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USE OF EPOXY COMPOUNDS WITH CONCRETE

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Epoxy compounds have found a wide variety of uses in the concrete industry as coatings, grouts, binders, sealants, bonding agents, patching materials, and general adhesives.

Properties, uses, preparations, mixtures, application, and handling requirements of epoxy resin systems when applied to and used with concrete and mortar are presented. The adhesiveness of epoxy and its chemical, thermal, and physical properties are given. The modification of the foregoing properties to accommodate given situations is reviewed.

Problems encountered in surface preparation are reviewed and procedures and techniques given to insure successful bonding of the epoxy to the other materials. Temperature conditioning of the base material and epoxy compound are outlined. The cleaning and maintaining of equipment is reviewed. Procedures to be followed in the application of epoxy compounds in the several use situations are given. The important factors which insure that the epoxy compound will harden (cure) and therefore perform its function are discussed together with alterations of the hardening rate. The allergenic and toxic nature of epoxies and the chemicals used with them in the industry create a hazard and precautions are detailed throughout the report.

Keywords: abrasion resistant coatings; abrasive blasting; acid treatment (concrete); adhesion; adhesives; aggregates; bonding; bridge decks; **chemical analysis;** chemical attack; cleaning coatings: compressive strength; concrete construction; concrete finishes (hardened concrete); concrete pavements; concretes; cracking (fracturing); electrical properties; **epoxy resins;** flexural strength; floor toppings; fresh concretes; grout; grouting; history; joints (junctions); metals; mix proportioning; mixing; mortars (material); patching; **plastics; polymers and resins;** popouts; repair; resurfacing; shrinkage; skid resistance; stairways; **temperature;** tensile strength; underwater construction; waterproof coating; wood.

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CHAPTER 1 -- INTRODUCTION

1.1 -- Background

1.1.1 -- There are many characteristics of epoxies and their uses which make them a desirable adhesive for use with concrete. Some of these advantages are:

1.1.1.1 *Adhesion* -- Epoxy resins have excellent adhesive qualities and will bond to nearly all construction materials. A few of the nonpolar thermoplastics such as polyethylene, present adhesion problems and are exceptions.

1.1.1.2 *Versatility* -- The wide range of available physical and chemical properties of epoxy resin systems makes their consideration requisite in any situation involving repair, overlay, coating, or adverse environment, of concrete. The variety of curing agents, extenders, diluents, fillers and other modifiers available to the formulator permit the attainment of special characteristics for any particular application.

1.1.1.3 *Chemical resistance* -- Epoxies are resistant to the attack of acids, oils, alkalies, and solvents.

1.1.1.4 *Low shrinkage* -- Compared to other thermosetting resins, epoxies have low autogenous shrinkage. Formulations are available in which effective linear shrinkage is as low as 0.001 percent.

1.1.1.5 *Rapid hardening* -- At normal ambient temperatures it is possible for a mixed resin and hardener system to go from a liquid to a solid state in a matter of several minutes, or the time can be extended several hours by changing the system.

1.1.1.6 *Moisture resistance* -- A thin coating of an appropriate epoxy system can provide a high degree of impermeability even when continuously inundated in water. Some, though not all, epoxy materials absorb significant amounts of water in a moist environment. Select and use epoxy products (adhesives, coatings, mortars) that have low water absorption. Water absorption will not be a problem if the material has less than 1 percent absorption as measured by ASTM D 570 and specified by ASTM C 881.

1.1.2 -- The benefits of using epoxy resins are noteworthy but caution must also be exercised. The following discussion briefly summarizes some of the precautions necessary:

1.1.2.1 *Strain compatibility*

1.1.2.1.1 Epoxy bonds very rapidly to a concrete surface and within a short time may be considered as monolithic. The autogenous shrinkage strains which take place in some epoxy formulations during curing can cause severe strains at the bond line and when combined with

antly to delamination,

generally by failure in the top ¼ in. (6 mm) of concrete interface.

1.1.2.1.2 There is a wide difference in the coefficients of thermal expansion between concrete and the cured epoxy. Even normal temperature variations can be the cause of delamination. Filling the epoxy system with fillers such as silica reduces the difference in thermal expansion in proportion to the amount used. The use of a flexible epoxy compound will allow the system to adjust for the difference in thermal coefficient of expansion.

1.1.2.2 *Thermosetting plastic* -- The components which make up the epoxy system must be mixed thoroughly and close control of temperature must be exercised before and during mixing and curing. Selection of the epoxy formulation that will cure at a given substrate temperature is crucial to the cure. All epoxies will not cure on cold substrates. Proper selection is the best solution. ASTM C 881 specifies three temperature cure classes. Once cured the epoxy will not melt. However, many systems lose some of their elasticity at higher temperatures and become cheesy since their mechanical properties change significantly beyond their heat deflection temperature (HDT). The HDT is different for each formulation but for those systems used in construction, it generally ranges from 60 to 160 F (15 to 71 C).

1.1.2.3 *Slabs on grade* -- Slabs on grade can present unique bonding problems if there is moisture present in or under the slab during application and cure of an epoxy (or any other impervious polymer) material on the slab. Rising moisture in the slab caused by capillary action can exert forces on the epoxy material that will prevent an adequate bond from being achieved. Even if moisture is not present during application and cure these same forces can subsequently cause loss of a bond that was weak because of other factors such as inadequate surface preparation.

1.1.2.4 *Safety* -- Epoxy compounds are allergenic and safe handling practices must be exercised in each instance. Solvents used on the job to clean epoxied equipment often require more caution than the epoxy. Previous experience dictates that the user be thoroughly familiar with the information contained in Chapter 9, Handling Precautions.

1.1.3 -- The foregoing cautions can be satisfied by using the appropriate epoxy system, selected on the basis of a carefully prepared listing and evaluation of all job and application restrictions (those which bear on handling are noted in Chapter 9) and requirements involved. Epoxies have very selective properties and it is unwise to rely on a general specification or general performance criteria.

1.2 -- General

1.2.1 *Recommended references* -- The documents of the various standards producing organizations referred to in this document are listed below with their serial designation.

224.1R Causes, Evaluation, and Repair of Cracks in Concrete Structures
503.1 Standard Specification for Bonding Hardened Concrete, Steel, Wood, Brick, and Other Materials to Hardened Concrete with a Multi-Component Epoxy Adhesive
503.2 Standard Specification for Bonding Plastic Concrete to Hardened Concrete with a Multi-Component Epoxy Adhesive
503.3 Standard Specification for Producing a Skid-Resistant Surface on Concrete by the Use of a Multi-Component Epoxy System
503.4 Standard Specification for Repairing Concrete with Epoxy Mortars
504R Guide to Joint Sealants for Concrete Structures
515.1R A Guide to the Use of Waterproofing, Dampproofing, Protective, and Decorative Barrier Systems for Concrete

ASTM
C881 Specification for Epoxy-Resin-Base Bonding Systems for Concrete
C884 Test Method for Thermal Compatibility Between Concrete and an Epoxy-Resin Overlay
D 570 Test Method for Water Absorption of Plastics
D 648 Test Method for Deflection Temperature of Plastics Under Flexible Load (1820 kPa/264 psi)

ANSI
Z 129.1 Precautionary Labeling of Hazardous Industrial Chemicals
K 68.1 Guide for Classifying and Labeling Epoxy Products According to their Hazardous Potentialities

Code of Federal Regulations
16 CFR 1500 Hazardous Substances and Articles; Administration and Enforcement Regulations
29 CFR 1910 Occupational Safety and Health Standards
49 CFR Transportation

The preceding publications may be obtained from the following organizations:

American Concrete Institute
P.O. Box 19150
Detroit, MI 48219-0150

ASTM
1916 Race Street
Philadelphia, PA 19103

American National Standards, Inc.
1430 Broadway