CONCRETE FLOOR HARDENERS

Many a time surface of a concrete floor is not hard enough for the type of use it is put to. The result is that it wears or dusts off rapidly. It is possible to increase the life of such floors by application of certain materials known as 'hardeners'.

Floor hardeners are generally used for the purpose of hardening the upper matrix of Portland cement concrete surface, reducing the suction of liquids into the surface pores, and minimizing or preventing possible chemical attack. They are effective if the floor is of good quality, although they have sometimes been used successfully on inferior quality concrete surfaces too. Even on good quality concrete the treatment needs renewal at intervals of one year or more depending on service conditions.

Surface Preparation

All surface treatments require a clean, dry and dust-free surface. As many surface hardeners are water sensitive or have poor resistance to vapour pressure from below, a concrete floor on the ground should be constructed with an impermeable membrane. If this membrane has not been provided, a vapour-proof barrier may be built with either bitumen mastic of 3 mm thickness or with three coats of epoxy resin solution to make up a thickness of about 1.25 mm.

Dry sand may be spread over the top surface of freshly laid concrete to provide a mechanical key to surface hardener treatment. Old floors should be scrubbed with soap and water, flushed clean with fresh water, and allowed to dry.

Detailed directions for applying various types of surface hardener are given below. General characteristics of different hardeners are shown in Table 1. For details of various floor finishes the CBRI Building Research Note No. 32 "Industrial Floor Finishes" may be referred.

Metallic Silico-Fluorides

The silico-fluorides of zinc and magnesium dissolved in water are generally used. Either of the silico-fluorides may be used separately, but a mixture of one part of zinc silico-fluoride with 4 parts of magnesium silico fluoride usually gives better results. These constituents may be supplemented with lead or aluminium silico-fluoride when the mixture is to be used for increasing the chemical resistance of concrete floors. Normally three coats are required. A 30 per cent solution of metallic silico-fluoride is diluted with 2 volume of water for the first coat, 1 volume for the second, and used neat for the third. An interval of at least 4 hours is allowed between each coat to ensure that the surface is sufficiently dry to allow the next coat to penetrate. For this treatment and the next, the concrete should not contain an integral water-repellant agent or be membrane cured with a liquid compound. After a further period of 24 hours the surface may be finished with boiled linseed oil, chlorinated rubber lacquers or synthetic resin for increasing the impermeability of the surface.

Table 1. **Characteristics of Different Hardeners**

Type	Resistant to				
	Chemicals	Heat	Sunlight	Water	Water
Metallic Silico-Fluorides	Good (A)	Good	Good	Fair	Fair
Sodium Silicate	Good (B)	Good	Good	Poor	Fair
Aluminium Sulphate	Good (A)	Good	Good	Fair	Fair
Zinc Sulphate	Good (A)	Good	Good	Fair	Fair
Ethyl Silicate	Good (A)	Good	Good	Fair	Fair
Drying oils	Good (A), (B), (C)	Fair	Good	Fair	Fair
Paint & Waxes	Good (A), (B), (C)	Fair	Fair	Excellent	Fair
Chlorinated Rubber Lacquers	Good (B), (C)	Fair	Fair	Good	Good
Epoxy Resins	Good (A)	Good (200°C)	Good	Good	Excellent
Coal-tar Epoxy	Good (A)	Good (150°C)	Good	Good	Good
Furane Resin	Excellent (A), (B)	Good (150°C)	Good	Good	Excellent
Polyurethane	Good (A)	Good (150°C)	Good	Good	Excellent
Polyvinyl Chloride and Polyvinyl Acetate Copolymers,	Good (A), (C)	Fair (100°C)	Fair	Good	Good (E)
Phenolic Resins	Good (B)	Good (150°C)	Good	Good	Excellent
Alkyd Resins	Good (B)	Fair (120°C)	Good	Fair	Fair
Silicone Acrylic Copolymer	Fair (D)	Excellent	Excellent	Excellent	Good
Fleximer Compound	Good (B)	Good	Good	Good	Good
Bituminous Seal	Good (B)	Fair	Good	Excellent	Fair

(A)—For dilute acids, alkalies, fats, oils and solvents
(B)—Strong oxidising acids excepted
(C)—Strong solvents expected
(D)—Strong acids and solvents excepted
(E)—Hard Grade

Silico-fluorides react with calcium hydroxide in Portland cement and precipitate compounds in the pores, thereby densifying and hardening the concrete but the treatment does not completely seal the pores. During the use of silico-fluorides it is possible that hydrogen fluoride gas may be given off which is dangerous to the eyes and open wounds. Good ventilation is, therefore, necessary when the treatment is being applied. Also the operators must use protective glasses or keep off the work if spurting occurs during the treatment.

Low Alkali Sodium Silicate

Sodium silicate is usually supplied as a 40 per cent solution, and it is diluted with 4 volumes of water for the first coat, 3 for the second and 2 for the third coat. The solutions are applied until they cease to be absorbed. Each coat is left for about 24 hours, washed with water and allowed to dry before the next coat is applied. Any unabsorbed material after the final application is washed off.

Sodium silicate reacts with calcium hydroxide in concrete to form calcium silicate in the pores. The treatment is a common way of increasing surface hardness, but it will not withstand heavy wear. In the presence of aggressive solutions it is less satisfactory than treatment with silico-fluorides. It should therefore, be supplemented with another treatment for increased resistance to chemical attack.

Aluminium Sulphate

The treatment consists of one or more applications of aluminium sulphate solution which is made in a wooden barrel or stoneware vessel. The sulphate does not readily dissolve and requires occasional stirring for a few days until the solution is complete. About 1.2 kg, of powdered sulphate will be required for each 5 litre of water, to which about one tea-spoonful of commercial sulphuric acid is added. The solution may be diluted with 2 volumes of water for the first treatment and a stronger solution may be used for the second treatment; twenty four hours should elapse between subsequent applications.

Zinc Sulphate

About 0.6 kg of zinc sulphate and a teaspoonful of commercial sulphuric acid are added to about 5 litres of water. The mixture is applied in 2 coats, the second coat being applied 4 hours after the first. The surface should be scrubbed with hot water and mopped dry just before the application of the second coat. The treatment gives the concrete floor a darker appearance.

Ethyl Silicate

Ethyl silicate solutions are applied by brush or spray when the floor is dry. Application should continue until the surface ceases to absorb and remains moist but not wet. Except in extreme cases, one application will suffice. If a second coat is necessary at least 7 days should elapse between two applications.

Drying Oils

Most common drying oils used are linseed oil, dehydrated castor oils tung (china wood), soyabean and fish oil. Boiled or raw linseed oil with or without a thinner is extensively used but boiled oil dries more rapidly. The concrete surface should first be treated with a 10 per cent solution of ammonium carbonate and after drying for 48 hours cleaned with wire brushes.

Two or three coats of the oil are applied and each coat must be allowed to dry thoroughly before the next application. The first coat consists of a mixture of equal parts of oil and turpentine or other suitable thinner applied at a temperature of 70 to 72°C. Slightly diluted oil is used for the succeeding coats.

Drying oils form dry, tough and durable surface films. Their individual behaviour as regards the rate of drying, hardness, flexibility and water penetration varies but all oils withstand outdoor exposure to a marked degree. Drying oil treatment should not be used where conditions are likely to be damp. The floor darkens after oil treatment. Linseed oil provides protection against chlorides, sulphates, light petroleum oils and fats.

Painting and Waxing

The surface resulting from any of the above treatments provides a good base for applying paint, varnish or wax and these, in addition to improving the appearance, will assist in sealing the pores and preventing penetration of corrosive liquids. The paint or wax should, however, be resistant to chemical attack. Solid or liquid wax may be used but solid is preferable for the initial application. Steel trowelled concrete floor should be scrubbed with e 10 per cent solution of hydrochloric acid, flushed with clean water and dried before painting.

Chlorinated Rubber Lacquers

Lacquers consisting of chlorinated rubber or synthetic rubber give good protection to concrete. Two or more coats should be applied and surface penetrating grade is used in preference to a thinned finishing grade.

One of the most suitable varnishes consists of chlorinated rubber of low molecular weight dissolved in a high aromatic solvent and suitably plasticized to improve the adhesive and lasting properties of the dried film. It is applied in three coats with a drying period of 3 to 5 hours. For a non-slip surface. the finishing coat of a varnish or lacquer may be compounded with a hard filler consisting of aluminium oxide, carborundum, fine sand, silica flour or silicon carbide. Alternatively, a liquid coating may be covered with fine abrasive grit or dry sand.

Plastic or Synthetic Resin Compounds

Various synthetic resin products, as one or two-part mixes which harden *in-situ* by chemical reaction, are used for the protection of concrete floors. Those widely used include solventless liquid epoxy, epoxy solution, furane, polyurethane, polyvinyl chloride and acetate copolymer and siliceous acrylic copolymer compounds. Other types include alkyd, cashewnut shell liquid, coumarone, phenol formaldehyde, phenol furfural and polyester. Main characteristics of the major types of these resin based hardeners are given below :—

Epoxy Resin

The most common epoxy resin, resulting product of bisphenol A and epichlorohydrin, possesses high degree of flexibility and impact resistance.

Epoxy Esters

These are reaction products of epoxy resins and vegetable oil formulated by conventional driers and cured by atmospheric exposure. The films have good gloss and colour retention and possess excellent adhesion, flexibility and chemical resistance. The epoxy esters although economical than pure epoxy resins are inferior in alkali resistance properties.

Coal-tar Epoxy

Epoxy resin-coal tar combinations possess excellent resistance to many type of corrosive and abrasive environments by forming hard and durable coatings. They have excellent outdoor weather resistance properties. Some chalking and blushing may take place but this does not affect their protective function. They harden with increasing temperature, do not cold flow and are dimensionally stable. The water absorption of cured film is negligible. These coatings contain strong solvents and need adequate ventilation. They should not be allowed to come in contact with skin or eyes.

Furane

These resins possess excellent chemical resistance even at high temperatures towards most acids, alkalies and salts except hypochlorites and most solvents except pyridine and aniline. At elevated temperatures formaldehyde modified resins are more durable and retain their mechanical properties better than furane resins based on straight furfuryl alcohol.

The use of furane resins on concrete is however, limited because they are acid catalysed. Where necessary the substrate is insulated from acid catalyst by primers. Also the furane films are rather brittle and less flexible which further restricts their use.

Polyurethane

These coatings are prepared from the reaction products of an isocynate with another compound having an active hydrogen group. Urethane coatings are oustanding in their toughness and abrasion resistance even on weathering. But their gloss retention is not very good and pigmented coatings show early unsightly chalking though unaffecting their protective function.

Urethane films, clear or pigmented, require excellent surface preparation prior to application. If there are adhering old paint films on the surface the coating of urethane films may strip off the substrate in large sheets. Polyurethane films cannot be easily recoated after being completely cured. Hence, for subsequent applications vigorous sanding of the previous films is necessary. Since nearly all urethane coatings contain strong, lacquer type solvents, their effect on the previous coating should be tested before repainting as there might be chances of the solvant softening and lifting the previous coatings.

Polyvinyl Chloride and Acetate Copolymer

These may be used as an emulsion in surface coatings in place of rubber latex. PVA has good adhesive properties and good resistance to dilute acids, alkalies, fats, oils, and solvents except esters, ketones and chlorinated aromatic and chlorinated hydrocarbons. But it has low resistance to water and low abrasion resistance when wet. It tends to flow at higher temperatures.

Phenolic Resins and Phenolic Oils

Phenolic resins are alkaline or acidic condensation products of a phenol and formaldehyde or furfural. The phenolic coatings are supplied as a syrup to which a catalyst is added just before use. The coating sets hard in cold but its resistance to corrosive liquids is greatly enhanced if the film is heated gently. It resists most acids except nitric and sulphuric and dilute alkalies. It is attacked by mineral and vegetable oils with some swelling, and also by aromatic hydrocarbons, ketones and esters.

Varnishes made by combination of phenolic resins and unsaturated vegetable oils can be used either clear or pigmented as surface hardener for concrete. Tung, linseed and dehydrated castor oils are most commonly used. A good alkali resistant concrete coating is para-phenyl phenol tung oil combination.

The phenolic coatings may be applied by brush, roller or spray. They are not very tough but abrasion resistance is fair and resistance to impact is good. Phenolic coatings resist ordinary temperatures but become brittle at elevated temperatures.

Alkyd Resins

Alkyd resins are of low cost and very resistant to deterioration. Concrete must be aged or specially treated before applying the alkyd resins. Some of these resins are resistant to weak acids while special alkyds offer resistance to alkalies.

Alkyd resin coatings are mixtures of drying oils and cure by oxidation. These coatings may be pigmented, if desired, and are noted for their good colour retention, toughness adhesion, flexibility, ease of application and retention of good appearance even on long outdoor exposure.

Silicone Acrylic Copolymer

The surface hardeners based on these resins possess excellent resistance to heat, sunlight and water and are good wear resistant. They have only fair chemical resistance and should not be used where strong acids and solvents come in contact with the floor.

Fleximer Compounds

These proprietary compounds are of two types; the more common one consists essentially of specially compounded rubber latex and either high alumina or blended hydraulic cement with suitable fillers. It is characterised by strong bonding and surface sealing qualities and resists abrasion and corrosion by dilute acids as well as alkalies.

In the second type, plasticized synthetic resin emulsion is used instead of rubber latex and confers resistance to abrasion and to corrosion by chemicals, oils, fats and solvents. This compound, if based upon PVA emulsion, must be modified for water resistance and used under dry conditions as far as possible. A vapour proof barrier is required in the floor.

Bituminous Seal

A priming or tack coat is first applied to the concrete surface to ensure bond for the subsequent protective coatings of bitumen. The primer should be cut-back bitumen of such a concentration that it can be applied cold. Aggregate should not be scattered over this primer, and even in warm weather the drying period should be at least one day. A film of bitumen emulsion is then uniformly applied and immediately covered with clean 3 mm grit or coarse washed sand before the emulsion turns black. The grit or sand is uniformly distributed and is then lightly broomed and rolled.

Some hours later the excess aggregate is carefully swept off and a second coat of emulsion is applied in the same way. This is covered with grit or sand but excess material is left on the surface for a day or two after rolling. Grit or sand is then allowed to be worked as much as possible into the bitumen by subsequent traffic. The excess material is then swept off. A thin uncovered continuous film of slow-breaking bituminous emulsion, applied just after the fresh concrete has hardened, may serve as a curing medium as well as the subsequent priming coat in certain cases.

Bituminous coatings do not resist nitric acid, fruits juices, oils, fats, blood, grease and other organic solvents, particularly at temperatures above 60°C.

Surface treatments described above should be judiciously selected for particular hazards. The selection of one or more of these treatments will be governed by satisfactory performance under specific working conditions and by cost. All types of surface hardeners and coatings need periodical renewals. Increased cost with some of the treatments is often justified under certain difficult conditions.

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