UNIT 5 WEAR RESISTING MATERIALS

Structure

5.1 INTRODUCTION

You have already studied the calcareous cementing materials, carbonacious cementing materials, chemical cementing materials and concrete i.e. their types, properties and usage with construction field, in earlier first block. Now existing second block, unit 5, you will study about wear resisting materials.

You may be aware that wear resistant flooring constitutes the most important component of constructional activities. Amongst the various components of building construction, flooring is the one which is most frequently used and is widely subjected to continuous stresses, strains and abrasion. Selection of a correct wear assistant material to meet the qualitative requirements of a flooring therefore assumes paramount importance in the field of constructional activities. In this unit, we will discuss the qualitative requirements, structures, types and methods of construction of flooring with an emphasis on industrial flooring.

Objective

After studying this unit you should be able to:

* describe different types of wear resistant materials and their advantages,
* discuss their qualitative and functional requirements,
* understand the methods of construction of these wear resistant materials and their field of application.

5.2 HISTORY OF FLOORING

Construction of a floor is not a new concept. From tiine immemorial, it has been constructed using the various available materials. The history of floor commences with a construction of mud floor using cowdung as a finishing and wearing material. Materials like stone, stone slabs, wood, etc. which are readily available, and are very commonly used but without any regard to the functional needs. With the advent of the industrial revolution, manufactured materials like

bricks, cement concrete, concrete tiles etc. came into increasing use. Today there is a varietyof wearresistant materialsavailableinthemarketrnanufacturedout ofnatural or synthetic materials. Some of them are ceramic tiles, magnesite, bitumen mastic, rubber, polymer etc. which are covered in this unit.

5.3 FUNCTIONAL REQUIREMENTS

You may be aware of the functional requirements for domestic flooring as it is very common but the functional requirements of industrial flooringdiffer. They are :

a) **Domestic Flooring**

This type of flooring requires light wear resistance. Besides the flooring should be durable, easily cleanable, and should be a esthetically good in appearance.

b) Industrial **Flooring**

Industrial flooring is expected to meet qualitative requirements like withstanding heavy abrasion, resilience against impact, durability against corrosion and chemical attack etc.

5.4 QUALITATIVE REQUIREMENTS

Since no floor topping is ever ideal in all respects, it is important to achieve the best compromise between the desired qualities having regard to appearance, abrasion, resistance, resistance to slipperiness, dust proofness, comfort, cleanability and above all durability. These qualities are described in succeeding paragraphs.

5.4.1 Abrasion Resistance

The floor should be resistant to mechanical wear due to constant use and frequent movement of traffic. For domestic floors abrasion quality is not of much concern as most of the materials used can withstand domestic wear fairly well. But industrial floors are subjected to very heavy abrasion especially due to movement of heavy components, dragging of machineries, traffic of loaded trucks, steel tyred vehicles, tractors etc.

5.4.2 Impact Resistance

At times, factory floors are subjected to various impact of loads. These impacts, generally, occur in heavy engineering industries, dockyards, freight handling areas, warehouses and jettys, etc. Even in a normal factory where industrial droppings of heavy tools, etc. are expected, it would be advisable to provide a floor which will sustain the desired impact, otherwise it may result in cracking, breaking and potholing of floor surfaces.

5.4.3 Skid Resistance

Surface of all types of floors is expected to be skid-resistance unless there is a specific demand for absolute smooth surfaces. You must have observed dancing floors and skatting arenas on the TV. These floors are necessarily required to be absolutely smooth. Skid resistant quality is required to avoid accident due to slipperness. Even in bathrocms, floors having non skid surface are more desirable than the smooth surfaces. Floor therefore should be smooth but non skidding, free from cracks and undulations, and safe for movement of men, materials and vehicular traffic.

5.4.4 Dust Proof

In certain situations, floor is required to be dust proof, i.e. it should not accumulate dust on the surface and should be easy to clean. This requirement may arise in watch factories, electronic establishments, signal and communication industries, precision instrumental laboratories, computer centres, etc. Such floors are expected to be jointless, fairly smooth but non skid and easy to clean. Many new flooring materials are now available which can meet these requirements. This will be further discussed when we deal with types of floor materials.

5.4.5 Aesthetic Appearance

In domestic flooring this factor is of prime concern. Every user desires that the floor of his house or commercial establishment should be smooth and sparkling. Even in schools the flooring provided is expected to look esthetically pleasing. However, this factor is not of much importance, and other factors and qualities may have an over riding effect due to functional requirements.

5.4.6 Corrosion Resistance

In chemical industries, laboratories and certain types of factories and establishments, there is a frequent spillage of oils, acids and alkalies. Floor may also come in contact with products having chemical/corrosive effect such as in chemical godowns, food processing plants, breweies and paper plants. Unless the floor provided is resistant to such chemicals it would cause corrosion on the floor surface and in turn would damage the surface by pitting, staining and rusting. One should therefore, be very caulious and selective in providing a floor material which would be free from chemical effect depending upon the type of chemical or material with which it may come in contact.

5.4.7 Non Sparking

In certain locations such as explosives factories, ammunition factories or floors of sea going vessels, handling explosive materials require provision of this type of flooring materials such that the floor should not produce sparks due to friction as happens in the case of stone masonry floors. Non sparking floor topping such as rubber, bitumen mastic or magnesium oxychloride would be desirable in this situation. At times, floor is required to be antistatic i.e. floor should conduct electricity in order to reduce the risk of sparking due to accumulation of static electricity charges. Such flooring is required in tropostation, computer centres, operation theatres etc. To make the floor non static metal strips especially of copper or aluminium are embedded in floor in a grid pattern these and are connected to earthpits.

5.4.8 Temperature Resistance

Some floors are subjected to high temperature, normally in foundries or furnaces. Spillage of oils, greases and inflammable materials increases the risk of the fire hazard. If the floor is absorbent or combustible in itself as in the case of wooden or bituminous floor materials. In order that fire should not cause any irrepairable damage l o floors, inert and dense substances like concrete, refractory tiles, etc, are more desirable. Floors made out of refractory tiles, should be jointed and pointed with refractory mortars. Magnesium oxychloride floor toppings are supposed to be fire proof. Fire resistance property is also obtained by ceramic tiles.

5.4.9 Cost

This is one of the most important consideration. One has to weigh a long term economic criteria rather than simply considering the cost. It is generally said that the cheapest need not necessarily be the most economic. In long term use, floor should be trouble free, provide durability and efficient surface, should be easy for maintenance and eventual repairs without affecting the productivity.

SAQ 1

1. List the functional requirement of the floors.

2. List the qualitative requirements of the floors.

5.5 TYPES OF WEAR RESISTANT MATERIALS

We have discussed about the qualitative requirements of wear resistant surfaces. Having known the various requirements, we could decide the type of wear resistant materials or floor system that are currently in vogue especially in contemporary industrial establishments. Some of the types of flooring that we are going to discuss here are :

a) Plain cement concrete floor
b) Granolithic concrete floor topping
c) Magnesium oxychloride flooring
d) Bitumastic flooring
e) Nito floor system

f) Epoxy Resin floor topping
g) Surface sealants (Liquid Hardeners)
h) Ceramic tiles floor topping
i) Tremix system of concrete flooring
j) Metallic flooring system
k) Stone set pavings
1) Miscellaneous

5.6 STRUCTURAL COMPONENTS

Before we discuss the above mentioned types of floorings and wear resistant materials, it will be worthwhile to discuss the structural components of floor. Any floor essentially consists of the followingstructuralcomponents:

(a) Sub base
(b) Base course
(c) Base concrete
(d) Wear resistant topping.

Figure5.1indicatingvariousstructuralcomponentsare given below. Thecomposition and propertiesarediscussedinsucceedingparagraphs.

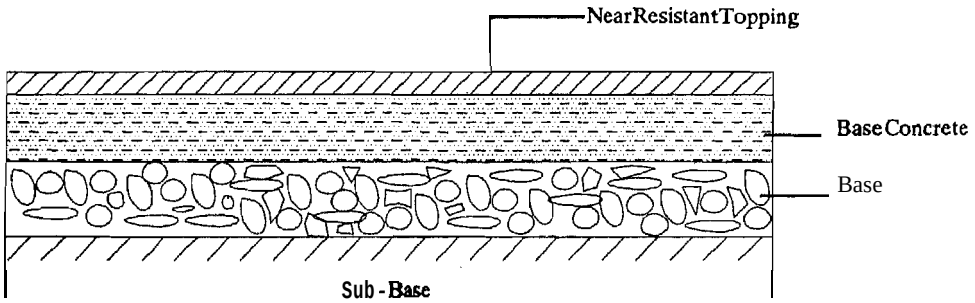

Fig. 5.1: Typical Wear Resistant Flooring

5.6.1 Sub Base

Sub base is a level prepared harddense mass which a d s as a formation support. Its prevents flooring from settling and other distresses. Depending on the loadingpattern, sub-base is prepared from compacted earth, moorum, brick paving, sand or crushed stone dust.

5.6.2 Base Course

This helps in distribution of load andstresses within the bearing capacity of sub base. This is a resilient medium prepared out of coarse granular materials such as gravel, broken pebbles or crushedstone aggregate, broken bricks, etc. This is also termed as hardcore.

5.63 Base Concrete

This constitutes the main body of flooring over which wear resistant layer is laid. This is a medium which absorbs impact and helps in transferring the load to the base course and sub base. PCC of M 15 is most widely used for this purpose. However, leaner mixes like 1:3:6 or 1:4:8 with 40mm aggregate size RCC, wood, stone slabs, etc. are not uncommon, For structures with first floor and above, RCC slab itself acts as a base concrete. In this case provision of sub base or base course is not necessary.

5.6.4 Wear Resistant Toppings

This is the most important constituent of a floor. Selection of a wear resistant topping which should be decided the basis of on the qualitative requirements including cost effect is described in section 5.4.

5.7 CEMENT CONCRETE FLOOR TOPPING

It is a most common and widely used material especially for domestic buildings flooring. It has a fair degree of resistance to abrasion, impact, heat and also very cost effective. PCC is also used as topping for industrial flooring.

It has the following qualities :

a) It withstands moderate abrasion and impact.

t) It is heat resistant

c) Cost is relatively low when compaired to the other type of floorings

d) Surface finish can be controlled to avoid slipperiness

e) It can withstand heavy traffic if designed

Cement concrete floors of good quality will last for years, but badly graded aggregates and inadequatc control of proportioning of materials may result in rapid disintegration.

5.7.1 Method of Laying

PCC floor finish may be laid in two ways :

a) Monolithic while the base is plastic

b) Bonded after the base has hardened

5.7.2 Monolithic Floor Finish

It is suitable as a moderately strong and economic floor finish with good wearing quality. Even a small thickness of topping is adequate in this case. However, it has a difficulty to get a close surface tolerance.

5.7.3 Bonded Floor Finish

Generally this type of floor finish is used over structured slabs alter major activities of construction are over. It is suitable where floor finish is to be laid on old concrete or for repairing old floor finishes. If the bond between topping and base is not perfect, change in temperature and moisture may cause cracking, curling or warping.

5.7.4 Precautions

a) Selection of aggregates

It should bc hard, tough and should have good resistance to abrasion. It should conform to the specifications laid down in IS-383 of 1970 specifications for coarse and fine aggregates from natural sources for concrete.

b) **Water** cement ratio

A fully compacted flooring with the lower water cement ratio gives greater durability and higher wear resistance.

c) **Mix** Proportion

Mix proportion will depend on the qualitative requirements and situation where it is to be laid, Nominal mixes of proportions 1:3:6, 1:2:4 and 1:1½:3 are commonly used and should be prepared in accordance with IS 456-1978 code of practice for plain and reinforced concrete (Third revision) including Amt No. 1 of Mar 1981. This code of practice specifies methods of mixing, laying, compaction and curing.

5.7.5 Joints

Since the PCC floor toppings are laid in panels, provision of construction joints between the bays of floor finish need to be plain, untreated and vertical butt joints. Wooden beading or battens may be used for laying panels in alternate bays. Glass or Aluminium strips are used if the floor topping is to be laid continuously.

5.7.6 Polished Cement Concrete Flooring

The surface of cement concrete floor can be finished to the required colour. A thin topping of not less than 3mm thick, consisting of one part of cement to two parts of sand coloured with mineral pigments readily available for the purpose. The coloured top layer is to be laid

monolithically with the concrete. Hard grinding or machine grinding is adopted for polishing purposes.

SAQ 2

1. Mention the structural components of a floor.

2. What precaution will you take while making a cement concrete floor topping?

5.8 GRANOLITNIC CONCRETE WEAR RESISTANT SURFACE

Where the surface course is subjected to heavy loads and constant abrasion combined with impact, the granolithic concrete topping is the answer. The topping is hardwearing, clean, unaffected by continued wetting and resistant to alkalis and mineral oils.

Granolithic floor toppings are generally preferred for floors of:

a) Heavy engineering factories
b) Workshops
c) Heavy vehicle garages
d) Warehouses etc.
e) Cpncrete pavements and parking aprons
f) Explosive store houses
g) Aircraft hangars
h) Spillways and causeways

Where the floor is subjected to severe abrasions, heavy loads and impact, the granolithic concrete essentially consists of a rich concrete made with specially selected aggregates of high hardness, surface structure and particle finish.

5.8.1 Role of Aggregates

In this type of floors, it is the aggregate that must withstand the bulk of wear and tear of traffic and other uses. The cement base, whatever be the compressive strength, has poor abrasion resistance. It is the aggregate whichlies at the surface of the floor that absorbs abrasion and impact. The types of aggregates generally in use are given below:

a) ***For* light traffic**

Well washed graded sound quartz or crystalline granite aggregate will usually suffice

b) ***For* heavy *duty floors***

Aggregates of hard traprock or basalt, silica, granite and emery are desirable.

c) ***For* hard wheeled *or* heavy *vehicular* traffic**

It is often preferable to use specially quarried or manufactured aggregates from metallic and nonmetallic materials.

5.8.2 Mix Proportion

The proportion for the granolithic concrete floor topping generally adopted 1:1:2 (cement: fine aggregate: coarse aggregate by volume) ratio. The process of mixing, laying, finishing and curing is the same as of PCC. The topping should be laid monolithic with the base concrete. Control of water cement ratio is very essential to avoid bleeding and slump should be kept as low as possible.

5.8.3 Suggested Grading of Aggregates

The grading of coarse aggregate used for preparation of granolithic floor toppings based on 5491-1969 IS specifications are given in Tables 1 & 2 below.

Table 1 : Coarse Aggregate

IS Sieve Designation	Percentage weight passing
12.50 mm	90 to 100
10.00 mm	40 to 85
4.75 mm	0 to 10

Table 2 : Fine Aggregate

I S Sieve Designation	Percentage weight passing	
	Grading Zone I	Grading Zone II
10 mm	100	100
4.75 mm	10 to 100	10 to 100
2.36 mm	60 to 95	75 to 100
1.18 mm	30 to 70	55 to 90
600 micron	15 to 34	35 to 59
300 micron	5 to 20	8 to 30
150 micron	0 to 10	0 to 10

5.8.4 Precautions While Laying

Method of laying is specified in IS:5491-1969 code of practice for laying insitu granolithic concrete floor topping. Some precautions, required to be taken while laying granolithic floors are given below :

a) Concrete should be thoroughly mixed to ensure even distribution of concretes throughout the mix and a thorough coating of each particle of aggregate by the cement base.

b) Slump should be kept as low as possible. This lessens the possibility of water bleeding to the surface, which will lead to a poor wearing surface.

c) Good curing procedure is essential for producing a strong granolithic floor.

d) Where a floor topping is laid over a base slab, the base slab should have a well roughened surface for providing the proper bond.

5.8.5 Manufactured Aggregate

As specified earlier, for very heavy vehicular traffic and where floors are subjected to very high abrasion and impact, it will be advisable to use the aggregates from metallic origin. Such situations mostly arise in industrial floors, foundries, concrete pavements etc. There are many fums who manufacture ready to use wear proof toppings under different brand names such as metalcrete, ironite, arconite etc. which are basically the additives in aggregate or powder form which are mixed with cement concrete and laid as floor toppings.

5.8.6 Properties of Metallic Aggregate

The metallic aggregate normally used is specially processed as graded hardened particles combined with cement disbursing agent and other components which improves the properties of

finished floors and gives the deflocculation of the metallic particles. The metallic particles are ductile and malleable. Oxidation of particles results in increasing density and strength. The metal tends to flatten and produce a smooth surface. This quality together with high flextural strength fortifies this aggregates to withstand plumb impact and shock without crushing and curling.

5.8.7 Advantages

The floor, be it PCC or RCC, when laid with these floor toppings, has the following advantages:

a) Greater wear resistance

b) Easy to clean surface

c) Corrosion resistant surface

d) Prevents shrinkages, stresses

e) Gets polished as it wears out

f) Offers high impact resistance.

SAQ 3

1. List some of the fields where you will use the granolithic concrete wear resistant surface.

2. Mention the precautions to be taken while laying the granolithic floors.

5.9 CONSTRUCTION OF GRANOLITHIC FLOOR

The wear resistance toppings are laid with a design or nominal mix concrete floors. Depending on the qualitative requirements such as heavy duty or light duty, impact resistant required ctc., the mix preparations and thickness of toppings will follow.

Precaution is required to be taken to see that the metal topping should be laid when the base concrete surface is green, so that it ensures that the concrete floor is monolithic with the wear resistant topping. There are a number of ready-to-use products under some brandns. Some of which are given below:

a) Metalcrete

b) Arconete

5.9.1 General Specifications

a) Heavy duty floors

The base concrete is composed of 1:2½:3 and half cement, sand and metal chips of 1" and under and should be laid 1/2" below the FFL. While the best concrete is green 1/2", topping should be laid consisting of 1 part of cement 2½ parts of bricks (1/2" with 15% dust) and 10 Kg of metalcrete per bag of cement. Metalcrete and cement should first be mixed dry. Total quantity of metalcrete required is 35 Kgs per 100 Sq.ft.

b) Medium **duty floors**

1½ to 2" thick concrete 1:2½:3 as base slab is laid to the finished floor layer and while the surface is still wet and soft broadcast a dry shake (2 parts metalcrete and 1 part of cement) crisscross wise after floating the concrete with wooden thappis and finishing with steel trowels. Total quantity of metalcrete required is 25 Kgs per 100 Sq.ft. The quantity of metallic wear proof materials should be used as per the instructions of manufacturers.

5.9.2 Joints in Floors

Concrete floors, including those with hardwearing surface are required to be laid in bays to reduce the risk of cracking. The size of the panel will depend upon the thickness of floor finish, and type of construction (monolithic and pointed), local condition of temperature, humidity and the season in which the flooring is laid. Generally the dimension of panel should not exceed 4 metre in case of the monolithic floor and 2 metre in case of floor laid on hardened base. The length of panel should not exceed 1½ times its breadth. The joints are to be filled carefully with premodulated joint layer with a bitumen sealing compound.

5.10 TERRAZO FLOORING

A common requirement for a terrazo finish is that it shoulcl riot only a hard wearing but also be easily cleanable from hygienic considerations and should have an aesthctic appearance and imperviousness to water. This type of floor topping is extensively used for floors in residential buildings, hospitals, public buildings, offices, commcrcial shops, canteelis and other industrial establishments.

Terrazzo is based on a mixture of cement with marblc chips of different colours. Colour pebbles or marble pieces are exposed by grounding and polishing the surfaces after the matrix is hardened. This type of flooring is either laid insitu or in the form of tiles.

5.10.1 Construction of insitu Flooring

The method of laying is specified in IS:2114-1962: code of practice for laying in situ terrazzo floor finish. The floor while laying the underlayer (base coarse) and toppings should be divided into panels not exceeding 2 m^2 ensuring that the longer dimension of any panel does not exceed 2 mtrs. The adjacent panels may be laid alternatively by using glass or metal dividing strips.

Mixing of Materials

Ordinary portland cement or colourcd cement could be used for making matrix for terrazzo topping. Use of white cement with pigment of desired colour is also made where quality finish is required.

To avoid variation in colour, the complete quantity of cement and pigment required for one operation slioulcl be mixed at one go and stored properly. Similarly chips of different colours and sizes shouldbe well niixed in required proportion separately.

The proportion of cement and marble powder by weight slioulcl be 3:1. For every part of cement and marble powder mix the proportion of aggregates recommended by volume is 1:7.5 parts of 1 to 7mm size and 1.5 parts of 7 to 15mm size. All ingredients should be mixed in the dry condition first, and then water is added, preferably in the fine spray while the inaterials are workeduiitil proper consistency is obtained. The mix thus prepared should be used in the work within half an hour of the addition of water.

5.11 MAGNESIUM OXYCHLORIDE FLOORING

The industrial floor while demanding the abrasion and impact resistance should also be smoolh resistant to attack of oil, grease aiid fats. At times the floor is required to have pleasing colours. These requirements can be met with by using magnesium oxychloride floor toppings. It is also known as Magnesite flooring or plastic flooring. This flooring is jointless, smooth, hard wearing and is capable of giving excellent services in most of the indoor situations. It is also used for resurfacing of old floor.

Magnesium oxychloride composition provides a good floor if proper ingredients are mixed in correct proportions and skilled labour is employed in laying the floor. Too wet a mix with excess of magnesium chloride results in sweating of the floor surfaces. Mineral oils, greases or vegetable oils do not affect the floor. The flooring is not seriously affected by alkalies but strong alkalies such as soda or harsh cleaning agents tend to attack the protective dressing and thus expose the flooring to action of water. The finished floor however needs to be protected from water or excessive moisture by periodic applications of wax polish or oil at regular intervals.

Magnesium oxychloride flooring should not be used in any situation wlicrc it would be exposed to damp conditions for long periods, unless other suitable protcctive measures are taken. Under normal conditions proper waxing or oiling of flours will provide adequate protection against the attack of acids and salts.

5.11.1 Materials

Materials for magnesium oxychloride composition floors are supplied in two parts, namely, dry mix and magnesium chloride. The proportions of the dry mix to the gauging solution and the strength of latter shall be furnished by the manufacturer of the dry mix. All materials used in the dry mix and magnesium chloride should comply with the requirements of IS-657 of 1962 and specifications materials for used in the manufacture of magnesium oxychloride flooring compositions. These materials are mixed into a plastic state and applied to floor in two separate coats totaling 12mm to 20mm thick. A considerable quantity of coarse fibrous filler is mixed with the first coat to give it a strength and flexibility. The second coat has no fiber, but a pigment is mixed to give the desired colour.

5.11.2 Types of Magnesium Oxychloride Floors

The floors are of the following types:

a) General Purposes

This type of floor contains an adequate amount of calcined magnesite fillers such as Talc, sawdust and asbestos; and fine aggregate which with magnesium chloride of suitable strength make a product which may be trowelled to a dense, smooth and semi-glossy finish. The composition is applied monolithically. This type is used in offices, ship decking, railway carriages, hospital rooms and residences.

b) Heavy Duty Floor

This is similar to a general purpose floor, with the difference that the quantity of fillers used is the minimum and the proporation of aggregates is increased The aggregates should have a good hardness similar to crushed granite. Such floors are used in industrial and restaurant kitchens, light industrial plants, corridors and lobbies of business establishments having large usage.

c) Non Spark/Static Discharging Floor

This is similar to a heavy duty floor except that the aggregates used are not siliceous, and do not contain materials which will produce a spark when struck with any object. This floor is suitable for hospital operation theatres, ammunition and chemical plants, and other areas subject to explosion hazards.

d) Non slip Floor

This again is similar to a heavy duty floor except that a certain proportion of the aggregates is of the abrasive type, This type is used in entrance lobbies, ramps, stairs, treads and landings.

e) Mosaic or Terrazo Floor

The matrix is similar to general purpose, non sparking or non slip floors, but aggregate used is marble chips, with each 100 Kg of dry mix a quantity of 125 to 200 Kgs of coarse aggregate is used The floor is finished by grinding similar to normal terrazzo floor to expose the coarse aggregate.

f) Industrial Granolithic Floor

This is similar to the mosaic and terrazo floor as described above but the coarse aggregate consists of granite chips or similar hard stand chips. This type of floor is used where most severe and abrasive service conditions exist.

The magnesium oxychloride composition is laid on sub floors which should be sound, rigid, free from rising damp and not unduly abrasive. The sub floors may be of wood, concrete, brick or any metallic floor such as aluminium, galvanised steel etc. IS-658-1962 lays down the code of practice of magnesium oxychloride composition floors. The gauging, mixing, laying and finishing should conform to the code of practice. It also lays down physical requirements for setting time, transverse strength, compressive strength, and permissible linear change etc.

In the country, Indian Railways are one of the largest users of magnesium oxychloride composition floors. IS-658-1962 is primarily intended to meet the requirements of the railways and also covers the requirements for laying and use of oxychloride floors in all types of buildings. This kind of floor is also being used by the Air India in their simulator room for Boeing 747.

5.11.3 Bitumen Mastic Floor

Bitumen mastic or bitumastic is a mixture of finely graded mineral matter as filler and bitumen. Bitumen mastic should conform to the requirements given in IS-1195-1968. It is delivered in the form of blocks, wherein about 25 Kgs are in molten condition in drums or prepared at the site. They are cooked at controlled temperature in a cooker to obtain a cohesive, impervious and voidless mass which at 180°C exhibits a plastic consistency but on being cooked to normal temperature solidifies into a hard mass. Bitumen mastic floors are dustless, odourless, jointless and impervious to the transmission of moisture, either in liquid or vapour form. The surface is easily cleaned, noiseless under traffic, and is resilient. It is alkali resistant and when with suitable fillers like silica dust and slate dust can house a good resistance to acids also. A special grade known as acid and alkali resistant grade (AA grade) of bitumen mastic is also available, and could be used to withstand diluted acids, alkali and salts.

Thickness

The total thickness to which bitumen mastic should be laid will depend upon the traffic conditions to which the flooring will be subjected. Usually the bitumen mastic is laid in one coat but two coat work may also be used depending on the thickness of the floor finish. The recommended thickness for different service conditions are given in the table 3 below:

Table 3: Thickness of Bitumen Mastic for Different Service Conditions

Sl. No.	Examples of service conditions	Type of flooring	Recommended Thickness in mm
1.	Medium wear due to foot traffic. Example: Small scale industries, such as those manufacturing electronic and electrical equipments.	Light duty	15 to 20
2.	Severe abrasion due to continuous foo~ traffic. Example: Passenger platforms, footpaths, workshops etc.	Medium duty	20 to 25
3.	Severe abrasion combined with impact. Example: Heavy engineering workshops, despatch yards, loading docks, goods platforms, loading platforms for trucks carrying milk bottles in dairy, etc.	Heavy duty	25 to 30 and more

5.11.4 Construction

IS-1196-1978 covers the method of laying bitumen mastic floors. The steps involved in the construction are as under and are specified in the IS exhaustively:-

a) Preparation of the Base

The base should have an even and dry surface which has been solidly roughened by means of a wire brush or broom and should be free from ridges and hollows.

b) Treatment of the Base

The treatment of the base will depend upon the design aspects. Normally, the following methods are adopted:

i) A screeded bed of cement concrete or lime concrete not less than 25 mm thick;

ii) On metal floors a thin priming coat of bitumen paint applied over a clean and dry surface.

c) Isolating Membrane

An isolating membrane may be provided on timber base or base with porous or open texture, concrete surfaces containing fine cracks, etc.

d) **Laying**

The material should be sufficiently molten and workable: Bitumen mastic is generally laid in bays in one coat, and spread to the specified thickness by means of hand tools. It is then floated to a uniform level surface by a heavy wooden float, and should be free from roughness and imperfections.

e) **Surface finish**

The following two types of surface finishes are preferable :

i) Matt finish

The surface is made rough with sand during the final floating operations.

ii) Polish finish

The surface is finished with float without the use of an abrasive. The various types of bitumen masticare manufactured by:

a) India Tar and Bitumen Products, Calcutta

b) M/s Shalimar Tar Products, Calcutta

c) M/s Coromandal Prodorite Pvt. Ltd., Madras.

SAQ 4

1. What is magnesium oxychloride flooring ?

2. Describe the construction of bitumen mastic floor

5.12 EPOXY RESIN FLOORING

This is a synthetic resin system for flooring which has been use in the advanced countries in critical industrial environment where conventional flooring materials have given constant problems. The three principle systems used for this type of applications are epoxies, polyster and polyurethanes. The epoxy resin which have come into use in a large extent in this country arediscussedinsucceedingparagraphs.

Epoxy resin flooring is increasinglybeing used in the building industry on account of its qualities of adhesion and chemical resistance. They are found very suitable for use on industrial floors, such as in chemicalplantsmanufacturingfertilizers,pharmaceuticals, acids and solvents, in dairies, tanneries, breweries, garages etc. The use of epoxy resin for industrial floor toppings is characterised by its exceptional, physicalandchemicalproperties,such as abrasion resistance, compressive, impact and flexural strength, hardness, chemicalresistanceandabrasion resistance.

As the mechanical and chemical properties of epoxy resin depends on the composition, it is very essentialthat the formulation should takenoteofdifferent situationsforobtaining optimum results.

5.12.1 Types of Epoxy Resin

In general, three types of epoxy resin products are available for flooring viz, paints, pourable or flowapplied, and screeds and mortars, or trowell type.

a) **Paints**

These are generally based on the use of solid epoxy resin dissolved in solvent and cured with a poly-amide, amine or amine abduct. These materials are generally filled with fine fillers, and pigments are added to achieve a pleasing appearance. Two or three coats are applied. The finish is

generally suitable for pedestrian or light vehicular traffic, and is used in warehouses, stores, laboratories, food process and packing areas, etc.

b) Pourable or flow applied

These materials are usually available in two pack system. They are mixed together at site, and poured on the prepared floor surfaces and spread to provide a uniform layer of thickness of about 1 to 1.5 mm. Because of thickness of coating the sub striate requires to be smooth, even and free from blemishes, such as high spots, cracks, etc. Skilled workmen are required for laying. The finish achieved is generally smooth and glossy providing a hard wearing chemical resistant surface. The system is used in laboratories, clean rooms, food process areas and ready packing areas. It is most useful, where decontamination is of paramount importance.

c) Screeds and mortars of trowel type

These are usually three component systems consisting of resin base, hardeners and aggregates. They are troweled, applied at a nominal thickness of approximately 5mm. The solid aggregates may constitute as much as 90% of the flooring material. The very nature of this material enables it to be laid on to the existing floors which may be worn out or damaged It is necessary that substrate is of sufficient strength and soundness to support a thin topping. Weak porous substrate will lead to bend failure with an epoxy screed system.

5.12.2 Method of Application of Epoxy Resin Floors

Thepreparation ofsurface, mixing of epoxy resin paint, and applicationetc. shouldconform to IS-4631-1968, a code of practice for layingepoxy resin floor toppings. These are briefly discussed as under:

a) Preparation of floor surface

Before the application of the epoxy resin topping, the base concrete should be properly cured and dried The surface should be rough at the time of application of epoxy resin topping. To ensure proper adhesiveness of the epoxy resin mix, the sub strata should be clean, free from grease and oil. Sand blasting or hacking may be adopted for roughing the concrete surface.

In case of existing concrete floor the structural soundness of concrete surface should be examined and all cracks, broken areas etc. should be sealed. Fresh concrete floor may thus be laid if it is necessary from structural point of view. Grease and oil should be removed by washing the surface with suitable solvents or detergents. It may also be washed by a hydrochloride solution of 10 to 15 percent. In case the surface is of mild steel or cast iron, it should be washed with a suitable solvent or detergent solution to remove the grease or oil and then it should be sand plasted or abraded with emery cloth or wire brushes.

5.12.3 Mixing of Epoxy Resin

Theconstituentsrequired for a particular epoxy resin topping shouldbemixed in the correct proportionspecified by the formulator. In the mix blend, the components are generallyresin, hardener and aggregate. The aggregates should be added to the blend in the mixture in a absolute dry condition. The duration of mixing separate components of epoxy resin blend should be adequate to ensure thorough mixingand the quantity of the resin mix at any one time should be such that the mix can be applied and spreadwithin known pot life i.e. time taken after addition ofthe hardener for a resin to reach a unusuable state and is greatly influenced by the prevailing temperature,

5.12.4 Application

The blended epoxy resin mix should be applied anduniformly spread over the prepared area to give the required thickness. Where the heavily filled trowelling compound is to beapplied the prepared areashouldbe first covered wilh a tack coat of the unfilledresin - hardener mix and it should be allowed to cure partly but a tacky stage before the actual topping is applied. Since miled steel tools are liable to cause stains it is recommended that stainlesssteel or chromium plated or rigid PVC tools be used for the laying of epoxy resin floor toppings.

5.12.5 Setting

After application ths floor shouldbeallowed to set without disturbance for a minimum period of 24 hours. The floor may be brought to use after minimum period of 7 days at a temperature of 20°C. However, light traffic may be permitted to cross over after 24 hours of laying the floor topping.

5.12.6 Safety Precautions

Epoxy resins may cause irritation to persons having sensitive skin. Providing good ventilation of the work area and storage rooms, maintaining cleanliness at work and taking maximum care when processing resins and hardeners are recommended to minimise these hazards. Rubber or polyethylene gloves may be used while handling.

5.12.7 Commercial Formulation

A number of commercial formulations are available in the market. Amongst them are "**Prodofloor**" manufactured by M/s Coromandal Prodorite Pvt Ltd., Madras and "**Nitofloor** TF 5000" manufactured by FOSROC. Prodofloor flooring composition is based upon epoxy resins inerts and aggregates. The mix proportions generally recommended are 6.35:1 for powder to binder and 10:1 for binder to hardener, and the potlife is about 20 minutes. It is laid in standard thickness 6mm for light traffic conditions and 8 to 10mm for heavy traffic conditions.

Nitofloor is a 3 parts solvent free component of epoxy resin, modified amine hardener filled with specially graded and selected high crushing strength, chemically inert aggregates. It is laid by trowel to a screed of 5mm thick. The system includes NITOPRIME 25 a two-pack epoxy resin primer and Nitofloor TF 5000 which are both supplied in preweighed units ready for on site mixing and application. The system provides an extremely high strength floor topping with exceptional resistance to attack from mechanical wear and chemical spillage which is impervious and at the same time produces a safe nonslip finish for personnel and vehicular traffic. This is ideally suited for heavy engineering plants chemical handling and process area, steel works, dairies, oil refineries, plating factories, battery rooms etc. There is another product recently marketed by MC BAUCHEMIE (India Pvt Ltd). The product is known as "Dreitop FH". It is a ready to use non metallic floor and surface hardening agent based on a very hard natural aggregates. It is to be applied by dry shake method in two operation on freshly floated concrete or as a compensatory mortar topping. The application of Dreitop Floor hard provides wear resistance to concrete surface thereby extending the service life of the industrial, commercial and residential floors. The floors are rendered tough, wear resistant, dust free, physiologically harmless, and all above floors durable and maintenance free.

Dreitop floorhard is claimed to be an unique combination of selected cementatious binder modified by polymers, to impart the mix plasticity and high strength, blended with well graded cubical natural hard aggregates. The grading is most critical and insures maximum possible surfacc density. When applied Dreitop floorhard provides a denser surface with lower permeability coupled with increased wear and impact resistance.

Dreitop floorhard bonds monolithically to the base concrete and is suitable for old as well as new floorings and surfaces. The greatest advantage of Dreitop floorhard over conventional metallic hardeners is the non rusting property which enables its use in wet rooms as well as for out door application. Dreitop floorhard floors are able to withstand almost all types of mechanical stresses such as rolling, sliding, percussion, impact, abrasion etc. Dreitop floorhard surfaces are very economical compared to alternative possibility with epoxy and other liquid plastics.

5.12.8 Advantages of Epoxy Flooring

The advantages of epoxy flooring are as under:

a) Highly wear and abrasion resistant toppings which are non dusting
b) Non slip and anti skid even in cases of oil spillages
c) Resistant to petrol, mineral oils, etc.
d) Deicer resistant
e) Waterproof – suitable for constantly wet rooms and exteriors
f) Suitability for interior and exterior applications
g) Non rusting and therefore problem free
h) Not electrostatically chargeable

i) Non combustible and durable

j) Physiologically harmless and easy to clean

k) High density and requiring the minimum maintenance

1) Suitable for old floors, new floors and repairs

m) Increased strength and impact resistant

n) About twice abrasion resistant compared to the normal concrete floor

o) Increased serviceable life and therefore economical.

Application of Epoxy Resin

The various fields of application of epoxy resin are as under:

a) Production, assembly, storage halls and warehouses

b) Loading and unloading rafts and bays

c) Civil engineering structures like hydraulic structures, airport construction and passage ways

d) Exhibition halls, stadiums, railway platforms and staircases for public utilities buildings

e) Paper stores, bunkers and courtyards used by traffic

f) Workshops, shop floors and production areas

g) Hangers, ship yards, car ramps and park places

h) Hard toppings for any indoor or outdoor floor installations

i) Road way surfacings, road repairs, runways and loading areas

j) Ice staking rinks, other skating arenas and sport places

k) Shopping centers, hotels, hospitals, schools, etc.

1) Grain silos and other silos storing abrasive material

m) Suitable for normal applications as well as vacuum dewatering process applications

n) All areas subjected to heavy wear, tear, rolling and impact.

SAQ 5

1. What are the advantages of epoxy flooring ?

2 Where the epoxy flooring is used ?

5.13 SURFACE SEALANTS (LIQUID HARDENERS)

There are large varieties of materials, which are applied to the floor surface to render it hard and to make it resistant to chemical attack. Some of the materials used are given below:

a) Aqueous solution of sodium silicate

b) Magnesium and zinc silica fluoride

c) Dying oil s.a. linseed oil or tung oil

d) Silicon fluoride

e) Liquid monomer

f) Polyurethane floor sealer

But of all the liquid sealants (hardeners), polyurethane based sealants are finding large applications. Number of firms have come out with commercial formulations. Some of them are discussed in succeeding paragraphs to make you aware of their qualities and applications.

a) Florgard

Strengthens the base floor, and transforms it into a tough, elastic, waterproof, abrasion resistant, oil and chemical resistant, jointless floor. Application is in 3 coats like paint applied over clean and *dry* oil, and grease free surface, i.e, 1st coat as impregnation layer and two coats for sealing. Average consumption is 150 gms per sqm area. Application is useful for pharmaceutical industry, food and dairy industry, ware houses, hospitals, high traffic areas, etc.

b) Nitofloor FC 110

It is a high duty surface sealer for concrete floors, and in easily applied in 2 coats by brush applications. After application the floors becomes washable, dustproof, and easy to clean. It prevents oil, grease and contaminates staining the concrete. It is used in industrial buildings, textile plants, food processing plants, computer rooms and electronic factories. Another sealant, Nitoflor FC 140, is also a pack system based on epoxy resin and amine curing agents, and is ready to mix and use on site type. Fine textured non slip finish can be obtained if anti slip grain material is added to the base resin prior to the mixing of the hardener.

Similarly certain monolithic surface hardening compounds in the powder form are also available and these bonds monolithically to the base concrete to provide highly abrasion resistant and hard wearing surface. These are manufactured by MC-Bauchemie, Fosroc, etc.

5.14 STEEL FLOORING SYSTEM

At times, floors of certain heavy engineering factories, workshops and garages etc. have to withstand most severe conditions of wear accompanied by repeated heavy impact loads and abrasion by steel tyre trucks. Therefore, there is a need for providing a suitable floor for withstanding those conditions. Steel tiles or steel plates or open metal grates embedded in ceramic concrete are considered to be suitable for the above requirements. The various types are described in the succeeding paragraphs:

a) **Open Grid** Floors

These are intended mainly for industrial applications. They are used lor work ways and platforms around the plant for power stations and similar buildings. They are made by rivetting or welding together steel flats or shaped bars so as to form a flat network. Such floors can be made in a wide range of strength so that supporting structure can bc designed at any suitable space. The panels can be cut so as to provide access for pipes or projections. The steel so used may be uncoated, painted, galvanised or galvanised and painted according to the exposure conditions in service.

b) Pressed Steel Planks

This type of flooring differs in the method of manufacture and in the form of end-product from the earlier one. Pressed steel planks are usually of narrow width and are solid in standard sizes which may be cut to fit at site. The planks are usually ribbed or serrated to provide an anti slip upper surface. Planks could be painted or galvanised.

c) Embossed Plates

These are solid steel plates, the under surface of which is usually bent, while the upper surface is raised in a diamond grid pattern for anti slip purposes. The plates are fixed by bolts or welding and need closer spacing of supports than either of the two types described above. They are very suitable for heavy duty. Thickness of plates could extend upto 10mm. Steel plates are also fixed into concrete to provide a hard and tough non skid surface. In this form the tiles are inverted trays bonded into concrete by a series of lugs, which are pressed out of the sheet surface. It is also possible to obtain concrete slabs on to which a non slip steel surface has been bonded in the factory.

5.15 STONE SET PAVINGS

In certain locations, the floor topping is required to have wear resistance of a very high degree, and resistance to heavy abrasion and impact loads. Such situations are encountered in the heavy engineering industry where a single load of the order of 10 to 15 tonne is handled or heavy vehicle factory such as manufacturing tracked vehicles and armoredvelucles. The floor is subjected to abrasion due to churning action of the trackplates. Even storage garages and roads .for movement of vehicles are also provided with stone set pavements. This type of floor topping is also suitable for loading platforms in docks, railway locomotive repair workshops and floors ofearthmoving plants.

5.15.1 Types of Stones

The types of stone suitable for heavy duty flooring are generally granite and basalt. Granite is very hard and resistant to wear by abrasion and impact. It is also resistant to avariety of chemical agents. It is used in thick slabs of various sizes depending upon the conditions of use. Basalt is very suitable for heavy engineering factories andgarages, as it can withstand impact andwear.

The stone set "wearing coarse" is providedover the cement concrete base and sub base such as stone soling. The thickness of the cement concrete base will depend on the design and constraints and sometimes even RCC floor will be preferable, if it is expected that sub base is not strong enough. The stones for stone set should be of best quality granite, trap or other variety ofigneous origin. Even stones with metamorphic formation are considered equallygood for providingstone sets, but sedimentarystones to in no case are bepermitted.

Stones for stone toppings are generally rectangular in shape, 200 to 250 mm long, 150 to 200 mm wide, and 150mm deep, with a tolerance of plus or minus 12mm. They should be hammer dressedon top to the extent that the maximum depressionof thedressedsurfacewhenmeasured by straight edge across in parts ol the surface for testingdoes not exceed 20mm. The dressing on the sides should be similarly carried out. Stone sets are set on the base concrete over a bedding mortar 1:3, 20mm thick with joints not exceeding 20mm in width. The joints are grouted with cement mortar 1:2 containing admixture of metal hardener such as tronite, hardonateor an equivalentvarietyin the proportion recommended bythemanufacturers. Jointsshouldbe struck off level as the work proceeds.

5.16 CERAMIC TILES

Use of glazed ceramic or earthen wear tiles in domestic buildings is very common. Such tiles should conlorm with the IS-777-1970, specification lor glazedearthenwear tiles. The tiles should be flat, true to shape, sound and free fromflaws and manufacturing defects. The tiles are laid over the bedding not less than 10mm thick of cement mortar 1:4 or 1:3. The joints should be as thin as possible but not cxcceding 1.5mm wide. The tiles should be washed clean and fixed in the grout one after the other, each tile being gently tapped in its position till it is properlybedded in level and line with adjoining tiles. These tiles are also used in dados. Of course heavy duty cintered ceramic tiles have come into the market for use in heavy duty flooring especially in chemical and pharmaceutical industries, paper mills, airports, auditoriums, railwaystations and other industrial blocks. These tiles are non skid, scratch resistant, abrasionresistant, acid and alkali resistant, electrostatically neutral and impervious to bacteria, and fulfilling other similar **industrialundcrtakingrequirements.**

These tiles have high compressive strength, as much as 1500 kg/m^2, good flexural strengthand a marginal water absorption. The tiles are generally available in a variety of shades and sizes of 200/100mm, 200/200mm, 200/300mm, 300/300mm and 300/400mm. Heavy duty industrial floor tiles are also available in non glazed pattern. Unglazed industrial tile should be as per IS-4457. Such tiles aremanufactured by Regency Ceramics Ltd., Kera Center Ltd and Spartek Ceramics Ltd.

5.17 PREMIX SYSTEM OF CONCRETE FLOOR

It is emphasized that concrete is a good material for industrial flooring. But the method of concrete making in the past, particularly using high water/cement ratio, lack of compaction and undesirable method of troweling, fimshingand provision of joints, have made the concrete floor unsatisfactoryat times.

Anew system of floor construction bythe name of "TREMIXSYSTEM" has been introduced in European Countries and this technologyhas been now transferred to India.

The system consists of following operations :

a) Prepare quality concrete using strong, durable mineral aggregates, such as Granite, basalt or trap with sufficient water/cement ratio to make it workable.

b) Lay the concrete in bays sufficiently large in area, desirably as large as the suction mat.

c) Compaction and leveling is achieved by screed board vibrator or surface vibrator mounted on rails.

d) A specially designed suction mat is spread on the concrete. This suction mat is connected to a vacuum pump, and the superfluous extra water is sucked and taken away from concrete. This removal of unwanted water from surface and interior of concrete makes the concrete stiff and sufficiently hard within about 20 minutes of laying which otherwise require about 2 to 3 hrs.

e) The suction mat is removed and the surface is subjected to mechanical power troweling. The power trowel by its own weight and action, to an extent, revibrates the concrete and seals the capillary channels caused in the movement of water from interior to surface. The power troweling also cuts the excess cement paste at the surface and levels the surface in a much better and faster way than conventional troweling operation by masons working with hand trowels.

f) Once the preliminary leveling is done the blades of the power trowel is replaced by polishing disc and it is run on the surface. This operation removes even the small thickness of cement paste or laitance at the top surface of the floor and almost exposes the fine aggregate and coarse aggregate in the concrete, which contain the paste, rendering wear resistance quality of a highest order.

Although the dummy joints, where required, could be made by special arrangements, while laying the concrete, it is better to make a jointless floor, and then cut dummy joints in the hardened concrete by concrete saw, designed for such purposes.

The Tremix system of concrete floor construction is a combination of modern technology of vacuum processing of concrete, modern method of compaction and finishing of concrete with orthodox method of concrete floor construction. This system should really foot the bill of an industrial floor in an average situation.

5.18 MISCELLANEOUS WEAR RESISTANT MATERIALS

In addition to the above mentioned wear resistant materials, the following additional types of materials can also be incorporated for a floor finish of an industrial building as per IS-4971-1968. Recommendations or selection of industrial floor finishes.

a) Precast Concrete Tiles

Concrete tiles have good resistance to wear and chemical attack but cannot withstand heavy impact. Where good appearance and cleanliness is a prime consideration for a flooring, concrete tiles may be selected

b) Paving Bricks

Paving bricks, conforming to IS-3583-1966 standards, may be used for heavy duty and industrial floors, loading and unloading platforms where the floor is subjected to heavy wear and tear.

c) Fire Clay Bricks

Any situation, where high temperature is to be met with, such as those around metallurgical furnaces; fire clay bricks may be laid in fire clay mortar.

d) Acid Resistant Bricks

The acid resistant bricks, conforming to IS-4860-1968 have good resistance to all acids except hydrofloric acid and perchloric acid and other chemicals. They are suitable for flooring subject to acid attack and abrasion.

e) Ceramic Unglazed Vitreous Acid Resistant Tiles

These tiles, conforming to IS-4457-1967, have good resistance to acids, and are suitable for flooring subject to acid attack, impact and abrasion.

f) Wooden Block with **Lead** Lining

This type of floor provides a eon sparking floor finish and is suitable for floors where explosives are stored.

g) **Linoleum** Flooring

Linoneun provides a clean, dust free and resilient flooring. In light industries, such as electronic industry, linoleum flooring may be used as the risk or damage by wetting to which linoleum is vulnerable is small. If linoleum gets wet, it expands and mildews and eventually rots. The linoneun should comply with the requirements of IS-653-1980 - specification for sheet linoleum. There should be adequate adhesion between the composition and the hessian backing. The top surface should be smooth, uniform, free from indentations and protrusions. Linoleum comes in various thicknesses and sizes, and the main thickness should not vary more than 0.1mm from the specified thickness. The adhesive used for the linoleum floors should be vegetable and casein glues, grues spirit adhesions, bitumen rubber emulsion or bitumen rubber solution.

11) Rubber Flooring

This type of flooring is resilient and noiseless. The flooring is suitable for electronic industry, computer rooms, etc. Rubber sheets or tiles for flooring should conform to IS- 809-1970- Specifications for rubber flooring materials. Rubber flooring material should be free from sulphurboom and objectionable odour, blisters and cracks etc. The surface finish could be either glossy or mat. The net site of the floor covering may be furnished with a cloth impression or be buffed smooth. The colour of the flooring should not be affected by cleaning water and washing soap or by treatment with a suitable floor polish. The adhesive as recommended by the manufacturer should be used and precautions to be taken for using adhesion laid down by the manufacturer should be followed.

i) **PVC** Floor

The PVC floor covering should conform to IS-3462-1979-Specifications for PVC flooring. The flooring sliould have a uniform wear surface. The PVC floor covering could be in the form of sheets/rails or tiles of the thickness and sizes as specified. The permissible tolerance on the thickness sliould not be more than 0.15mm. The PVC flooring provides, clean, dust free ancl resilient flooring. The flooring may be easily cleaned with a wet cloth.

j) **PVC** Asbestos Floor Tiles

The PVC asbestos tiles should conform to IS-3661-1980 - specification of PVC Asbestos floor tiles. The plain tiles should have colour uniformly disturbed through out the tile. The material should not develop any defect while in service. Permissible tolerance on thickness is ±1.5mm.

5.19 SUMMARY

The floor element of a building is one which comes in the maximum contact with the users. It is not only walked upon and trampled, but heavy loads are dragged and thrown upon the surface. The floor is subjected to chemical attacks of numerous types. Yet, the floor toppings generally provided in industrial buildings in the country are given the least importance and too often a floor is laid which cannot cope with the operating conditions resulting in constant maintenance problems, which ultimately reflect on the overall performance of the industrial unit.

We must make use of different types of wear resisting materials available to suit the functional requirements. The choice is very large comprising, cement concrete floor, terrzo floor, granolithic concrete, magnesium oxychloride, epoxy resin, steel flooring, stone set paving, ceramic tiles and tremix system of flooring, among others.

5.20 KEY WORDS

Thoppie	It is a trowell which is used by mason in thceonstructionfield.
Metalcreate	It is a brand name of granolithic flooring material.

Abrasion Resistant	Resistanttomechanicalwear
Non sparking	No production of spark due to friction
PCC	Plaincementconcrete
RCC	Reinforcecementconcrete
Bitumastic	Mixtureofbitumen and mineral matter

5.21 FURTHER READINGS

IS-383

IS-2144-1962

IS-1195-1968

IS-1195-1968

IS-4631-1968

IS-777-1970

Literaturepublishedbyvariousmanufacturers.

5.22 ANSWER TO SAQs

Check your Answers of all SAQs with respective preceeding text of each SAQ.