinforced concrete: Part 1 Pull-out test.
4	IS 1599:2023	Metallic materials – Bend test (fifth revision)
5	IS 18255:2023	Fibre-reinforced polymer (FRP) bars for concrete reinforcement – Methods of tests

9.2 Prestressing Steel Bars/Wires/Strands

9.2.1 Prestressing steel is a critical component in prestressed concrete construction, enhancing the material's strength and performance by applying intentional internal stresses. This technique involves the use of high-strength steel tendons or cables that are tensioned before or after the concrete is poured, effectively counteracting the tensile stresses that the concrete will experience under load. By pre-compressing the concrete, prestressing steel significantly increases its load-bearing capacity, allowing for longer spans and thinner slabs while reducing the overall amount of concrete required. This results in more efficient, cost-effective structures with improved crack resistance and reduced deflection. Prestressed concrete is extensively used in manufacturing of railway sleepers and electric poles and in the construction of large span beams, large span bridge girders, segmental units, etc. In prestressed concrete, high tensile steel wires, bars and strands are used as reinforcement instead of mild steel bars.

FIG. 28 PRESTRESSING STRANDS

9.2.2 The following Indian Standards specifications have been formulated to lay down the requirements of various types of prestressing steel:

SI No.	IS Number	Title
1	IS 1785 (Part 1):1983	Specification for plain hard-drawn steel wire for prestressed concrete: Part 1 Cold-drawn stress relieved wire (*second revision)*
2	IS 1785 (Part 2):1983	Specification for plain hard-drawn steel wire for prestressed concrete: Part 2 As-drawn wire (*first revision*)
3	IS 2090:1983	Specification for high tensile steel bars used in prestressed concrete (*first revision*)
4	IS 6003:2010	Indented wire for prestressed concrete - Specification
5	IS 6006:2014	Uncoated stress relieved strand for prestressed concrete - Specification (*second revision)*
6	IS 10790 (Part 1):1984	Methods of sampling of steel for prestressed and reinforced concrete: Part 1 Prestressing steel

7	IS 14268:2022	Uncoated stress relieved low relaxation seven-wire (Ply) strand for prestressed concrete % Specification (*second revision)*
8	IS 16644:2018	Stress-relieved low relaxation steel wire for prestressed concrete - Specification

9.2.3 *Test Methods*

The following Indian Standards lay down the test methods for checking the quality of prestressing steel:

SI No.	IS Number	Title
1	IS 228 (Parts 1 to 24)	Methods for chemical analysis of steels
2	IS 1608 (Part 1):2022	Metallic materials - Tensile testing - Part 1: Method of test at room temperature
3	IS 1501 (Part 1):2020	Metallic Materials — Vickers Hardness Test: Part 1 Test Method (*fifth revision*)

9.3 Stacking and Storage

Steel bars should ordinarily be stored in such a way as to avoid distortion and to prevent deterioration and corrosion. Bars of different classification, sizes and lengths should be stored separately to facilitate issues in such sizes and lengths so as to minimize wastage in cutting from standard lengths. In case of long storage, reinforcement bars should be stacked above ground level by at least 150 mm. Also, in coastal areas or in case of long storage a coat of cement wash should be given to prevent scaling and rusting.

For more details on storage of reinforcing and prestressing bars/wires , a reference may be made to IS 4082:1996 'Stacking and storage of construction materials and components at site - Recommendations (*second revision*)'.

CHAPTER X
CHEMICAL ADMIXTURES

CHAPTER X
CHEMICAL ADMIXTURES

10.1 General

Admixtures are materials added to the concrete before or during its mixing, with a view to modifying one or more of the properties of concrete in the plastic or hardened state. The performance of an admixture is evaluated by comparing the properties of concrete with the admixture under test with those of concrete without any admixture or with a reference admixture.

There are following type of admixtures depending on their capability to affect the properties of concrete:

a) *Accelerating admixtures* - An admixture when added to concrete, mortar or grout, increases the rate of hydration of a hydraulic cement, shortens the time of set, or increases the rate of hardening or strength development.

b) *Retarding admixtures* - An admixture which delays the setting of cement paste, and hence of mixtures, such as mortar or concrete containing cement.

c) *Water-reducing admixtures* - An admixture which either increases workability of freshly mixed mortar or concrete without increasing water content or maintains workability with a reduced amount of water.

d) *Air-entraining admixtures* - An admixture for concrete or mortar which causes air to be incorporated in the form of minute bubbles in the concrete or mortar during mixing, usually to increase workability and resistance to freezing and thawing and disruptive action of de-icing salts.

e) *Superplasticizing admixtures* - An admixture for mortar or concrete which imparts very high workability or allows a large decrease in water content for a given workability.

10.2 Specifications

The following Indian Standard has been formulated to lay down the requirements of various types of chemical admixtures and test methods for evaluating the same:

SI No.	**IS Number**	**Title**
1	IS 9103 : 1991	Concrete admixtures – Specification (*fifth revision*)

This standard lays down the procedure for relative evaluation of admixtures for concrete. In recent times there has been a lot of development in the field of admixtures. The admixtures covered in this standard are intended mainly for modifying a single property in concrete, but some of the admixtures available in the market are often capable of modifying more than one property of-the concrete. In addition, an admixture may be used to improve the desirable properties of concrete in more than one way. For example, water reducing admixtures may be used to improve the workability of concrete with

the same water and cement contents, to increase the compressive strength without changing the workability by reduction of the water content in the concrete mix or to effect saving in cement content by reduction in both the cement and water contents in the mix while maintaining the same workability and compressive strength as in the reference concrete. In such cases, the procedure of evaluation of the admixture may have to be appropriately chosen.

The standard, IS 9103 also covers various test methods for evaluation of the properties of chemical admixture, as follows:

a) Maximum water content, as percent of control sample

b) Slump, maximum below control sample

c) Time of setting, allowable deviation from control sample

d) Minimum compressive strength, as percent of control sample

e) Minimum flexural strength, as percent of control sample

f) Maximum length change, as percent increase over control sample

g) Maximum bleeding, as percent increase over control sample

h) Maximum loss of workability, as compared to control sample

i) Maximum air content (%), over control

In addition, the standard prescribes uniformity requirements, as follows:

a) Dry material content

b) Ash content

c) Relative density

d) Chloride ion content, determined as per IS 6925:1973 'Methods of test for determination of water soluble chlorides in concrete admixtures'

e) *p*H

CHAPTER XI
PULVERIZED FUEL ASH/FLY ASH

CHAPTER XI
PULVERIZED FUEL ASH/FLY ASH

11.1 General

Pulverized fuel ash is a residue resulting from the combustion of ground or powdered or crushed bituminous coal or sub-bituminous coal (lignite). About 80 percent of the total ash is finely divided and get out of boiler along with flue gases and is collected by suitable technologies. This ash is termed as fly ash. It is sometimes referred as chimney ash and hopper ash. The balance about 20 percent of ash gets collected at the bottom of the boiler and is taken out by suitable technologies and is referred as bottom ash. Fly ash is collected and stored in dry condition. When fly ash and/or bottom ash is carried to storage or deposition lagoon or pond in the form of water slurry and deposited, it is termed as pond ash. Whereas, if fly ash and/or bottom ash is carried to a storage or deposition site in dry form and deposited, it is termed as mound ash. The pulverized fuel ash may, therefore, be in any of the following form:

a) *Fly ash* – Pulverized fuel ash extracted from flue gases by any suitable process such as by cyclone separator or electro-static precipitator.

FIG 29. FLY ASH

b) *Bottom ash* – Pulverized fuel ash collected from the bottom of boilers by any suitable process.

c) *Pond ash* – Fly ash or bottom ash or both mixed in any proportion and conveyed in the form of water slurry and deposited in pond or lagoon.

d) *Mound ash* – Fly ash or bottom ash or both mixed in any proportion and conveyed or carried in dry form and deposited dry.

The fly ash is further classified as follows:

1) *Calcareous Fly Ash* — Fly ash conforming to the provisions of calcareous fly ash given in this standard and having reactive calcium oxide not less than 10 percent by mass. Such fly ash is normally produced from burning lignite or sub-bituminous coal and has both pozzolanic and hydraulic properties.

2) *Siliceous Fly Ash* — Fly ash conforming to the provisions of siliceous fly ash given in this standard and having reactive calcium oxide less than 10 percent, by mass. Such fly ash is normally produced from burning anthracite or bituminous coal and has pozzolanic properties.

11.2 Specifications

The following Indian Standards have been formulated to lay down the requirements of various types of pulverized fuel ash:

SI No.	IS Number	Title
1	IS 3812 (Part 1) : 2013	Pulverized fuel ash – Specification: Part 1 For use as pozzolana in cement, cement mortar and concrete (*third revision*)
2	IS 3812 (Part 2) : 2013	Pulverized fuel ash – Specification: Part 2 For use as admixture in cement mortar and concrete (*third revision*)

The standard specifies various chemical requirements, physical requirements and uniformity requirements. Some of the important physical requirements specified in the standard are as follows:

SI No.	Characteristic	Requirement
1	Fineness — Specific surface in m2/kg by Blaine's permeability method, Min	320
2	Particles retained on 45 micron IS sieve (wet sieving) in percent1), Max	34
3	Lime reactivity — Average compressive strength in N/mm2, Min	4.5
4	Compressive strength at 28 days in N/ mm2, Min	Not less than 80 percent of the strength of corresponding plain cement mortar cubes
5	Soundness by autoclave test — Expansion of specimen in percent, Max	0.8

11.3 Test Methods

The following Indian Standards lay down the test methods for checking the quality of pulverized fuel ash:

SI No.	IS Number	Title
1	IS 1727:1967	Methods of test for pozzolanic materials (*first revision*)
2	IS 4032:1985	Method of chemical analysis of hydraulic cement (first revision)
3	IS 6491 : 1972	Methods for sampling fly ash

11.4 Storage

Pulverized fuel ash should be stored in such a manner as to permit easy access for proper inspection and identification of each consignment. The ash in bulk quantities should be stored in stack similar to fine aggregates avoiding any intrusion of foreign matter. Fly ash in bags should be stored in stacks not more than 10 bags high.

For more details on storage of pulverized fuel ash, a reference may be made to IS 4082:1996 'Stacking and storage of construction materials and components at site - Recommendations (*second revision*)'.

CHAPTER XII
GRANULATED IRON SLAG

CHAPTER XII
GRANULATED IRON SLAG

12.1 Slag is a non-metallic product consisting essentially of glass containing silicates and aluminates of lime and other bases, as in the case of blastfurnace slag, which is developed simultaneously with iron in blast furnace or electric pig iron furnace. Granulated slag is obtained by further processing the molten slag by rapidly chilling or quenching it with water or steam and air.

Granulated slag is used for the manufacture of hydraulic cement by mixing Portland cement clinker, gypsum and granulated slag in suitable proportions and grinding the mixture to get a thorough and intimate mix between the constituents. Portland slag cement may also be manufactured by separately grinding Portland cement clinker, gypsum and granulated slag and then mixing them intimately. The physical state of aggregation of granulated slag is in the form of granules. The proportion of lumps exceeding 50 mm size should not constitute more than 5 percent of the mass of granulated slag.

Ground granulated blast furnace slag (GGBS) may be used for manufacture of Portland cement by blending process in which cement may be manufactured by separately grinding Portland cement clinker and mixing the same intimately with GGBS and gypsum. GGBS is also used for making concrete by direct addition during concrete making process. It has minimum fineness requirements of 320 m^2/kg when measured using Blaines air permeability method.

FIG 30 GROUND GRANULATED BLAST FURNACE SLAG (GGBS)

Ultrafine ground granulated blast furnace slag (UGGBS) may be used during concrete making process for improving the properties of concrete. It has minimum fineness requirements of 1500 m^2/kg when measured using BET nitrogen adsorption process.

12.2 Specifications

The following Indian Standards have been formulated to lay down the requirements of various types of granulated slag:

SI No.	IS Number	Title
1	IS 12089:1987	Specification for granulated slag for the manufacture of Portland slag cement
2	IS 16714:2018	Ground granulated blast furnace slag for use in cement, mortar and concrete - Specification
3	IS 16715:2018	Ultrafine ground granulated blast furnace slag - Specification

The Indian Standards specify requirement of glass content as minimum 85 percent, and chemical and physical requirements for different types of above slags, the important being as follows:

GGBS as per IS 16714:

SI No.	Characteristic	Requirement
1	Glass content, Percent, Min	85
2	Fineness, m2/kg, Min	320
3	Slag activity index (see Note) :	
	a) 7 days	Not less than 60 percent of control OPC 43Grade cement mortar cube
	b) 28 days	Not less than 75 percent of control OPC 43Grade cement mortar cube

NOTE - Slag activity index (SAI) shall be determined using blend of 50 percent GGBS and 50 percent control OPC 43 conforming to IS 269, having total alkalies (Na_2O +0.658 K_2O) not less than 0.6 percent and not more than 0.9 percent). The blend shall be tested in accordance with IS 4031 (Part 6), for determining compressive strength of mortar. SAI shall be determined as:

$$\frac{\text{Compressive strength of the mortar cube using blend}}{\text{Compressive strength of control OPC mortar cube}} \times 100$$

UGGBS as per IS 16715:

SI No.	Characteristic	Requirement
1	Glass content, Percent, Min	85
2	Fineness, m2/kg, MinBET Method (Nitrogen adsorption)	1500
3	Particle size, ìm, Max:Using laser diffraction PSDanalyze	
	a) D50	5
	b) D95	15
4	Slag activity index (see Note) :	
	a) 7 days	Not less than 60 percent
	b) 28 days	Not less than 75 percent

NOTE - Slag activity index (SAI) shall be determined using blend of 50 percent UGGBS and 50 percent control OPC 43 conforming to IS 269, having total alkalies (Na_2O +0.658 K_2O) not less than 0.6 percent and not more than 0.9 percent). The blend shall be tested for compressive strength by casting and testing prisms in accordance with IS 4031 (Part 8). The mortar mix proportions by mass are, 1 part of the cement blend under test, 3 parts of standard sand and 0.5 part of water. SAI shall be determined as:

$$\frac{\text{Compressive strength of the mortar cube using blend}}{\text{Compressive strength of control OPC mortar cube}} \times 100$$

12.3 Test Methods

The following Indian Standards lay down the test methods for checking the quality of granulated slag:

SI No.	IS Number	Title
1	IS 4031 (Part 2):1999	Methods of physical tests for hydraulic cement: Part 2 Determination of fineness by Blaine air permeability method (second revision)
2	IS 4032:1985	Method of chemical analysis of hydraulic cement (first revision)
3	IS 4031 (Part 8):1988	Methods of physical tests for hydraulic cement: Part 8 Determination of transverse and compressive strength of plastic mortar using prism (first revision)
4	11578:1986	Method for determination of specific surface area of powder and porous particle using low temperature gas adsorption techniques

12.4 Storage

UGGBS should be stored in silos free from the entry of moisture, and dampness, to minimize internal condensation. UGGBS packed in bags should be kept away from ground contact to avoid damage.

CHAPTER XIII
WOOD AND OTHER LIGNOCELLULOSIC PANEL PRODUCTS

CHAPTER XIII
WOOD AND OTHER LIGNOCELLULOSIC PANEL PRODUCTS

13.1 General

Today, wood has become a scarce material which was extensively used for manufacture of wooden doors, windows, ventilators, furniture, cabinets, and for panelling and partitioning works in buildings apart from structural applications. Therefore, over a period of time, lot of wood-based materials have been developed which are now extensively used for such purposes successfully. These in turn not only save precious wood and convert the available wood into large number of useful panel products but also result in number of versatile and aesthetically pleasing products. In the process, it has also become possible to utilize wood wastes as well as number of lignocellulosic and agri-wastes such as cotton stalk and bagasse, apart from use of plantation timbers such as poplar and eucalyptus, thus promoting sustainability. These products can be broadly classified as follows:

a) Plywood, which is further classified based on end applications;

b) Block board;

c) Particle board, which is further classified based on density;

d) Fibre board, which is further classified based on density;

e) Wood-based laminates and lumber; and

f) Bamboo, coir and jute based products

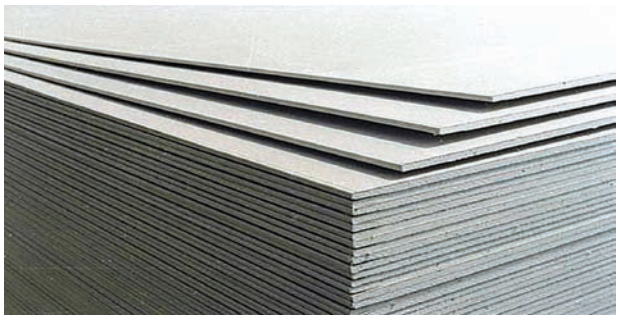
FIG. 31 PLYWOOD

FIG. 32 CONCRETE SHUTTERING PLYWOOD

FIG. 33 BLOCK BOARD FIG.

34 PARTICLE BOARD

FIG. 35 PRELAMINATED PARTICLE BOARDS FIG.



36 CEMENT BONDED PARTICLE BOARDS

FIG. 37 MDF BOARD FIG.

38 LAMINATED VENEER LUMBER

FIG. 39 BAMBOO MAT BOARD

13.2 Specifications

The following Indian Standard specifications have been formulated to lay down the requirements of various types of wood and other lignocellulosic panel products:

SI No.	IS Number	Title
	Plywood	
1	IS 303:1989	Plywood for general purposes Specification
2	IS 710:2010	Marine plywood Specification
3	IS 1328:1996	Veneered decorative plywood Specification
4	IS 4990:2011	Plywood for concrete shuttering work Specification

5	IS 5509:2021	Fire retardant plywood Specification (*third revision*)
6	IS 10701:2012	Specification for structural plywood Specification
7	IS 13957:1994	Metal faced plywood Specification
8	IS 15791:2007	Museum plywood Specification
Block Boards, Particle Boards and Fibre Boards		
9	IS 1658:2006	Fibre hardboards Specification
10	IS 1659:2004	Block boards Specification
11	IS 3087:2005	Particle boards of wood and other lingnocellulosic materials (medium density) for general purposes Specification
12	IS 3097:2006	Specification for veneered particle boards (*second revision)*
13	IS 3129:1985	Specification for low density particle boards (*first revision*)
14	IS 3308:1981	Specification for wood wool building slabs (*first revision*)
15	IS 3348:1965	Specification for fibre insulation boards
16	IS 3478:1966	Specification for high density wood particle boards
17	IS 12406:2021	Medium density fibre boards for general purpose Specification (*second revision)*
18	IS 12823:2015	Prelaminated particle boards from wood and other lignocellulosic material Specification (*first revision)*
19	IS 13745:2020	Method for determination of formaldehyde content in wood-based panels by extraction method called perforator method (*first revision)*
20	IS 14276:2016	Cement bonded particle boards Specification (*first revision*)
21	IS 14587:2023	Prelaminated medium density fibre board — Specification (*first revision*)
22	IS 15786:2008	Prelaminated cement bonded particle board Specification
Wood-based laminates and lumber		
23	IS 3513 (Part 1):1989	Specification for resin treated compressed wood laminates (compregs): Part 1 For electrical purposes (*first revision*)
24	IS 3513 (Part 2):1989	Specification for resin treated compressed wood laminates (compregs): Part 2 For chemical purposes (*first revision*)

25	IS 3513 (Part 3):1989	Specification for resin treated compressed wood laminates (compregs): Part 3 For general purposes (*first revision*)
26	IS 14616:1999	Laminated veneer lumber Specification
27	IS 16171:2014	Veneer laminated lumber Specification
Bamboo, coir and jute based products		
28	IS 13958:1994	Specification for bamboo mat board for general purpose
29	IS 14588:1999	Bamboo mat-veneer composite for general purposes Specification
30	IS 14842:2000	Coir veneer board for general purposes Specification
31	IS 15476:2004	Bamboo mat corrugated sheets Specification
32	IS 15491:2004	Medium density coirboards for general purposes Specification
33	IS 15877:2010	Coir faced block boards Specification
34	IS 15878:2010	Coir hardboard for general purposes Specification
35	IS 15972:2012	Bamboo-Jute corrugated and semi-corrugated sheets Specification
36	IS 17571:2021	Flattened bamboo board Specification
37	IS 17572:2022	BWP grade bamboo mat-veneer composite board — Specification
38	IS 17573:2021	BWP grade bamboo mat board Specification

13.3 Test Methods

The following Indian Standards lay down the test methods for checking the quality of various types of wood and other lignocellulosic panel products:

SI No.	IS Number	Title
1	IS 1734 (Parts 1 to 20): 1983	Methods of test for plywood (*second revision*): Part 1 Determination of density and moisture content Part 2 Determination of resistance to dry heat Part 3 Determination of fire resistance Part 4 Determination of glue shear strength Part 5 Test for adhesion of plies Part 6 Determination of water resistance Part 7 Mycological test Part 8 Determination of *p*H value Part 9 Determination of tensile strength Part 10 Determination of compressive strength

		Part 11 Determination of static bending strength Part 12 Determination of scarf joint strength Part 13 Determination of panel shear strength Part 14 Determination of plate shear strength Part 15 Central loading of plate test Part 16 Vibration of plywood plate test Part 17 Long time loading test of plywood strips Part 18 Impact resistance test on the surface of plywood Part 19 Determination of nail and screw holding power Part 20 Acidity and alkalinity resistance test
2	IS 2380 (Parts 1 to 21): 1977	Methods of test for wood particle boards and boards from other lignocellulosic materials: Part 1 Preparation and conditioning of test specimens Part 2 Accuracy of dimensions of boards Part 3 Determination of moisture content and density Part 4 Determination of static bending strength (modulus of rupture and modulus of elasticity in bending) Part 5 Determination of tensile strength perpendicular to Surface Part 6 Determination of tensile strength parallel to surface Part 7 Determination of compression perpendicular to plane of the board Part 8 Compression parallel to surface test Part 9 Determination of resistance to shear in plane of the board Part 10 Falling hammer impact test Part 11 Surface hardness Part 12 Central loading of plate test Part 13 Long time loading bending test Part 14 Screw and nail withdrawal test Part 15 Lateral nail resistance Part 16 Determination of water absorption Part 17 Determination of swelling in water Part 18 Determination of mass and dimensional changes caused by moisture changes Part 19 Durability cyclic test for interior use Part 20 Accelerated weathering cyclic test for exterior use Part 21 Planeness test under uniform moisture content
3	IS 3513 (Part 4):1966	Specification for resin treated compressed wood laminates (compregs): Part 4 Sampling and tests
4	IS 7638:1999	Wood/lignocellulosic based panel products - Methods of sampling (*second revision*)

13.2 Stacking and Storage

These boards should be stored flat in a covered clean and dry place. Different sizes and types of each of these boards should be stacked separately. The board should be stacked on a flat platform on which a wooden frame should be constructed with 50 mm x 25 mm battens in such a way that it will give support to all four edges and corners of the boards with intermediate battens placed at suitable intervals to avoid warping. The boards should be stacked in a solid block in a clear vertical alignment. The top sheet of each stack should be suitably weighed down to prevent warping wherever necessary. The boards should be unloaded and stacked with utmost care avoiding damage to the corners and surface. In case of decorative plywood and decorative boards, the surfaces of which are likely to get damaged by dragging one sheet over another, it is advisable that these are lifted as far as possible in pairs facing each other.

For more details on storage of wood products, a reference may be made to IS 4082:1996 'Stacking and storage of construction materials and components at site - Recommendations (*second revision*)'.

CHAPTER XIV
GYPSUM BASED MATERIALS

CHAPTER XIV
GYPSUM BASED MATERIALS

14.1 General

Gypsum is a soft sulphate mineral composed of calcium sulphate dihydrate, with the chemical formula $CaSO_4.2H_2O$. Gypsum may be natural (or mineral) gypsum or chemical (or by-product) gypsum. The by-product gypsum may further be classified into phospho-gypsum, fluoro-gypsum, marine gypsum and sulpho-gypsum. Sulpho-gypsum is also known as flue gas desulphurization gypsum or FGD gypsum.

Phospho-gypsum is obtained as a by-product in the manufacture of phosphoric acid by wet process. Fluoro-gypsum is produced as a by-product during the manufacture of hydrofluoric acid. Marine gypsum is obtained during the process of recovering common salt by solar evaporation of seawater. Sulpho-gypsum is produced as a by-product during desulphurization of flue gas produced from the combustion of coal in power plants. The limestone slurry is used for scrubbing oxides of sulphur in flue gas and producing sulpho-gypsum as a byproduct.

Gypsum is used in manufacture of cement for regulating its setting time, and for manufacture of various products like gypsum plasters, gypsum boards, gypsum panels and ceiling tiles.

FIG. 40 GYPSUM PLASTER BOARDS

FIG. 41 GYPSUM CEILING TILES

14.2 Specifications

The following Indian Standard specifications have been formulated to lay down the requirements of various gypsum and gypsum-based products:

SI No.	IS Number	Title
1	IS 2095 (Part 1):2023	Gypsum plaster boards — Specification: Part 1 Plain gypsum plaster boards (*fourth revision*)
2	IS 2095 (Part 2):2022	Gypsum plaster boards – Specification: Part 2 Coated/ laminated gypsum plaster boards (*third revision*)
3	IS 2095 (Part 3):2022	Gypsum plaster boards – Specification: Part 3 Reinforced gypsum plaster boards and ceiling tiles (*fourth revision*)

4	IS 2547 (Part 1):1976	Specification for gypsum building plaster: Part 1 Excluding premixed lightweight plasters (*first revision*)
5	IS 2547 (Part 2):1976	Specification for gypsum building plasters: Part 2 Premixed lightweight plasters (*first revision*)
6	IS 2849:1983	Specification for non-load bearing gypsum partition blocks (solid and hollow types) (*first revision*)
7	IS 8272:1984	Specification for gypsum plaster for use in the manufacture of fibrous plaster boards (*first revision*)
8	IS 12679:2023	By-Product gypsum for construction — Specification (*second revision*)
9	IS 17400:2021	Glass fibre reinforced gypsum panels - Specification
10	IS 18387:2023	Gypsum ceiling tiles — Specification

14.3 Test Methods

The following Indian Standards lay down the test methods for checking the quality of various gypsum and gypsum-based products:

SI No.	IS Number	Title
1	IS 2542 (Part 1/Sec 1) : 2023	Gypsum plaster, concrete and products — Methods of test: Part 1 Plaster and concrete: Section 1 Determination of normal consistency of gypsum plaster (*second revision*)
2	IS 2542 (Part 1/Sec 2) : 2023	Gypsum plaster, concrete and products — Methods of test: Part 1 Plaster and concrete: Section 2 Determination of normal consistency of gypsum concrete (*second revision*)
3	IS 2542 (Part 1/Sec 3) : 2023	Gypsum plaster, concrete and products — Methods of test: Part 1 Plaster and concrete: Section 3 Determination of setting time of plaster and concrete (*second revision*)
4	IS 2542 (Part 1/Sec 4) : 2023	Gypsum Plaster, Concrete and Products — Methods of test: Part 1 Plaster and concrete: Section 4 Determination of transverse strength of gypsum plaster (*second revision*)
5	IS 2542 (Part 1/Sec 5) : 2023	Gypsum Plaster, Concrete and Products — Methods of test: Part 1 Plaster and concrete: Section 5 Determination of compressive strength and dry set density of gypsum plaster (*second revision*)
6	IS 2542 (Part 1/Sec 6) : 2023	Gypsum Plaster, Concrete and Products — Methods of test: Part 1 Plaster and concrete: Section 6 Determination of soundness of gypsum plaster (*second revision*)

7	IS 2542 (Part 1/Sec 7) : 2023	Gypsum Plaster, Concrete and Products — Methods of test: Part 1 Plaster and concrete: Section 7 Determination of impact resistance of gypsum plaster by dropping ball test (*second revision*)
8	IS 2542 (Part 1/Sec 8) : 2023	Gypsum plaster, concrete and products — Methods of Test: Part 1 Plaster and concrete: Section 8 Determination of mass of coarse particles (*second revision*)
9	IS 2542 (Part 1/Sec 9) : 2023	Gypsum plaster, concrete and products — Methods of test: Part 1 Plaster and concrete: Section 9 Determination of expansion of gypsum plaster (*second revision*)
10	IS 2542 (Part 1/Sec 10) : 2023	Gypsum plaster, concrete and products — Methods of test: Part 1 Plaster and concrete: Section 10 Determination of sand in set gypsum plaster (*second revision*)
11	IS 2542 (Part 1/Sec 11) : 2023	Gypsum plaster, concrete and products — Methods of Test: Part 1 Plaster and concrete: Section 11 Determination of wood fibre content in wood fibre gypsum plaster (*second revision*)
12	IS 2542 (Part 1/Sec 12) : 2023	Gypsum plaster, concrete and products — Methods of test: Part 1 Plaster and concrete: Section 12 Determination of dry bulk density (*second revision*)
13	IS 2542 (Part 1/Sec 13) : 2023	Gypsum plaster, concrete and products — Methods of test: Part 1 Plaster and concrete: Section 14 Determination of free water (*second revision*)
14	IS 2542 (Part 1/Sec 14) : 2023	Gypsum plaster, concrete and products — Methods of test: Part 1 Plaster and concrete: Section 14 Determination of fineness (*second revision*)
15	IS 2542 (Part 2/Sec 1 to 8):1981	Methods of test for gypsum plaster, concrete and products: Part 2 Gypsum products (*first revision*) Section 1 Measurement of dimensions Section 2 Determination of mass Section 3 Determination of mass and thickness of paper surfacing Section 4 Transverse strength Section 5 Compressive strength Section 6 Water absorption Section 7 Moisture content Section 8 Nail retention of precast reinforced gypsum slabs

14.4 Stacking and Storage

For details on stacking and storage of gypsum boards, a reference may be made to IS 4082:1996 'Stacking and storage of construction materials and components at site - Recommendations (*second revision*)'.

CHAPTER XV
DOORS, WINDOWS AND VENTILATORS

CHAPTER XV
DOORS, WINDOWS AND VENTILATORS

15.1 General

Doors, windows and ventilators including their frames are important components of a building which ensure security and comfort to the occupants. The doors include the door frame which is fixed to the door opening and the door shutter. Based on material types, these may be made of wood, wood and other lignocellulosic based panel products, steel, aluminium, plastic, and even glass particularly in case of windows, etc. The door and window shutters may be single leaf or double leaf type. The wooden doors may be further classified as ledged, braced and battened doors; panelled doors; and flush doors.

FIG. 42 PANELLED DOOR

FIG. 43 FLUSH DOOR

FIG. 44 LEDGED, BRACED AND BATTENED DOOR

FIG. 45 PRESSED STEEL DOOR FRAMES

FIG. 46 WOODEN DOOR FRAMES

15.2 Specifications

The following Indian Standard specifications have been formulated to lay down the requirements of various types of doors, windows and ventilators:

SI No.	IS Number	Title
Wooden Doors, Windows and Ventilators		
1	IS 1003 (Part 1):2003	Timber panelled and glazed shutters - Specification: Part 1 Door shutters (*fourth revision*)
2	IS 1003 (Part 2):1994	Timber panelled and glazed shutters - Specification: Part 2 Window and ventilator shutters (*third revision*)
3	IS 2191 (Part 1):2022	Wooden flush door shutters (Cellular, hollow and tubular core type) — Specification Part 1 Plywood face panels (*fifth revision*)
4	IS 2191 (Part 2):2022	Wooden flush doors shutters (Cellular, hollow and tubular core type) – Specification: Part 2 Particle Board, high density fibre board, medium density fibre board and fibre hardboard face panels (*fourth revision*)
5	IS 2202 (Part 1):2023	Flush door shutters (solid core type) — Specification: Part 1 Plywood face panels (*seventh revision)*
6	IS 2202 (Part 2):2022	Wooden flush door shutters (Solid core type) — Specification: Part 2 Particle Board, high density fibre board, medium density fibre board and fibre hardboard face panels (*fourth revision*)
7	IS 4021:1995	Timber door, window and ventilator frames - Specification (*third revision*)
8	IS 6198:1992	Ledged, braced and battened timber door shutters - Specification (*second revision)*
Metal Doors, Windows and Ventilators		
9	IS 1038:1983	Specification for steel doors, windows and ventilators (*third revision*)
10	IS 1361:1978	Specification for steel windows for industrial buildings (*first revision*)
11	IS 1948:1961	Specification for aluminium doors, windows and ventilators
12	IS 1949:1961	Specification for aluminium windows for industrial buildings
13	IS 4351:2003	Steel door frames - Specification (*second revision*)

14	IS 6248:1979	Specification for metal rolling shutters and rolling grills (*first revision*)
15	IS 7452:1990	Hot rolled steel sections for doors, windows and ventilators - Specification (*second revision)*
16	IS 10451:1983	Specification for steel sliding shutters (top hung type)
17	IS 10521:1983	Specification for collapsible gates
Plastic Doors and Windows		
18	IS 14856:2000	Glass fibre reinforced plastic (GRP) panel type door shutters for internal use - Specification
19	IS 15380:2023	Moulded high density fibre (HDF) panelled door shutters —Specification (*first revision*)
20	IS 15931:2012	Solid panel foam UPVC door shutters - Specification
21	IS 17953 : 2023	UPVC profiles for windows and doors — Specification
Concrete Door and Window Frames		
22	IS 6523:1983	Specification for precast reinforced concrete door and window frames (*first revision*)
Other Composite Material Doors and Windows		
23	IS 16073:2013	Bamboo – Jute composite panel door shutter - Specification
24	IS 16074:2013	Steel flush door shutters - Specification
25	IS 16096:2013	Bamboo – Jute composite hollow core door shutter - Specification
	Fire Check Doors	
26	IS 3614:2021	Fire doors and doorsets - Specification (*first revision*)
Mesh/Net for Mosquito/ Vector Prevention		
27	IS 1568:1970	Specification for wire cloth for general purposes (*first revision*)
28	IS 3150:1982	Specification for hexagonal wire netting for general purposes (*second revision)*
29	IS 11199:2024	Textiles – High density polyethylene HDPE monofilament twine door nets - Specification (*first revision*)

15.3 Test Methods

The following Indian Standards lay down the test methods for checking the quality of doors and windows:

SI No	IS Number	Title
1	IS 4020 (Parts 1 to 16): 1998	Door shutters - Methods of tests: Part 1 General (*third revision*) Part 2 Measurement of dimensions and squareness (*third revision*) Part 3 Measurement of general flatness (*third revision*) Part 4 Local planeness test (*third revision*) Part 5 Impact indentation test (*third revision*) Part 6 Flexure test (*third revision*) Part 7 Edge loading test (*third revision*) Part 8 Shock resistance test (*third revision*) Part 9 Buckling resistance test (*third revision*) Part 10 Slamming test (*third revision*) Part 11 Misuse test (*third revision*) Part 12 Varying humidity test (*third revision*) Part 13 End immersion test (*third revision*) Part 14 Knife test (*third revision*) Part 15 Glue adhesion test (*third revision*) Part 16 Screw withdrawal resistance test (*third revision*)
2	IS 17909:2022 / ISO 8274:2005	Windows and doors resistance to repeated opening and closing -Test method
3	IS 17910 (Part 1) : 2022 / ISO 12567-1 : 2010	Thermal performance of windows and doors — Determination of thermal transmittance by the Hot-Box Method : Part 1 Complete windows and doors
4	IS 17910 (Part 2) : 2022 / ISO 12567-2:2005	Thermal performance of windows and doors – Determination of thermal transmittance by the Hot-Box Method : Part 2 Roof windows and other projecting windows
5	IS 17911:2022 / ISO 15099:2003	Thermal performance of windows, doors and shading devices – detailed calculations
6	IS 17920:2022 / ISO 10077-2:2017	Thermal performance of windows, doors and shutter – Calculation of thermal transmittance – Numerical method of frames
7	IS 17953:2023	UPVC profiles for windows and doors — Specification
8	IS 18268:2023 / ISO 9379:2005	Standard operating forces: Method of test – Doors

9	IS 18434:2023	Field measurement of air permeability and water penetration through installed curtain wall, windows, doors, sliders and skylights under static air pressure difference — Method of test
10	IS 18459:2024	Water penetration of curtain walls, windows, sliders, doors and skylights by uniform static air pressure difference — Method of test
11	IS 18473:2024	Wind resistance for curtain walls, windows, sliders, doors and skylights – Method of test
12	IS 18647:2024	Water penetration of curtain walls, windows, sliders and doors by dynamic air pressure - Method of test
13	IS 19006:2023 / ISO 8248:1985	Standard windows and door height windows — Mechanical tests

15.4 Stacking and Storage

While unloading, shifting, handling and stacking timber or other lignocellulosic material based, or metal and plastic door and window frames and shutters, care should be taken that the material is not dragged one over the other as it may cause damage to the surface of the material particularly in the case of decorative shutters. The material should be lifted and carried preferably flat avoiding damage of corners or sides. Separate stacks should be built up for each size, each grade and each type of material. When materials of different sizes, grades and types are to be stacked in one stack due to shortage of space, the bigger size should be stacked in the lower portion of the stacks. Suitable pallets or separating battens should be kept in between the two types of material.

For more details on doors, windows and ventilators a reference may be made to IS 4082:1996 'Stacking and storage of construction materials and components at site - Recommendations (*second revision*)'.

CHAPTER XVI
BUILDER'S HARDWARE

CHAPTER XVI
BUILDER'S HARDWARE

16.1 Builder's hardware are building products which are mounted on the moving parts in buildings to enable their smooth movement, closing and opening, etc such as on doors and windows. The various types of builder's hardware may be door handles, hinges, bolts, etc. These may be manufactured using mild steel, stainless steel, aluminium, brass, etc and may take various surface finishes.

FIG. 47 TOWER BOLTS

FIG. 48 BUTT HINGE

FIG. 49 TEE AND STRAP hinges

FIG. 50 DOOR HANDLE

FIG. 51 PARLIAMENT HINGE

16.2 The following Indian Standards has been formulated to lay down the requirements of various types of builder's hardware:

SI No.	IS Number	Title
1	IS 204 (Part 1):1991	Tower bolts - Specification: Part 1 Ferrous metals (*fifth revision*)
2	IS 204 (Part 2):1992	Tower bolts - Specification: Part 2 Non-ferrous metals (*fifth revision*)
3	IS 205:1992	Non-ferrous metal butt hinges - Specification (*fourth revision*)

4	IS 206:2010	Tee and strap hinges - Specification (*fifth revision*)
5	IS 208:2020	Door handles - Specification (*sixth revision*)
6	IS 281:2009	Mild steel sliding door bolts for use with padlocks - Specification (*fourth revision*)
7	IS 362:1991	Parliament hinges - Specification (*fifth revision*)
8	IS 1341:2018	Steel butt hinges — Specification (*sixth revision*)
	IS 1823:1980	Specification for floor door stoppers (*third revision*)
9	IS 3564:1995	Hydraulically regulated door closers - Specification (*fourth revision*)
10	IS 3818:1992	Continuous (Piano) hinges - Specification (*third revision*)
11	IS 4992:1975	Specification for door handles for mortice locks (vertical type) (*first revision*)
12	IS 6315:1992	Floor springs (hydraulically regulated) for heavy doors - Specification (*second revision)*
13	IS 7196:1974	Specification for hold fast
14	IS 7534:1985	Specification for sliding locking bolts for use with padlocks (*first revision*)
15	IS 8756:1978	Specification for mortice ball catches for use in wooden almirahs
16	IS 10019:1981	Specification for mild steel stays and fasteners
17	IS 12817:2020	Stainless steel butt hinges - Specification (*third revision*)
18	IS 15833:2009	Stainless steel tower bolts - Specification
19	IS 15834:2020	Stainless steel sliding door bolts (aldrops) for use with padlocks - Specification (*first revision*)

CHAPTER XVII
CONSTRUCTION CHEMICALS

CHAPTER XVII
CONSTRUCTION CHEMICALS

17.1 General

Construction chemicals are various products used in the construction activity to improve various properties, action or performance of building products or the buildings and structures themselves. These may include the following:

a) Anti-termite chemicals

b) Chemical admixture/water proofing compounds

c) Sealants/fillers

d) Adhesives

17.2 The following Indian Standards has been formulated to lay down the requirements of various types of construction chemicals:

SI No.	IS Number	Title
	Anti-termite chemicals	
1	IS 8944:2005	Chlorpyrifos, emulsifiable concentrates — Specification (first revision)
2	IS 15936:2011	Pesticide — Bifenthrin, technical — Specification
3	IS 16131:2015	Imidacloprid suspension concentrate (SC) — Specification
	Chemical admixture/water proofing compounds	
4	IS 2645:2003	Integral waterproofing compounds for cement mortar and concrete - Specification
5	IS 9103:1999	Specification for concrete admixtures
	Sealants/fillers	
6	IS 1834:1984	Specification for hot applied sealing compounds for joints in concrete (*first revision*)
	IS 1838 (Part 1):1983	Specification for preformed fillers for expansion joint in concrete pavement and structure (non-extruding and resilient type): Part 1 Bitumen impregnated fibre (*first revision*)
7	IS 1838 (Part 2):1984	Specification for preformed fillers for expansion joint in concrete pavement and structure (non- extruding and resilient type): Part 2 CNSL Aldehyde resin and coconut pith

8	IS 1838 (Part 3):2011	Preformed fillers for expansion joints in concrete pavements and structures (non-extruding and resilient type) - Specification: Part 3 Polymer based
9	IS 10566:1983	Methods of tests for preformed fillers for expansion joints in concrete paving and structural construction
10	IS 11433 (Part 1):1985	Specification for one-part gun-grade polysulphide-based joint sealants: Part 1 General requirements
11	IS 11433 (Part 2):1986	Specification for one-part gun-grade polysulphide-based joint sealants: Part 2 Methods of tests
12	IS 12118 (Part 1):1987	Specification for two-part polysulphide-based sealants: Part 1 General requirements
13	IS 12118 (Part 2):1987	Specification for two-part polysulphide-based sealants: Part 2 Methods of tests
	Adhesives	
14	IS 848:2006	Synthetic resin adhesives for plywood (phenolic and amino plastic) - Specification (*second revision)*
15	IS 851:1978	Specification for synthetic resin adhesives for construction work (non-structural) in wood (*first revision*)
16	IS 852:1994	Animal glue for general wood-working purposes - Specification (*second revision*)
17	IS 1508:1972	Specification for extenders for use in synthetic resin adhesives (urea-formaldehyde) for plywood (*first revision*)
18	IS 4835:1979	Specification for polyvinyl acetate dispersion based adhesives for wood (*first revision*)
19	IS 9188:1979	Performance requirements for adhesives for structural laminated wood products for use under exterior exposure condition
20	IS 12830:1989	Rubber based adhesives for fixing PVC tiles to cement – Specification
21	IS 12994:1990	Epoxy adhesives, room temperature curing, general purpose – Specification
22	IS 15477:2019	Adhesives for use with ceramic, mosaic and stone tiles - Specification (*first revision*)

CHAPTER XVIII
WATERPROOFING AND DAMP-PROOFING MATERIALS

CHAPTER XVIII
WATERPROOFING AND DAMP-PROOFING MATERIALS

18.1 Bathroom, kitchen, water closet and to a lesser extent verandah, balconies may be vulnerable to seepage of water due to their location and functional requirements. These wet areas are one of the main sources of seepage and dampness in a building which leads to unhygienic conditions affecting badly the health and comfort of inhabitants and may seriously deteriorate the durability of a building. The causes of dampness and leakage may be due to defective design, sub-standard material, improper execution and incorrect usage by the occupant. Various waterproofing and damp-proofing materials may be appropriately employed to improve the performance of the building surfaces in this regard. These materials may be bituminous based or polymer based, with or without glass fibres, etc.

FIG. 52 BITUMEN FELT

18.2 The following Indian Standards have been formulated to lay down the requirements of various types of water proofing and damp-proofing materials:

SI No.	IS Number	Title
1	IS 1322:1993	Bitumen felts for water-proofing and damp-proofing - Specification (*fourth revision*)
2	IS 1580:1991	Bituminous compounds for waterproofing and caulking purposes - Specification (*second revision)*
3	IS 3037:1986	Specification for bitumen mastic for use in water proofing of roofs (*first revision*)
4	IS 3384:1986	Specification for bitumen primer for use in waterproofing and damp-proofing (*first revision*)
5	IS 5871:1987	Specification for bitumen mastic for tanking and damp- proofing (*first revision*)

6	IS 7193:2013	Glass fibre base bitumen felts - Specification (*second revision)*
7	IS 12027:1987	Specification for silicone-based water repellents
8	IS 14695:1999	Glass fibre base coal tar pitch outerwrap - Specification
9	IS 16471:2017	Protection of below ground structures against water from the ground - Guidelines
10	IS 16525:2017	Styrene butadiene styrene (SBS) modified bituminous waterproofing and damp-proofing membrane with polyester reinforcement - Specification
11	IS 16526:2017	Atactic polypropylene (APP) modified bituminous waterproofing and damp-proofing membrane with glass fibre reinforcement - Specification
12	IS 16532:2017	APP modified bituminous water-proofing and damp-proofing membrane with polyester reinforcement - Specification
13	IS 16540:2017	Atactic polypropylene (APP) modified high molecular high density polyethylene (HMHDPE) bituminous waterproofing and damp-proofing membrane - Specification

18.3 The following Indian Standards lay down the test methods for checking the quality of quality of water proofing and damp-proofing materials:

SI No.	**IS Number**	**Title**
1	IS 13435 (Part 1):2021	Acrylic polymer based waterproofing materials - Methods of test: Part 1 Determination of solid content (*first revision*)
2	IS 13435 (Part 2):1992	Acrylic based polymer waterproofing materials - Methods of test: Part 2 Determination of coarse particles
3	IS 13435 (Part 3):1992	Acrylic based polymer waterproofing material - Methods of test: Part 3 Determination of capillary water take-up
4	IS 13435 (Part 4):1992	Acrylic based polymer waterproofing material - Methods of test: Part 4 Determination of *p*H value
5	IS 13826 (Part 1):1993	Bitumen based felt - Methods of test: Part 1 Breaking strength test
6	IS 13826 (Part 2):2022	Bitumen based felt - Methods of test: Part 2 Pliability test (*first revision*)
7	IS 13826 (Part 3):1993	Bitumen based felts - Methods of test: Part 3 Storage sticking test
8	IS 13826 (Part 4):1993	Bitumen based felts - Methods of test: Part 4 Pressure head test

9	IS 13826 (Part 5):1994	Bitumen based felt - Methods of test: Part 5 Heat resistance test
10	IS 13826 (Part 6):1993	Bitumen based felts - Methods of test: Part 6 Water absorption test
11	IS 13826 (Part 7):1993	Bitumen based felt - Methods of test: Part 7 Determination of binder content

CHAPTER XIX
PAINT AND ALLIED PRODUCTS

CHAPTER XIX
PAINT AND ALLIED PRODUCTS

19.1 Paints, varnishes, lacquers and their related products have an important role in enhancing the life of structures as well as in increasing the aesthetic appearance of the building surfaces and the structure as a whole. Various varieties of paints and allied products are primers, cement paints, enamel and emulsion paints, industrial coatings, road marking paint, etc.

19.2 The following Indian Standards have been formulated to lay down the requirements of various types of paints and allied materials:

SI No.	IS Number	Title
	Primers	
1	IS 2074:2023	Ready mixed paint, air drying, red oxide - Zinc chrome, priming – Specification (*fourth revision*)
2	IS 3536:2016	Ready mixed paint, brushing, wood primer - Specification (*second revision*)
3	IS 12744:2013	Ready mixed paint air drying red oxide - zinc phosphate priming - Specification (*first revision*)
4	IS 13238:2021	Epoxy based zinc phosphate primer two pack – Specification (*first revision*)
5	IS 13759:2017	Polyurethane primer, zinc phosphate (Two - Pack) for exterior painting of railway coaches – Specification (*first revision*)
	Enamel and Emulsion paints	
6	IS 15489:2013	Paint plastic emulsion - Specification (*first revision*)
7	IS 13213:2018	Polyurethane full gloss enamel (Two Pack) - Specification (*first revision*)
8	IS 2933:2013	Enamel, exterior: (A) undercoating (B) finishing - Specification
9	IS 2932:2013	Enamel synthetic exterior (A) undercoating (B) finishing – Specification (*fourth revision*)
10	IS 8662:2024	Enamel, synthetic - undercoating and finishing for exterior of railway coaches - Specification (*third revision*)
11	IS 6125:2017	Enamel, synthetic, stoving, for automobiles – Specification (*first revision*)

	Cement Paint	
12	IS 5410:2013	Cement paint - Specification (*second revision*)
	Putty	
13	IS 17545:2021	White cement based polymeric putty-Specification
14	IS 419:2023	Putty for use on window frames – Specification (*second revision*)
	Distempers	
15	IS 427:2013	Distemper dry colour as required - Specification (*third revision*)
16	IS 428:2013	Washable distemper - Specification (*third revision*)
	Varnishes	
17	IS 344:2023	Varnish stoving - Specification (*second revision*)
18	IS 524:1983	Specification for varnish, finishing, exterior, synthetic, air - drying (*second revision*)
19	IS 347:2023	Varnish shellac for general purposes - Specification (*second revision*)
20	IS 6127:2023	Varnish spar and fungicidal - Specification (*first revision*)
	Road Marking Paint	
21	IS 164:2023	Ready mixed paint for road marking - Specification Third Revision (*third revision*)
	Lacquers	
22	IS 5691:1970	Specification for lacquer cellulose nitrate pigmented finishing glossy
23	IS 10018:1981	Specification for lacquer, cellulose nitrate, clear, finishing, glossy for wood

19.3 The following Indian Standards lay down the test methods for checking the quality of paints and allied products:

SI No.	**IS Number**	**Title**
1	IS 101 (Part 1)	Methods of sampling and test for paints, varnishes and related products: Part 1 tests on liquid paints (general and physical): Sec 1 to 8
2	IS 101 (Part 2)	Methods of sampling and test for paints, varnishes and related products: Part 2 test on liquid paints (chemical examination): Sec 1 to 5
3	IS 101 (Part 3)	Methods of sampling and test for paints, varnishes and related products: Part 3 tests on paint film formation: Sec 1, Sec 2, Sec 4, and Sec 5

4	IS 101 (Part 4)	Methods of sampling and test for paints, varnishes and related products: Part 4 optical test: Sec 1 to 4
5	IS 101 (Part 5)	Methods of sampling and test for paints, varnishes and related products: Part 5 mechanical test on paint films: Sec 1 to 5
6	IS 101 (Part 6)	Methods of sampling and test for paints, varnishes and related products: Part 6 durability tests: Sec 1 to 5
7	IS 101 (Part 7)	Methods of sampling and test for paints, varnishes and related products: Part 7 environmental tests on paint films: Sec 1 to 4
8	IS 101 (Part 8)	Methods of sampling and test for paints, varnishes and related products: Part 8 tests for pigments and other solids: Sec 1 to 6
9	IS 101 (Part 9)	Methods of sampling and test for paints, varnishes and related products: Part 9 tests for lacquers and varnish: Sec 1 to 2
10	IS 101 (Part 10)	Methods of sampling and test for paints varnishes and related products: Part 10 instrumental analysis: Sec 1 to 5

19.4 All containers of paints, thinners and allied materials should preferably be stored in a separate room on floors with sand cushions. The room should be well-ventilated and free from excessive heat, sparks of flame and direct rays of sun. The containers of paint should be kept covered or properly fitted with lid and should not be kept open except while using. The containers of paints have expiry date marked by the manufacturers, which should be highlighted so as to facilitate use of paint within due period.

For more details on storage of paints a reference may be made to IS 4082:1996 'Stacking and storage of construction materials and components at site - Recommendations (*second revision*)'.

CHAPTER XX
GLASS

CHAPTER XX
GLASS

20.1 General

Glazing has become an important item in building construction. Glass, the primary glazing element has to be selected to cater to several requirements and the glazing has to be designed to meet various engineering requirements. Fixing of glass, a specialized operation, when properly done, will avoid the hazards of broken glass. Growing trend in resorting to glazed windows/doors in buildings has considerably increased the importance of glazing and the need for proper workmanship. The Glass may be classified into:

a) Normal (annealed) glass
b) Laminated glass
c) Toughened or tempered glass
d) Heat strengthened glass
e) Coated (reflective) glass
f) Tinted (body-coloured) glass
g) Insulating glass unit
h) Bullet resistant security glass
i) Fire resistant glass
j) Wired glass

a) *Normal (Annealed) Glass* – It is the most basic and commonly produced type of glass used in buildings and construction. It may further be classified into following categories based on the manufacturing process:

1) *Float glass* – Molten glass, at approximately 1000 °C, is poured continuously from a furnace onto a shallow bath of molten tin. It floats on the tin, spreads out and forms a level surface. Thickness is controlled by the speed at which solidifying glass ribbon is drawn off from the bath.

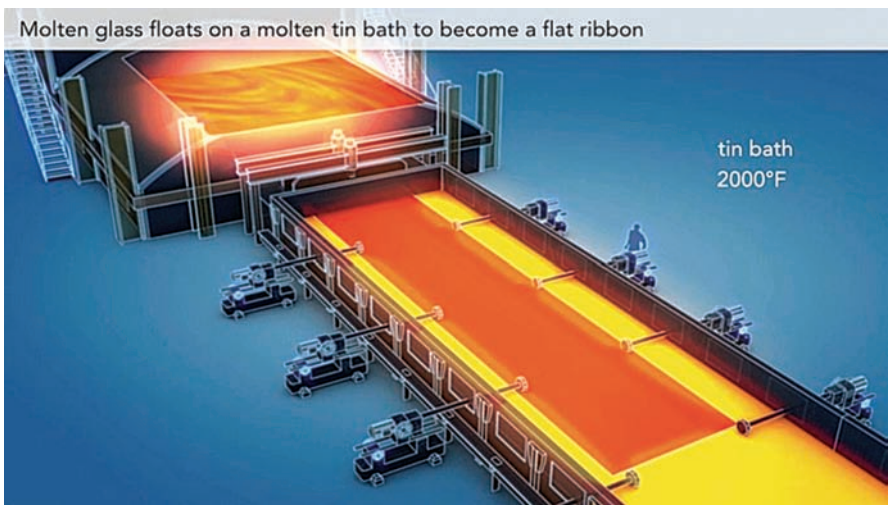


FIG. 53FLOAT GLASS

2) *Sheet Glass* – Older method of glass production, where the molten glass is drawn vertically from a tank, producing a less uniform thickness and surface quality compared to float glass.

3) *Rolled Glass* – Produced by passing molten glass between rollers, which can also be used to impart a texture or pattern to the surface (Textured/ Patterned Glass).

b) *Laminated Glass* – It is a type of safety glass that is composed of two or more layers of glass with an interlayer, typically made of polyvinyl butyral (PVB) or ethylene-vinyl acetate (EVA), sandwiched between them.

FIG. 54 LAMINATED GLASS

c) *Toughened or Tempered Glass* – Toughened glass, also known as tempered glass, is a type of safety glass that is treated through controlled thermal processes to enhance its strength and durability. This glass undergoes a special heat treatment where it is heated to a high temperature and then rapidly cooled, creating compressive stresses on the surface and tensile stresses in the interior. These stresses significantly increase the glass's strength compared to normal (annealed) glass and alter its breakage pattern to minimize injury.

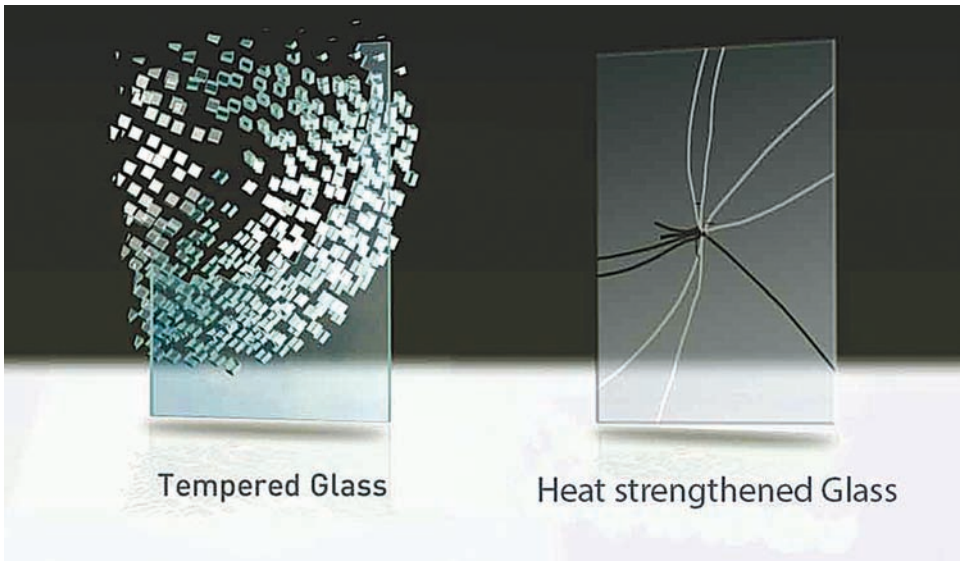


FIG. 55

d) *Heat Strengthened Glass* – It is a glass that has been partially tempered through a process of heating to around 600°C (1112°F) and then slowly cooling it to produce a glass that is approximately twice as strong as annealed glass but not as strong as fully tempered glass. This process induces compressive stresses on the surface and tensile stresses in the core, enhancing its mechanical and thermal properties.

e) *Coated (Reflective) Glass* – Glass that has been coated with a thin layer of metallic or metal oxide, giving it a reflective quality. This coating reflects a portion of the sunlight and heat that strikes the glass, improving energy efficiency and reducing glare.

FIG. 56 COATED GLASS

FIG. 57 TINTED GLASS

f) *Tinted (Body-Coloured) Glass* – In this type of glass, the colour is incorporated into the glass itself during the manufacturing process. This is achieved by adding metal oxides or other colorants to the raw materials before the glass is formed. The resulting tint is integral to the glass, giving it a uniform colour throughout its thickness which can range from light hues to darker shades. It is a versatile and practical material used in various applications to enhance energy efficiency, comfort, and aesthetic appeal. By reducing solar heat gain, glare, and UV radiation, it provides significant benefits in different architectural designs. The uniform colour and durability make it a preferred choice for many designers and architects looking for both functional and decorative glass solutions.

g) *Insulating Glazing Unit (IGU)* – An assembly consisting of two or more glass panes separated by a spacer and hermetically sealed around the edges. The space between the glass panes is typically filled with air or a specialized gas, such as argon or krypton, which provides thermal insulation, sound insulation benefits. The primary purpose of an IGU is to improve the energy efficiency of buildings by reducing heat transfer through windows and doors.

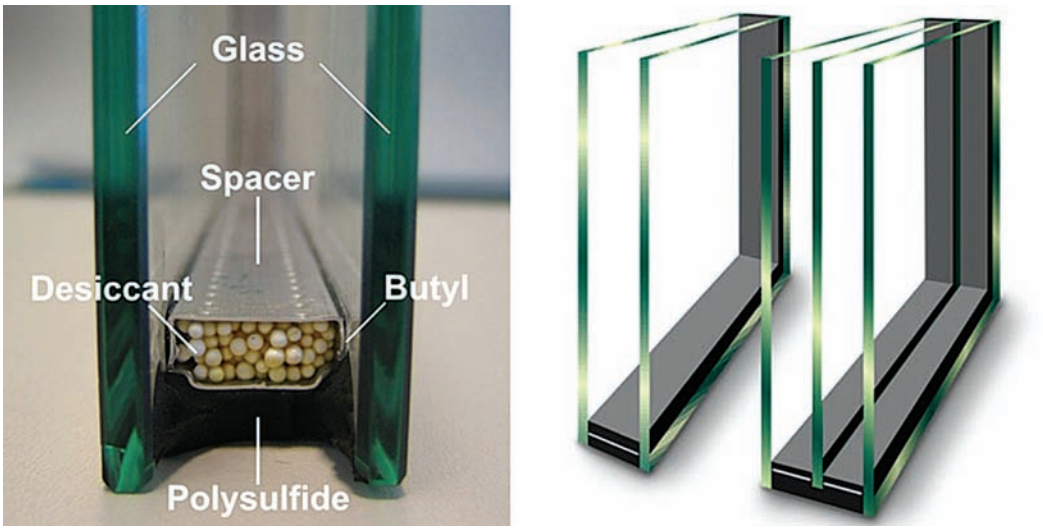


FIG. 58 INSULATING GLAZING UNIT (IGU)

h) *Bullet-Resistant Security Glass* – It is a composite material engineered to resist penetration by bullets and fragments. It is typically constructed by laminating multiple layers of glass with one or more layers of tough, transparent plastics, such as polycarbonate or thermoplastic, using strong interlayer materials like polyvinyl butyral (PVB) or ethylene-vinyl acetate (EVA). The thickness and number of layers vary based on the level of protection required, ranging from handgun-resistant to high-powered rifle-resistant.

FIG. 59 BULLET-RESISTANT SECURITY GLASS

i) *Fire-Resistant Glass – It* is a type of glass that has been tested to maintain its integrity and stability during exposure to fire for a rated time. Unlike standard glass, which can break under thermal stress, fire-resistant glass is engineered to resist cracking, breaking, or disintegrating when exposed to flames and high temperatures. It helps to compartmentalize fire and smoke, thereby containing the spread of fire and providing additional time for safe evacuation and fire suppression efforts.

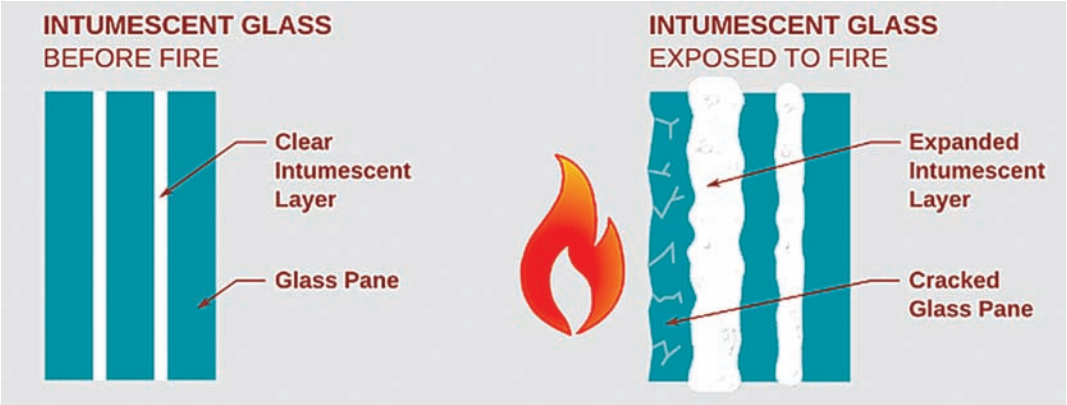


FIG. 60 INTUMESCENT-LAYER TYPE FIRE-RESISTANT GLASS

j) *Wired Glass* – It is a fire-resistant glass that includes a metal wire mesh or grid embedded within the glass sheet during production. This wire reinforcement is distributed evenly throughout the glass to provide additional strength and safety benefits. The primary purpose of the wire mesh is to prevent the glass from disintegrating into large, sharp shards when subjected to impact or thermal shock, such as during a fire. However, in some regions, building codes and regulations are increasingly favouring alternative fire-rated glass solutions that offer better clarity, impact resistance, and overall safety performance. This trend has led to a decline in the use of wired glass in favour of more modern and effective fire-rated glass options.

FIG. 61 WIRED GLASS

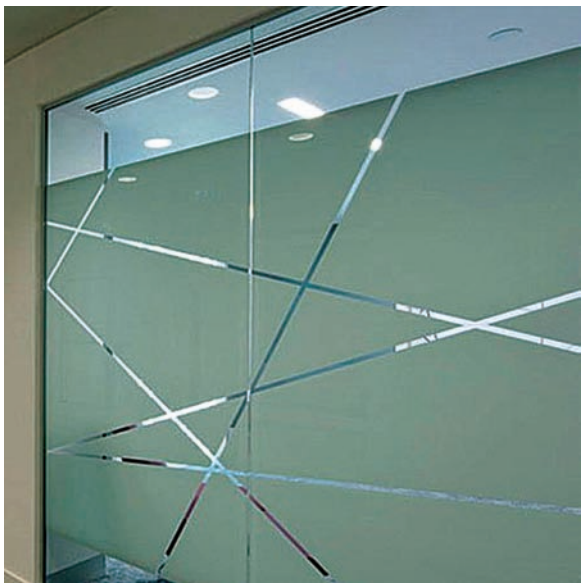


FIG. 62 FROSTED GLASS

In addition to the above, some other types of glasses are now being used in buildings and construction for specialized purposes such as **frosted glass** is being used for office cabins, it has a textured surface that diffuses light, providing privacy while allowing light to pass through. **Digitally printed, painted or enamelled glass** is being used for decorative purposes, etc. **Smart (switchable glass)** which can change its light transmission properties when voltage, light, or heat is applied, thereby offering dynamic control over privacy, day lighting, and energy efficiency.

FIG. 63 ENAMELLED GLASS PANEL

FIG. 64 DIGITAL CERAMIC PRINTED GLASS

FIG. 65 SWITCHABLE SMART GLASS

20.2 Specifications

The following Indian Standard specifications have been formulated to lay down the requirements of various types of glasses:

SI No.	IS Number	Title
1	IS 2553 (Part 1):2018	Safety glass - Specification: Part 1 architectural, building and general uses (*fourth revision*)
2	IS 2835:1987	Specification for flat transparent sheet glass (*third revision*)
3	IS 3438:2023	Silvered glass mirrors for general purposes – Specification (*third revision*)
4	IS 5437:2024	Rolled glass : patterned, extra clear patterned, wired and wired-patterned glass – Specification (*second revision*)
5	IS 14900:2018	Transparent float glass – Specification (*first revision*)
6	IS 16982:2018	Heat strengthened glass – Specification
7	IS 17346:2020	Insulating glazing unit – Specification
8	IS 18518:2023	Bullet resistant security glass – Quality and performance requirements

20.3 Test Methods

The following Indian Standards lay down the test methods for checking the quality of glass:

SI No.	IS Number	Title
1	IS 16945:2018	Fire resistance test for glass walls
2	IS 16947:2018	Fire resistance tests for doors with glass panes, openable glass windows and sliding glass doors

3	IS 16978 (Part 1):2022	Glass in Building – Forced-Entry Security Glazing Part 1 Test and Classification by Repetitive Ball Drop (First Revision)
4	IS 16978 (Part 2):2018	Glass in building - Forced - Entry security glazing: Part 2 test and classification by repetitive impact of a hammer and axe at room temperature
5	IS 16978 (Part 3):2018	Glass in Building - Forced-Entry Security Glazing Part 3 test and Classification by Manual Attack
6	IS 16978 (Part 4):2018	Glass in building - Forced - Entry security glazing: Part 4 test and classification by pendulum impact under thermally and fire stressed conditions
7	IS 17004:2018	Testing methods for processed glass

20.4 Stacking and Storage

It is important that all glass sheets whether stored in crates or not should be kept dry. Suitable covered storage space should be provided for the safe storage of the glass sheets. In removing glass sheets from crates, great care should be taken to avoid damages. The glass sheets should be lifted and stored on its long edges against a vertical wall or other support with the first sheet so placed that its bottom edge is 25 mm from the vertical support. The stacks should be of not more than 25 panes and should be supported at two points by fillets of wood at 300 mm from each end. The whole stack should be as close and as upright as possible. The glass sheets of different sizes, thickness and type should be stacked separately. The distance between any two stacks should be of the order of 400 mm.

For more details on storage of glass, a reference may be made to IS 4082:1996 'Stacking and storage of construction materials and components at site - Recommendations (*second revision*)'.

CHAPTER XXI
FLOORING, ROOFING AND WALL FINISHING/CLADDING MATERIALS

CHAPTER XXI
FLOORING, ROOFING AND WALL FINISHING/ CLADDING MATERIALS

21.1 General

A series of building materials are used as flooring, floor covering and roofing for providing requisite surface characteristics and safety from weather. Flooring and floor materials provide safety from dampness as well as a well finished and aesthetically pleasing appearance and functionality. Roofing or roof covering materials provide protection from sun and rain as well as safety to the occupants while providing good aesthetic appearance.

FIG. 66 LINOLEUM FLOORING

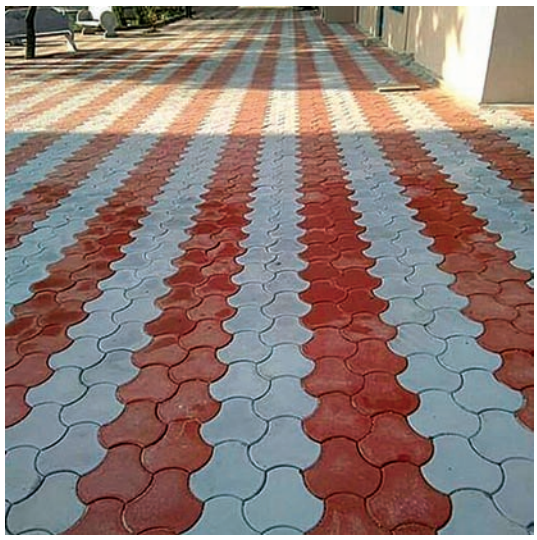


FIG. 67 CONCRETE PAVER BLOCKS

FIG. 68 CERAMIC TILES

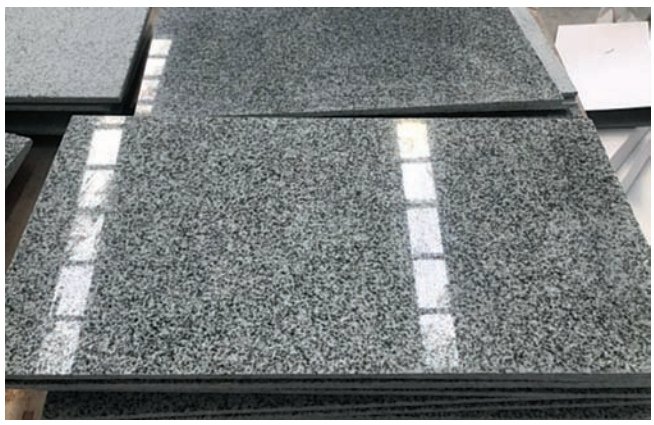


FIG. 69 POLISHED GRANITE FLOORING

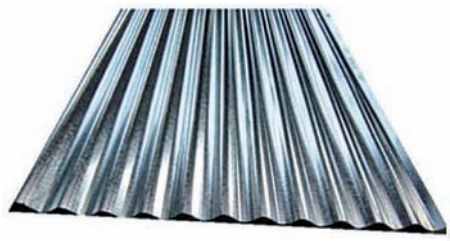


FIG. 70 GI ROOFING SHEET

FIG. 71 PREPAINTED PROFILED ROOFING SHEET

FIG. 72 GRP ROOFING SHEET

21.2 Specifications

The following Indian Standard specifications have been formulated to lay down the requirements of various types of flooring materials:

SI No.	IS Number	Title
	Linoleum Flooring	
1	IS 653:1992	Linoleum sheets and tiles - Specification (*third revision*)
	Rubberized Flooring	
2	IS 809:1992	Rubber flooring materials for general purposes - Specification (*first revision*)
	Bituminous Flooring	
3	IS 15194:2002	Pitch-mastic flooring for industries handling heavy hydrocarbon products like kerosene, diesel and furnace oil - Specification
	Concrete Flooring	
4	IS 1237:2012	Cement concrete flooring tiles - Specification (*second revision)*
5	IS 6073:2006	Autoclaved reinforced cellular concrete floor and roof slabs - Specification (*first revision*)
6	IS 13801:2013	Chequered cement concrete tiles - Specification (*first revision*)
7	IS 13990:1994	Precast reinforced concrete planks and joists for roofing and flooring - Specification
8	IS 14201:1994	Precast reinforced concrete channel units for construction of floors and roofs - Specification
9	IS 14143:1994	Prefabricated brick panel and partially precast concrete joist for flooring and roofing - Specification
10	IS 15658:2021	Concrete blocks for paving - Specification (*first revision*)

	Polymeric Flooring	
11	IS 3461:1980	Specification for PVC asbestos floor tiles (*first revision*)
12	IS 3462:1986	Specification for unbacked flexible PVC flooring (*second revision)*
13	IS 17897: 2022	Stone-Polymer composite flooring tiles and planks — Specification
	Acid Resistant Flooring	
14	IS 4457:2007	Ceramic unglazed vitreous acid resisting tiles - Specification (*second revision)*
15	IS 4860:1968	Specification for acid-resistant bricks
	Ceramic Flooring	
16	IS 4457:2007	Ceramic unglazed vitreous acid resisting tiles - Specification (*second revision)*
17	IS 13712:2019	Ceramic tiles - Definitions, classifications, characteristics and marking (*second revision)*
18	IS 15622:2017	Pressed ceramic tiles - Specification (*first revision*)
	Stone Flooring	
19	IS 1128:1974	Specification for limestone (slab and tiles) (*first revision*)
20	IS 1130:1969	Specification for marble (blocks, slabs and tiles)
21	IS 3316:1974	Specification for structural granite (*first revision*)
22	IS 3622:1977	Specification for sandstone (slabs and tiles) (*first revision*)
23	IS 14223 (Part 1):2023	Polished building stones - Specification: Part 1 Granite (*first revision*)
	Epoxy Resin Flooring	
24	IS 9197:1979	Specification for epoxy resin, hardeners and epoxy resin compositions for floor topping
	Clay Flooring	
25	IS 1478:2023	Clay flooring tiles - Specification (*third revision*)
26	IS 3951 (Part 1):2023	Hollow clay tiles for floors and roofs — Specification Part 1 Filler type (*third revision*)
27	IS 3951 (Part 2):2023	Hollow clay tiles for floors and roofs — Specification: Part 2 Structural type (*third revision*)

The following Indian Standard specifications have been formulated to lay down the requirements of various types of roofing materials:

SI No.	IS Number	Title
	Bituminous Roofing Sheet	
1	IS 12583:1988	Specification for corrugated bitumen roofing sheets
	Plastic Roofing Sheet	
2	IS 12866:2021	Plastic translucent sheets made from thermo-setting polyester resin (glassfibre reinforced) - Specification (*first revision*)
	Metal Roofing Sheets	
3	IS 277:2018	Galvanized steel strips and sheets (Plain and Corrugated) - Specification (*seventh revision*)
4	IS 14246:2024	Continuously pre-painted galvanized steel sheets and strips - specification (*second revision*)
5	IS 15965:2012	Pre - Painted aluminium zinc alloy metallic coated steel strip and sheet (Plain)
6	IS 18385:2023	Hot- Dip galvanized/galvannealed Steels Sheet and strips for Automotive Applications- Specification
	Stone Roofing Materials	
7	IS 6250:1981	Specification for roofing slate tiles (*first revision*)
	Coir, Woodwool, Cement Roofing Sheet	
8	IS 10388:1982	Specification for corrugated coir, woodwool, cement roofing sheets
	Cement Roofing Sheets	
9	IS 459:1992	Corrugated and semi-corrugated asbestos cement sheets - Specification (*third revision*)
10	IS 14862:2000	Fibre cement flat sheets - Specification
11	IS 14871:2000	Products in fibre reinforced cement - long corrugated or asymmetrical section sheets and fittings for roofing and cladding - Specification
	Clay Roofing Tiles	
12	IS 654:2023	Clay roofing tiles, Mangalore pattern - Specification (*fourth revision*)
13	IS 1464:1992	Clay ridge and ceiling tiles - Specification (*second revision)*
14	IS 2690 (Part 1):2023	Burnt clay flat terracing tiles — Specification: Part 1 Machine made (*third revision*)

15	IS 2690 (Part 2):2023	Burnt clay flat terracing tiles — Specification: Part 2 Hand made (*third revision*)
16	IS 3951 (Part 1):2023	Hollow clay tiles for floors and roofs — Specification Part 1 Filler type (*third revision*)
17	IS 3951 (Part 2):2023	Hollow clay tiles for floors and roofs — Specification: Part 2 Structural type (*third revision*)
18	IS 13317:2023	Clay roofing country tiles, half round and flat tiles — Specification (*first revision*)
	Concrete Roofing Elements	
19	IS 6073:2006	Autoclaved reinforced cellular concrete floor and roof slabs - Specification (*first revision*)
20	IS 13990:1994	Precast reinforced concrete planks and joists for roofing and flooring - Specification
21	IS 14201:1994	Precast reinforced concrete channel units for construction of floors and roofs - Specification
22	IS 14241:1995	Precast reinforced concrete L-panel for roofing - Specification
23	IS 14143:1994	Prefabricated brick panel and partially precast concrete joist for flooring and roofing - Specification

The following Indian Standard specifications have been formulated to lay down the requirements of various types of wall finishing/cladding materials:

SI No.	**IS Number**	**Title**
	Wall Coverings	
1	IS 15418:2003	Wall coverings in roll form for finished wall papers, wall vinyls and plastic wall coverings - Specification
	Metal Wall Cladding	
2	IS 17682: 2021	Aluminium composite panel - Specification
	Ceramic Wall Tiles	
3	IS 13712:2019	Ceramic tiles - Definitions, classifications, characteristics and marking (*second revision)*
4	IS 15622:2017	Pressed ceramic tiles - Specification (*first revision*)
	Plaster of Paris	
5	IS 2547 (Part 1):1976	Specification for gypsum building plaster: Part 1 Excluding premixed lightweight plasters (*first revision*)
6	IS 2547 (Part 2):1976	Specification for gypsum building plasters: Part 2 Premixed lightweight plasters (*first revision*)

21.3 Test Methods

The following Indian Standards lay down the test methods for checking the quality of flooring, roofing and wall finishing/cladding materials:

SI No.	IS Number	Title
	Ceramic Tiles	
1	IS 13630 (Parts 1):2019	Ceramic tiles - Methods of Test, sampling and basis for acceptance: Part 1 Determination of dimensions and surface quality (*second revision)*
2	IS 13630 (Part 2):2019	Ceramic tiles - Methods of Test, sampling and basis for acceptance: Part 2 Determination of water absorption and bulk density (*second revision)*
3	IS 13630 (Part 3):2019	Ceramic tiles - Methods of Test, sampling and basis for acceptance: Part 3 Determination of moisture expansion using boiling water (*second revision)*
4	IS 13630 (Part 4):2019	Ceramic tiles - Methods of Test, sampling and basis for acceptance: Part 4 Determination of linear thermal expansion (*second revision)*
5	IS 13630 (Part 5):2019	Ceramic tiles - Methods of Test, sampling and basis for acceptance: Part 5 Determination of resistance to thermal shock (*second revision)*
6	IS 13630 (Part 6):2019	Ceramic tiles - Methods of Test, sampling and basis for acceptance: Part 6 Determination of modulus of rupture and breaking strength (*second revision)*
7	IS 13630 (Part 7):2019	Ceramic tiles - Methods of Test, sampling and basis for acceptance: Part 7 Determination of chemical resistance unglazed tiles (*second revision)*
8	IS 13630 (Part 8):2019	Ceramic tiles - Methods of Test, sampling and basis for acceptance: Part 8 Determination of chemical resistance glazed tiles (*second revision)*
9	IS 13630 (Part 9):2019	Ceramic tiles - Methods of Test, sampling and basis for acceptance: Part 9 Determination of crazing resistance - glazed tiles (*second revision)*
10	IS 13630 (Part 10):2019	Ceramic tiles - Methods of Test, sampling and basis for acceptance: Part 10 Determination of frost resistance (*second revision)*
11	IS 13630 (Part 11):2019	Ceramic tiles - Methods of Test, sampling and basis for acceptance: Part 11 Determination of resistance of surface abrasion - Glazed tiles (*second revision)*

12	IS 13630 (Part 12):2019	Ceramic tiles - Methods of Test, sampling and basis for acceptance: Part 12 Determination of resistance to deep abrasion - Unglazed tiles (*second revision)*
13	IS 13630 (Part 13):2019	Ceramic tiles - Methods of Test, sampling and basis for acceptance: Part 13 Determination of scratch hardness of surface according to Mohs' scale (*second revision)*
14	IS 13630 (Part 14):2019	Ceramic tiles - Methods of Test, sampling and basis for acceptance: Part 14 Determination of impact resistance by measurement of coefficient of restitution (*first revision*)
15	IS 13630 (Part 15):2019	Ceramic tiles - Methods of Test, sampling and basis for acceptance: Part 15 Ceramic tiles sampling and basis for acceptance (*first revision*)
16	IS 13630 (Part 16):2019	Ceramic tiles - Methods of Test, sampling and basis for acceptance: Part 16 Determination of Lead and Cadmium Given off by glazed tiles
	Linoleum Flooring	
17	IS 9704:1980	Methods of tests for linoleum sheets and tiles
	Magnesium Oxychloride Flooring	
18	IS 10132:1982	Method of test for materials for use in the preparation of magnesium oxychloride flooring compositions
19	IS 18433 (Part 1):2023	Measurement of surface frictional properties — Methods of test: Part 1 Pendulum test
20	IS 18433 (Part 2):2023	Measurement of surface frictional properties — Methods of test: Part 2 Ramp test

21.4 Stacking and Storage

21.4.1 *Floor, Wall and Roof Tiles*

Floor, wall and clay roof tiles of different types, such as, cement concrete tiles (plain, coloured and terrazzo) and ceramic tiles (glazed and unglazed) should be stacked on regular platform as far as possible under cover in proper layers and in tiers and they should not be dumped in heaps. In the stack, the tiles should be so placed that the mould surface of one faces that of another. Height of the stack should not be more than one metre. During unloading, these should be handled carefully so as to avoid breakage. Tiles of different quality, size and thickness should be stacked separately to facilitate easy removal for use in work. Tiles when supplied by manufacturers packed in wooden crates, should be stored in crates. The crates should be opened one at a time as and when required for use.

Ceramic tiles and clay roof tiles are generally supplied in cartons which should be handled with care. It is preferable to transport these at the site on platform trolleys.

21.4.2 *Partially Prefabricated Wall and Roof Components*

The wall components comprise blocks, sills, lintels, etc. The blocks should be stacked as per 4.6. The lintel and sill blocks should be unloaded as individual component by holding them near the ends. These should be stacked on plane level ground having a floor of bricks or a thin layer of lean concrete.

The roof components such as precast R C joists, prefabricated brick panels, R C planks, channel units, cored units, waffle units, L-panel, single tee and double tee sections, ferrocement panels, etc should be unloaded as individual components. The components should be handled by holding at specified points so that the stresses due to handling are minimized. These should be stacked on plane level ground having a floor of bricks or a thin layer of lean concrete. R C planks, prefabricated brick panels and ferrocement panels should be stacked against a brick masonry wall in slightly inclined position on both sides of the wall. Channel units, cored units and L-panels should be stacked one over the other up to five tiers. The waffle units should be stacked upside down as individual units. The R C joists, single tee and double tee sections should be stacked as individual units one adjacent to the other. The distance between any two adjacent stacks should not be less than 450 mm.

21.4.3 *Roofing Sheets*

Roofing sheets should be stored and handled in such a manner as not to damage them in any way. Plain and corrugated asbestos cement sheets should be stacked horizontally to a height of not more than one metre on a firm and level ground, with timber or other packing beneath them. If stacked in exposed position, they should be protected from damage by the winds. Asbestos cement sheets of same variety and size should be stacked together. Damaged sheets should not be stacked with sound materials. All damaged sheets should be salvaged as early as possible.

For more details on storage of flooring, roofing and wall finishing/cladding materials, a reference may be made to IS 4082:1996 'Stacking and storage of construction materials and components at site - Recommendations (*second revision*)'.

CHAPTER XXII
GEOSYNTHETICS

CHAPTER XXII
GEOSYNTHETICS

Geosynthetics fabrics are natural (geonaturals) or synthetically engineered materials (geosynthetics). These are polymer materials used in the construction of roads, drains, harbour works, dams and breakwaters, and for land reclamation and many other civil engineering applications. Geosynthetics are manufacture from polymeric materials like high density polyethylene, polypropylene, polyvinyl chloride, polyester; and geonaturals from natural textile material like jute and coir. Geosynthetics being synthetic materials made from polymers, are designed to improve the overall stability, durability, and functionality of geotechnical structures.

It plays a vital role in modern civil engineering and construction practices by addressing a wide range of challenges related to soil stabilization, erosion control, drainage, filtration, separation and environmental protection in Mining, Coastal Engineering, roadways, railways. Quality of geotextiles is essential for ensuring performance and safety in applications of these products. Compliance with the Indian Standards can ensure longevity of infrastructure projects, minimizing the risk of failures and accidents.

Based on their configuration, geosynthetics may be classified as follows:

a) Geotextitles
b) Geomembranes
c) Geogrids
d) Geonets
e) Geobarriers
f) Geocells
g) Geomats
h) Geopipes/Geodrains
i) Geotubes
j) Geobags
k) Geostrips
l) Geocomposites
m) Geofoams

Indian Standards have been published catering to the following specific applications:

a) Transportation: (Roads and Railways)
    i) Road /pavement applications
    ii) Railways application
b) Water Resources and Flood Control
c) Waste Management
d) Rockfall Protection and Geohazard Mitigation
e) Mining
f) Other miscellaneous applications

GEOCELL

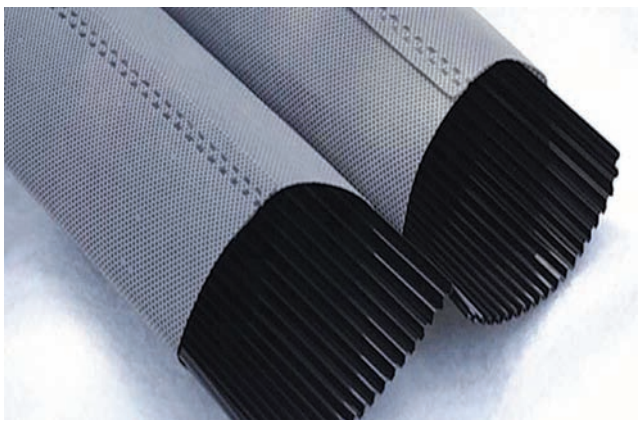
GEOGRID

GEOBAG

GEOMEMBRANE

GEOTEXTILE

POLYMER ROPE GABION



PREFABRICATED VERTICAL DRAINS

JUTE GEOTEXTILE

FIG. 73 GEOSYNTHETIC PRODUCTS

22.1 The following Indian Standards have been formulated to lay down the requirements of various types of geosynthetics:

SI No.	IS Number	Title
	For road/pavement applications	
1	IS 16362:2020	Geosynthetics — Geotextiles used in subgrade stabilization in pavement structures — Specification (*first revision*)
2	IS 17483 (Part 1):2020	Geosynthetics — Geocells — Specification (Part 1) Load Bearing Application
3	IS 17483 (Part 2):2020	Geosynthetics — Geocells — Specification (Part 2) Slope Erosion Protection Application
4	IS 16391:2015	Geosynthetics — Geotextiles used in sub-grade separation in pavement structures — Specification
5	IS 15869:2020	Textiles — Open weave coir *Bhoovastra* — Specification (*first revision*)
6	IS 17371:2020	Geosynthetics — Geogrids for flexible pavements — Specification
7	IS 14986:2001	Guidelines for application of jute geotextile for rain water erosion control in road and railway embankments and hill slopes
8	IS 14715 (Part 1):2016	Jute geotextiles — (Part 1) Strengthening of sub-grade in roads — Specification (*second revision*)
9	IS 14715 (Part 2):2016	Jute geotextiles — (Part 2) Control of bank erosion in rivers and waterways — Specification (*second revision*)
10	IS 15871:2009	Use of coir geotextiles (Coir Bhoovastra) in unpaved roads — Guidelines
	For railways applications	
11	IS 17483 (Part 1):2020	Geosynthetics — Geocells — Specification (Part 1) Load Bearing Application
12	IS 17483 (Part 2):2020	Geosynthetics — Geocells — Specification (Part 2) Slope Erosion Protection Application
13	IS 14986:2001	Guidelines for application of jute geotextile for rain water erosion control in road and railway embankments and hill slopes
	For water Resources and flood Control	
14	IS 16653:2017	Geosynthetics — Needle punched nonwoven geobags for coastal and waterways protection — Specification

15	IS 16654:2017	Geosynthetics — Polypropylene multifilament woven geobags for coastal and waterways protection — Specification
16	IS 17880:2022	Geosynthetics Polymer Gabions for Coastal and Waterways Protection Specification
	For waste management	
17	IS 16090:2013	Geo-synthetics — Geotextiles used as protection (or cushioning) materials — Specification
18	IS 15909:2020	PVC Geomembranes for Lining — Specification (*second revision*)
19	IS 16352:2020	Geosynthetics — High density polyethylene (HDPE) geomembranes for lining — Specification (*first revision*)
20	IS 17374:2020	Geosynthetics — Reinforced HDPE membrane for effluents and chemical resistance lining — Specification
21	IS 17483 (Part 2):2020	Geosynthetics — Geocells — Specification (Part 2) Slope erosion protection application
	Other miscellaneous applications	
22	IS 18309:2023	Geosynthetics — Prefabricated vertical drains for quick consolidation for very soft plastic soil — Specification

22.2 The following Indian Standards lay down the test methods for checking the quality of geosynthetics:

SI No.	**IS Number**	**Title**
	For road/pavement applications	
1.	IS 13162 (Part 2):1991	Geotextiles — Methods of test Part 2 Determination of resistance to exposure of ultraviolet light and water (Xenon - arc type apparatus)
2.	IS 13162 (Part 3):2021	Geosynthetics — Determination of thickness at specified pressures (Part 3): Single layers
3.	IS 13162 (Part 4):1992	Geotextiles — Methods of test (Part 4) : Determination of puncture resistance by falling cone method
4.	IS 13325:1992	Determination of tensile properties of extruded polymer geogrids using the wide strip — Test method
5.	IS 13326 (Part 1):1992	Evaluation of interface friction between geosynthetics and soil method of test: (Part 1) modified direct shear technique
6.	IS 14293:1995	Geotextiles — Method of test for trapezoid tearing strength

7.	IS 14324:1995	Geotextiles — Methods of test for determination of water permeability — Permittivity
8.	IS 14294:1995	Geotextiles — Method for determination of apparent opening size by dry sieving technique
9.	IS 14706:1999	Geotextiles — Sampling and preparation of test specimens
10.	IS 14714:1999	Geotextiles — Determination of abrasion resistance
11.	IS 14716:2021	Geosynthetics — Test method for the determination of mass per unit area of geotextiles and geotextile related products
12.	IS 15868 (Part 16):2008	Natural fibre geotextiles (Jute geotextile and coir *Bhoovastra*) — Methods of test
13.	IS 16237:2014	Geo - synthetics — Method for determination of apparent opening size by wet sieving
14.	IS 16342:2015	Geosynthetics — Method of test for grab breaking load and elongation of geotextiles
15.	IS 16346:2015	Geosynthetics — Method of test for evaluation of stress crack resistance of polyolefin geomembranes using notched constant tensile load test
16.	IS 16347:2015	Geosynthetics — Method of test for effects of temperature on stability of geotextile
17.	IS 16348:2015	Geosynthetics — Method of test for index puncture resistance of geomembranes and related products
18.	IS 16356:2015	Geosynthetics — Method of test for pore size characteristics of geotextiles by capillary flow test
19.	IS 16380:2020	Geosynthetics — Method of test for measuring pullout resistance of geosynthetics in soil (*first revision*)
20.	IS 16389:2015	Geosynthetics — Method of test for biological clogging of geotextile or soil/geotextile filters
21.	IS 16474:2015	Geosynthetics — Method of test for tensile properties of geogrids by the single or multi-rib tensile method
22.	IS 16475:2015	Geosynthetics — Method of test for determination of 2 percent secant modulus for polyethylene geomembranes
23.	IS 16477:2015	Geosynthetics — Method of test for determination of 2 performance strength of geomembranes by the wide strip tensile method
24.	IS 16483:2017	Geosynthetics — Method for microscopic evaluation of the dispersion of carbon black in polyolefin geosynthetics

25.	IS 16493:2017	Geosynthetics — Method of test for determination of pyramid puncture resistance of unprotected and protected geomembranes
26.	IS 17368:2020	Geosynthetics — Determination of damage to geosynthetic caused during installation
27.	IS/ISO 10769:2011	Clay geosynthetic barriers — Determination of water absorption of bentonite
28.	IS/ISO 10773:2011	Clay geosynthetic barriers — Determination of permeability to gases
29.	IS 15060:2018 ISO 10321:2008	Geosynthetics — Tensile test for joint seams by wide - width strip method (*first revision*)
30.	IS 16078:2013 ISO 12236	Geosynthetics — Static puncture test (CBR Test)
31.	IS 16635:2017/ ISO 10319:2015	Geosynthetics — Wide-Width tensile test
32.	IS 17179:2019/ ISO 12958:2010	Geotextiles and geotextile related products — Determination of water flow capacity in their plane
33.	IS 17360:2020/ ISO 13438:2018	Geosynthetics — Screening test method for determining the resistance of geotextiles and geotextile-related products to oxidation
34.	IS 17365:2020/ ISO TR 20432:2007	Guidelines for the determination of the long-term strength of geosynthetics for soil reinforcement
35.	IS 17420:2020/ ISO 10722:2019	Geosynthetics — Index test procedure for the evaluation of mechanical damage under repeated loading — Damage caused by granular materials (Laboratory test method)

ANNEX 1

CATEGORIZATION OF BUILDING MATERIALS (ALPHABETICAL)

1) Aluminium and other light metals and their alloys
2) Bitumen and tar products
3) Bricks, blocks and other masonry building units
4) Builder's hardware
5) Building chemicals
   a) Anti-termite Chemicals
   b) Chemical Admixture/Water Proofing Compounds
   c) Sealants/Fillers
   d) Adhesives
6) Building lime and products
7) Clay and stabilized soil products
   a) Blocks
   b) Stabilized Soil Products
   c) Bricks
   d) Jallies
   e) Tiles
8) Cement and concrete (including steel reinforcement for concrete)
   a) Aggregates
   b) Cement
   c) Supplementary Cementitious Materials (Mineral Admixtures including Pozzolanas)
   d) Chemical Admixtures
   e) Concrete
   f) Cement and Concrete Sampling and Methods of Test
   g) Treatment of Concrete Joints
   h) Steel Reinforcement and prestressing Steel for Concrete
9) Composite matrix products (including cement and resin matrix products)
   a) Cement Matrix Products
   b) Resin matrix Products
10) Conductors and cables
11) Doors, windows and ventilators
   a) Wooden Doors, Windows and Ventilators
   b) Metal Doors, Windows and Ventilators
   c) Plastic Doors and Windows
   d) Concrete Door and Window Frames

e) Other Composite Material Doors and Windows
f) Fire Check Doors
g) Mesh/Net for Mosquito/Vector Prevention

12) Electrical wiring, fittings and accessories
13) Fillers, stoppers and putties
14) Floor covering, roofing and other finishes
a) Concrete Flooring
b) Flooring Compositions
c) Linoleum Flooring
d) Rubber Flooring
e) Stone Flooring
f) Bituminous Flooring
g) Plastic Flooring
h) Ceramic/Vitreous Flooring and Wall Finishing
i) Clay Flooring
j) Roofing
k) Other Flooring and Roofings
l) Wall Coverings/Finishing
15) Glass
16) Gypsum based materials
17) Mortar (including sand for mortar)
18) Paints and allied products
a) Water Based Paints and Pigments
b) Ready Mixed Paints, Enamels and Powder Coatings
c) Thinners and Solvents
d) Varnishes and Lacquers
19) Polymers, plastics and geosynthetics/geotextiles
20) Sanitary appliances and water fittings
a) General
b) Pipes and Fittings excluding valves
c) Kitchen and Sanitary Appliances
d) Valves and Water Fittings (including Ferrules)
e) Water Meters
21) Steel and its alloys
a) General
b) Structural Steel
c) Sheet and Strip
d) Bars, Rods, Wire and Wire Rods

e) Plates and Studs

f) Tubes and Tubulars

g) Slotted Sections

22) Stones

23) Structural sections

a) Structural Shapes

b) Dimensional Standards

24) Thermal insulation materials

25) Threaded fasteners, rivets and nails

26) Timber, bamboo and other lignocellulosic building materials

a) Timber and Bamboo

b) Reconstituted Products

27) Unit weights of building materials

28) Waterproofing and damp-proofing materials

29) Welding electrodes and wires

30) Wire ropes and wire products (including wire for fencing)

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