BUILDING DIGEST

CENTRAL BUILDING RESEARCH INSTITUTE, INDIA

INDUSTRIAL FLOOR FINISHES

Floor finishes are provided in industrial buldings to protect the structural floor from abrasion and attack by chemicals. Since the type of traffiic and the chemicals involved are different in different industries it is possible only to provide general guidelines for the choice of floor finishes. Often it becomes necessary to select the most durable materials because a floor may come in contact with chemicals of widely different reactions.

Materials for Floor Finishes:

The more important considerations which govern the selection of a floor finish are : (a) nature of the chemicals being handled, (b) cleaning agents to be used, (c) temperature of water and other liquids spilling on the floor (d) possibility of crystallization of salts in pores and joints, and (e) the nature of traffic on the floor. Initial cost and estimated maintenance and renewal costs are also important considerations. The most important floor finishes are briefly discussed below and their characteristics are summarized in Table 1.

In-Situ Floor Finishes :

Portland Cement Concrete :

A well compacted or vibrated concrete is fairly satisfactory under mildly aggressive conditions. For the performance outlined in Table 1 it is assumed that the concrete is of good quality. Generally a concrete topping of about 2 cm is laid, but when concrete is to be replaced, about 3 to 4 cm concrete topping over the old concrete becomes necessary. This may require alteration of the plant floor level. Initially, therefore, a concrete topping of about 5 cm thick should be provided

High Alumina Cement Concrete :

High alumina cement has better resistance to acids than normal portland cement. However, at temperatures above 30°C and particularly in wet conditions high alumina cement concrete loses its strength, becomes porous and gets more prone to chemical attack. Its poor resistance to alkali is also a disadvantage.

Rubber Latex-Cement :

Rubber latex-cement is generally a mixture of normal portland cement or high alumina cement and rubber latex It provides strong bond to the subfloor and has good surface sealing property. It has better resistance to corrosion by acids than ordinary cement concrete but is unsuitable for use in contact with caustic alkalies, oils and grease. The use of synthetic rubber overcomes this weakness to some extent.

Magnesium Oxychloride Cement :

This cement is produced by a chemical reaction of lightly calcined magnesium oxide and magnesium chloride solution. Organic and inorganic fillers, sand and aggregates are used in the compositions. The cement is well known for high mechanical strength and durability under cover. On wetting it loses strength slightly but regains it on drying. Mineral oils, grease, vegetable oils, milk products, sugar and mild alkalies do not affect it. This cement is extensively used for railway coach flooring.

Bitumen Mastics :

Bitumen mastics provide a floor finish completely impermeable to liquids Special acid resistant mastics are compounded with siliceous fillers instead of the usual limestone filler. However, oxidising agents and halogens react with bitumen particularly at high temperatures. Bitumen mastics are also not resistant to oils, fats and solvents

Some bitumen mastics are applied cold while others have to be heated until fluid enough to be poured and trowelled. For cold application generally, a primary coat made of clay stabilized bitumen emulsion is followed by a body coat consisting of 1 part of portland cement or high alumina cement and 4 parts of sand mixed in 2 parts of clay stabilized bitumen emulsion.

Hot applied bitumen mastic usually consists of about 15 per cent bitumen binder, 20 per cent finely powdered siliceous filler, the remainder being sand graded to 6 mm maximum size. Local overheating, which causes degradation af bitumen and deterioration of the quality of mastic, usually happens during the preparation and remelting of mastics. In order to avoid this defect, proper mixing equipment should be used.

Resin Cement and Concrete :

A variety of synthetic resin cements are now available as two-part systems which harden by chemical reaction. Some of the important types are epoxy, coal tar modified epoxy and polyester resins Epoxy resins are characterized by their exceptional physical properties,

Table I

General Properties of Floor Finishes and Bedding and Jointing Mortars

Material	Resistance to abrasion	Resistance to impact	Resistance to heat	Resistance to attack by: Water	Mineral acids: Weak	Mineral acids: Strong	Organic acids	Alkalies	Solutions of sulphates, phosphates & nitrates	Mineral oils	Vegetable oils and fats	Organic solvents	Satisfactory pH range
1	2	3	4	5	6	7	8	9	10	11	12	13	14
Floor Finishes													
(i) Portland cement concrete													
(1) In-situ	VG-P	G-P	G	VG	P	VP	F-P	G	P	G	P	G	7–12
(2) Pre-cast	VG-G	G-F	G	VG	P	VP	F-P	G	P	G	P	G	7–16
(ii) High alumina cement concrete	VG	G	P	F	G	P	G	P	F	G	P	G	5–9
(iii) Rubber latex cement concrete	G-F	G	F	G	F	P	G-F	F-P	F	F	F	P	7–12 but better then mixes without latex.
(iv) Magnesium oxychloride cement	VG	G	G	P	P	VP	G	G	G	G	G	G	7–11
v) Bitumen mastic	G-F	G	P	VG	G	P	P	G	F	F	P	P	1–11
(vi) Epoxy resin concrete	VG	VG	G	G	G	F	G	G	G	G	F	G	0–12 (except in oxidising action)
(vii) Clay tile and brick	VG-G	VG-G	VG	VG-F	VG	VG	VG	P	G-P	G	G	G	0–8
(viii) Cast iron and steel	VG-G	VG	VG	G-F	F-P	P-VP	G	F	P	G	G	G	3–8
(ix) Stone slabs and tiles	VG-G	G	G	G	G-P	G-P	G	G-F	F	G	G	G	3–8

(x) Rubber sheets and tiles	F	G	P	G	G	F	G-F	F-P	F	P	P	P	1–7
(xi) PVC sheets and tiles	F	G	P	G	G	F	G-F	G-P	F	G	F	G-F	4–8
Bedding and Jointing Mortars													
(i) Portland cement	F	F	G	VG	P	VP	F-P	G	P	G	P	G	7–12
(ii) High alumina cement	F	F	P	F	G	P	G	P	F	G	P	G	5–9
(iii) Rubber latex cement	F	F	F	G	G	P	G-F	P	F	F	F	P	7–12
(iv) Super sulphated cement	F	F	F	VG	G	VP	G	G	G	G	F	G	4–12
(v) Silicate cement	F	F	VG (if dry)	P	VG	VG	VG	VP	G	G	G	G	0–7
(vi) Sulphur cement	P	P	P	VG	G	G	G	F	G	F	P	P	0–10
(vii) Epoxy resin	VG	VG	G	VG	VG	G-F	VG	VG	VG	G	G	G-F	0–12
(viii) Furace resin	VG	VG	G	VG	VG	G-F	VG	VG	VG	G	VG	G	0–12
(ix) Phenolic resin	G	G	G	VG	VG	G-F	G	F	G	G	G	G	1–8
(x) CNSL resin	VG	G	VG	VG	VG	G-F	G	F	G	G	G	P	1–8
(xi) Polyester resin	G	G	G	VG	VG	G-F	G	P	G	G	G	G	1–8

VG=Very good

G=Good

F=Fair

P=Poor

VP=Very poor

chemical resistance, adhesion to cured concrete and above all, negligible shrinkage. Blending with coal tar extenders reduces the cost of the material.

For obtaining non-slip and abrasion sesistant surfaces, siliceous fillers are frequently incorporated. Pigments used generally have high opacity and resistance to alkalies.

While using resin cements, suitable hygienic precautions should be taken and protective cream, gloves and goggles used whenever necessary.

Jointed Floor Finishes

Clay Tiles and Bricks :

Heavy duty paving bricks and acid resistant vitreous ceramic clay tiles and bricks are widely used for jointed floor finishes. Acid resistant tiles should normally have a compressive strength over 500 kg/cm^2, transverse strength over 100 kg/cm^2 and water absorption below 2 per cent. Clay tiles less than 2.5 cm thick have low resistance to impact. Normally for heavy traffic, tiles of a minimum 5 cm thickness should be preferred. Fire clay bricks are suitable for use around furnaces where the floor may get heated.

Brick and tile flooring is a specialised job. An underlay should be provided between the sub-floor and the tiles if a rigid mortar has been used for bedding. Moisture movement, differential thermal expansion, loss of adhesion and vibration are the main causes of failure of a tiled surface. To avoid moisture movements, tiles of negligible porosity should be selected. If the floor is likely to be subjected to much vibration, a properly designed flexible joint should be provided between the wall and the tile floor. Generally, expansion joints would not function usefully as the tiles are not free to move laterally. Control joints should however be provided to coincide with the joints in the base concrete, unless a separating membrane is used.

Stone Slabs and Tiles

Granite, basalt, quartzite and sandstones of the silica bonded type are the most common flooring stones, providing high resistance to abrasion and impact, and reasonably good chemical resistance. Stone floor surfaces become slippery after considerable wear and require mechanical roughening.

Cast Iron and Steel Floor Finishes

Cast iron tiles or plates and open metal grids embedded in granolithic concrete are used where impact and wear are caused by movement of iron wheeled trollies and wet and greasy conditions prevail. The impact and wear resistance of bitumen mastic floors are also improved by embedding metal grids. Open metal grids and steel tiles are liable to become slippery and also get corroded under constantly wet conditions. Solid faced cast iron tiles offer better resistance to the action of oils, fats, salts and alkalies.

Rubber and PVC Sheets and Tiles

These materials are recommended for comparatively mild exposure conditions. Several types with abrasive material surfacing and with metallic or glass fibre reinforcements are used where slipperiness is a problem under continuously wet conditions. Special adhesives are used for fixing these sheets and tiles to concrete. A damp proof course below the floor is essential.

Bedding and Jointing Materials

Bedding and jointing mortars should be selected with a view to providing adequate bond with the tiles and bricks, and resistance to corrosion in the environment in which they are used. Their properties are summarised in Table 1 Often it might be necessary, for economic reasons, to use a comparatively cheaper mortar for bedding and a more expensive, better quality material, for jointing For this reason, thickness of the joints should be the minimum required. A bedding mortar should not be excessively harsh or rigid lest loss of adhesion with tiles should take place. Lime-cement composite mortar, masonry cement or latex-cement mortar should therefore be usrd in preference to straight cement-sand mortar.

Portland Cement or HIgh Alumina Cement Mortar

These mortars provide adequate adhesion to brick and tiles but the joints are neither impermeable to liquids nor flexible. As already stated high alumina cement is better than portland cement in its resistance to acid but not to alkali

Rubber Latex-Cement Motar

Rubber latex-portland cement mortar offers very satisfactory joints to tiles. Under acidic conditions, when the portland cement component gets etched away, it continues to give a liquid tight joint as the remaining rubber swells and fills up the gap.

Super Sulphated Slag Cement Mortar

These are more resistant to acids and sulphate ions than normal portland or high alumina cement.

Silicate Mortar

The mortar is made by mixing sodium silicate or potassium silicate solution with quartz or brick dust filler to which a small amount of a silicofluoride has been added The mortar sets by the formation of silica gel, releasing alkali which must be neutralised by washing the joints with a 20 per cent solution of hydrochloric acid. Silicate mortars are resistant to hot and cold mineral acids (except hydrofluoric) but are affected by alkali and water. Flooring jointed by these mortars should have an underlay.

Sulphur Mortar

Sulphur mortar has good resistance to acids (except hydrofluoric and concentrated nitric and sulphuric) and water. Joints are made by pouring a mixture of sand and molten sulphur in the space between bricks or tiles. Sulphur mortar joints are brittle and have poor resistance to abrasion. This mortar is not suitable for use above 95°C because of its thermal expansion and change in properties.

Synthetic Resin Based Mortars

Synthetic resins such as phenol formaldehyde, furanes, epoxies, polyesters and cashew nut shell liquid resins compounded with chemical resistant fillers are used as mortars in floors resistant to almost all chemicals (except oxidising acids). The use of cheap non-resistant fillers should be carefully avoided.

Underlays

Liquids are likely to penetrate even through impermeable floor finishes because of minor defects in workmanship, or cracks due to thermal or structural movements. The sub-floor is thus attacked. It is good practice, therefore, to provide an underlay as a second line of defence below jointed floor finishes. The underlay should be impervious as well as resistant to the chemicals involved. It should also have adequate strength and toughness.

Underlays available in the country are bituminous materials and polyethylene films. Hot bitumen mastic applied in about 12 mm thickness hardens quickly and forms a compact impervious barrier to water. Cold application formulations harden slowly but have similar damp resisting properties. Bitumen coal tar pitch mixes are also used. To prevent puncturing the thickness of film should not be less than 3 mm. The mix should not be heated over 170°C for laying.

Bituminous felts (IS:1322-1965) especially those with fibre glass base make good underlays. Laps should be well sealed with bitumen.

Polyethylene films are completely impervious to water. Proper seal at laps must be maintained. Films should have a minimum thickness of 0.5 mm to avoid puncturing. Sheeting of 1 mm thickness or more is considered best.

Durability

In order to obtain the maximum benefit from the material chosen for the floor finish it is important to design, construct and maintain the floor properly. Apart from the structural aspects of design, factors such as spillage of liquids and drainage should receive adequate attention.

In industries such as fruit juice, milk and milk products, oils and fats and soap considerable spillage of liquids occur. This spillage must be minimised to protect the floor from chemical attack. It is worthwhile to arrange catchpots at all possible drip points so that the area requiring maximum protection may be kept to a minimum.

If service pipes must break the continuity of the floor finish they should be grouped together in a conduit

Adequate drainge is a must on all industrial floors. No matter how well a floor finish has been laid some minor depression will always be there which would collect liquids. To avoid this the floor finish should be sloped 1/80 to 1/60. A slope more than 1/40 is generally dangerous and makes the floor more slippery. The floor area must be so designed as to move the traffic across than down the slope.

Some of the best materials have shown poor durability because of inadequate cleaning arrangements. Thorough cleaning must be a regular practice. In places such as dairies where it is difficult to prevent excessive spillage of liquids, perforated water pipes must be provided around the floor for continuous flushing.

A completely chemical resistant and structurally sound floor finish is an elaborate construction. Users are advised to consult relevant I.S. specifications listed in Appendix 1. All the jobs should be carefully planned and the final floor finish should be laid only after installation of the plant and machinery.

APPENDIX I

I.S. Specifications on Industrial Flooring

1. I.S: 2571–1963 Code of Practice for Laying *In-situ* Cement Concrete Flooring.
2. I.S: 4457-1967 Specification for Ceramic Unglazed Vitreous Acid-Resistant Tiles.
3. I.S: 4456 (Part I)–1967 Methods of Test for Chemical Resistant Mortars (Silicate & Resin Type).
4. I.S: 4456 (Part II)–1967 Methods of Test for Chemical Resistant Mortars (Sulphur Type).
5. I.S: 4832–1969(Part I & II) Specification for Chemical Resistant Mortars (Silicate & Resin Type) (under preparation).
6. I.S: 4832 (Part III)–1968 Specifiation for Chemical Resistant Mortars (Sulphur Type).
7. I.S: 4441-1967 Code of Practice for Use of Silicate Type Chemical Resistant Mortars.
8. I.S: 4443-1967 Code of Practice for Use of Resin Type Chemical Resistant Mortars.
9. I.S: 4442-1967 Code of Practice for Use of Sulphur Type Chemical Resistant Mortars.

10. I.S: 4860-1968 Specification for Acid Resistant Bricks.

11 I.S: 4631-1968 Code of Practice for Laying of Epoxy Resin Floor Toppings.

12. I.S: 1195-1968 (Revised) Specification for Bitumen Mastic for Flooring.

13. I.S: 1196-1968 (Revised) Code of Practice for Laying Bitumen Mastic Flooring.

14. I.S: 4971-1968 Recommendations for Selection of Industrial Floor Finishes.

15. I.S: 658-1962 Code of Practice for Laying Magnesium Oxychloride Flooring.

There is a demand for short notes summarising available information on selected building topics for the use of Engineers and Architects in India. To meet the need, this Institute is bringing out a series of Building Digests from time to time and the present one is the 70th in the series. Readers are requested to send to the Institute their experience of adopting the suggestions given in this Digest.

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