

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.

ACI Committee Reports, Guides, Standard Practices, and Commentaries are intended for guidance in designing, planning, executing, or inspecting construction and in preparing specifications. References to these documents shall not be made in the Project Documents. If items found in these documents are desired to be a part of the Project Documents, they should be phrased in mandatory language and incorporated into the Project Documents.

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 thermal strains contribute significantly 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.

American Concrete Institute

- 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, Damp-proofing, 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
New York, NY 10018



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1.2.2 -- This report is based on those known and most accepted field practices for the use of epoxy resins with concrete. It provides the user with an adequate guide for successful application and performance of epoxy resins to the extent of its coverage. However, the epoxy supplier should always be consulted concerning each new variable introduced by the user.

1.3 -- Scope

1.3.1 -- The rapid growth of the use of epoxy compounds in the concrete industry and the proliferation of available epoxy systems emphasizes the need of this committee report. The wide range of epoxies which can be used as adhesives on, in, or with concrete limits the detail which can be given herein. The result is an often brief coverage of any particular topic with constant referral of the user to the formulator for details of application and performance. Nevertheless, those problems which are generally encountered in the use of epoxies with concrete are noted and their solutions presented.

1.3.2 -- Emphasis is given to the preparation of surfaces to receive epoxy adhesive, details of compound preparation, use and application, with notes concerning rate of hardening of compound, and cautions to be exercised when using any epoxy. Ranges of physical properties are noted as well as possible uses of the material.

CHAPTER 2 -- HISTORY OF EPOXIES

2.1 -- Origin of epoxies

2.1.1 General -- The word "epoxy" is of Greek derivation. The Greek word "epi," which means "on the outside of," was combined with the word "oxygen" which describes the presence of the oxygen atom in the molecular structure. In short, the word is a Greek description of the chemical symbol for the family of epoxies (see Fig. 2.1).

2.1.2 Discovery of epoxy applications -- The first practical application of epoxy resin took place in Germany and Switzerland in the 1930s with concurrent experiments being conducted in the United States, although the basic chemistry had been known for several decades. The first known patent on epoxy was issued to Dr. Pierre Castan in Switzerland in 1936. Three years later, Dr. S.O. Greenlee of the United States explored and developed several basic epoxy systems, many of which we use today as adhesives and coatings.

2.2 -- Early attempts at using epoxies

2.2.1 General -- Limited production of epoxy resins started in the late 1940s and commercially produced epoxy resin adhesives became available in the early 1950s. Initial laboratory tests using epoxies on concrete also began in the late 1940s and were directed toward

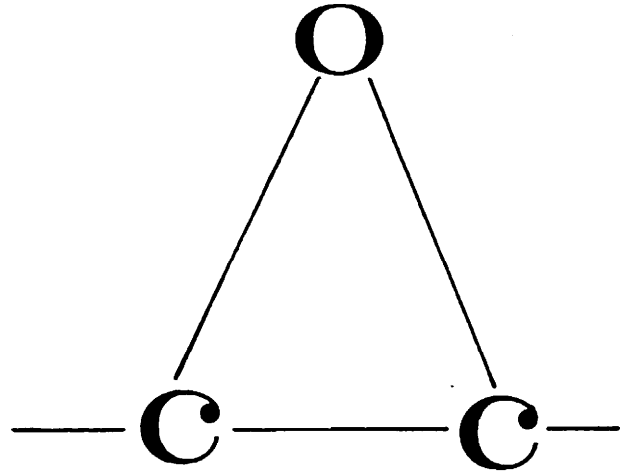


Fig. 2.1 -- Chemical symbol for the family of epoxies

their use as coatings on floors and highways. Developments were limited to the laboratory until about 1953, as engineers and scientists attempted to identify the basic physical properties and probe potential uses of epoxy systems.

2.2.2 Early field tests for bonding

2.2.2.1 First interest in the use of epoxy as an adhesive in the construction industry was in 1948 when it was used as a bond for two pieces of hardened concrete. Epoxy proved to be a satisfactory structural adhesive with the capability of being stronger than the concrete it bonded together.

2.2.2.2 In 1954 the California Highway Department became interested in epoxies as a bonding agent for raised traffic line markers on concrete highways. The successful utilization of an epoxy as a bonding agent encouraged the extension of research into the field of structural repair of concrete, and the eventual application of an epoxy-polysulfide polymer, as a bonding material for joining new concrete to old.

2.2.3 Early field tests for surfacing materials -- In 1953 the Shell Chemical Corp. initiated field tests to evaluate epoxy systems as surfacing materials on highways, following successful laboratory tests by the company. Favorable results encouraged the pursuit of this as a solution to an age-old problem of restoration of deteriorated concrete surfaces.

2.3 -- Development of epoxy applications with concrete

2.3.1 General -- Epoxy formulations developed until there were available systems with a combination of properties which made them uniquely suited for use as an adhesive with concrete. They had high bond strength, characteristics similar to other structural materials when cured and long-term resistance to aggressive environments, with easy application characteristics and low shrinkage during cure. These properties led to many different applications, some of which are discussed below.

2.3.2 Epoxy for bonding -- The ability of epoxy to

bond two pieces of concrete generated interest in the possibility of bonding fresh concrete to existing concrete. Experiments with the latter situation met with limited success until the development of epoxy resin-polysulfide systems. Since that time efforts with these and other recently developed adhesive systems have extended their desirable properties and their general acceptance by the concrete industry until they are now widely used.

2.3.3 Epoxy for grouting

2.3.3.1 Epoxy injection systems -- Epoxy injection as a means of performing structural grouting and repair was first used in the late 1950s. The approach was to premix the epoxy and then pump the mixed epoxy system. The injection of epoxy into structural cracks permitted for the first time a positive technique for the restoration of the structural integrity of cracked concrete. In 1960 a system was developed utilizing pressure injection with a mixing head at the nozzle of the injection gun which expanded the applications of epoxy as a grouting adhesive in structural concrete.

2.3.3.2 Epoxy bolt grout -- The use of epoxy as a grout to bond bolts or dowels to hardened concrete was first attempted in the late 1950s. This application came about from the need to grout bolts in existing concrete slabs for mounting heavy machinery. Concurrently, epoxy grout was used to bond dowels into the ends of existing concrete slabs as a shear transfer mechanism for extension of existing slabs.

The use of an epoxy grout which could attain high early strength and which would not shrink significantly during curing solved an old problem for manufacturing plants, that of rapid installation of new equipment with minimum delay until full operation.

Epoxy grout has also been successfully used for installation of handrails, architectural metals, precast concrete panels, structural members (both concrete and steel), concrete railroad ties, and for numerous other applications.

2.3.4 Epoxy coating materials

2.3.4.1 Epoxy seal coat

2.3.4.1.1 Epoxy seal coating was first applied as test patches in industrial plants along the eastern coast in 1953 and on highways in 1954. Although there were varying degrees of success and failure with these applications, the initial results were encouraging to many observers. Large scale experimental applications were attempted in 1956 on the Wilbur Cross Parkway, the Triborough Bridge and the George Washington Bridge. The apparent success of these latter applications led to more elaborate testing all across the United States by 1958. Tests at that time were conducted primarily with coal tar epoxies applied as seal coats and then given a skid-resistant surface by broadcasting fine sand or emery aggregate across the surface. This procedure, while successful in many respects, was not as utopian as had been hoped. Then in 1962 a thin topping of asphaltic concrete on top of a coal tar epoxy seal coat was tried as an alternative solution on a bridge in New York City which moved quite successful.

The method has since been extended using other epoxy systems.

2.3.4.1.2 Seal coats using epoxies of low viscosity have also been successfully applied on highway, industrial and commercial surfaces.

2.3.4.2 Epoxy polymer concrete as a wearing course -- Epoxy polymer concrete was first used as a wearing course in the repair of popouts and spalled areas on the surfaces of various concrete bridge decks in California in 1957, on the San Francisco-Oakland Bay Bridge, and in industrial plants and warehouses. The epoxy polymer concrete consisted primarily of the epoxy resin system and clean, dry well-graded sand. By 1963, several bridges in various parts of the United States had been successfully resurfaced with epoxy polymer concrete.

2.2.4.3 Epoxy resin specifications -- The U.S. Army Corps of Engineers published the first Federal specification for an epoxy resin system in 1959 and ASTM specification C 881 was first published in 1978. The use of the epoxy systems has since expanded in many directions, because of requirements for solution of coating, patching and resurfacing problems.

2.4 -- Present status of epoxies

2.4.1 Epoxies are presently used with concrete in the form of coatings, repair materials, grouts, bonding agents, paints, adhesives, epoxy mortars and polymer concrete, seal coats, penetrating sealers, wearing surfaces, and as admixtures to portland cement concrete to make epoxy polymer modified concrete. Thus, the appeal for epoxies has been enhanced, both from an economy and performance standpoint.

CHAPTER 3 -- CHEMICAL AND PHYSICAL CHARACTERISTICS OF EPOXY RESINS

3.1 -- General

Epoxy compounds are generally formulated in two or more parts. Part A is most often the portion containing the epoxy resin and Part B is its hardener system. Almost without exception, epoxy systems must be formulated to make them suitable for specific end uses.

3.2 -- Adhesion properties

3.2.1 General -- Epoxies bond well (Fig. 3.1) to almost every material providing that an appropriate surface preparation has been given (see Chapter 5). Because the quality and surface condition of concrete is rarely completely known, tests for adhesion are advised (see Appendix A). There are many reasons why epoxies make good adhesives including, but not limited to, the following:

- They can be in liquid form and yet contain no volatile solvent
- They adhere to most materials used in construction
- No by-products are generated during curing
- Curing shrinkage is low

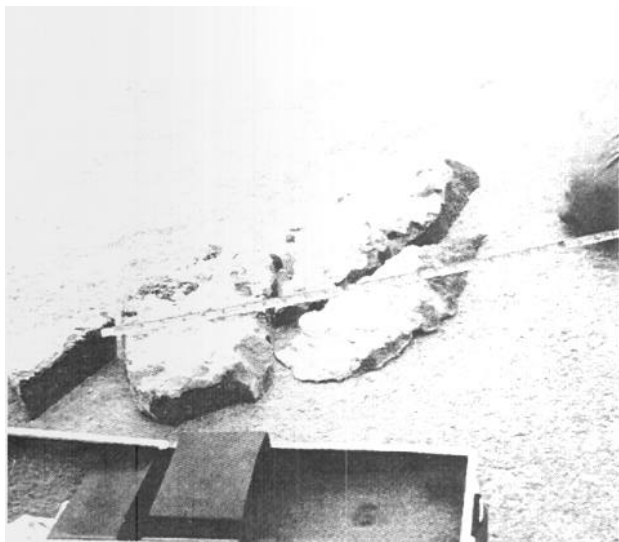


Fig. 3.1 -- Epoxy adhesive when properly applied can form a bond with greater strength than the concrete to which it is applied, as shown here (courtesy L. Mitchell, Consulting Engineer)

- e) Long time dimensional stability is good
- f) They have high tensile and compressive strengths
- g) Appropriate formulations are resistant to the action of weathering, moisture, acids, alkalis and most other environmental factors

3.2.2 Mechanical property comparisons of epoxies and concrete

3.2.2.1 Physical properties -- In Table 3.1 epoxy strengths and tensile elongation are the values at time of rupture. However, even highly elongating epoxy binders may have negligible stretch when heavily filled.

Table 3.1 -- Comparative mechanical properties of epoxy system and concrete

	Flexural strength psi (MPa)	Tensile strength psi (MPa)	Compressive strength psi (MPa)	Tensile elongation percent
Structural concrete (typical)	500-1000 (3.4-6.9)	300-700 (2.1-4.8)	3000-10,000 (20.7-68.9)	0.01
Epoxy compounds (typical)	1500-5000 (10.3-34.1)	500-7000 (3.4-48.9)	500-12,000 (3.4-82.7)	0.2 to 150

3.2.2.2 Temperature effects -- Epoxy resins react upon combination to form a thermosetting plastic which thereafter does not melt. The properties of a cured epoxy system generally change very little with temperatures well below the Heat Deflection Temperature (HDT) as measured by ASTM D 648. Beginning in the region about 18 F (10 C) below the HDT rigidity, creep resistance and chemical resistance are adversely affected as temperature is increased. Above 572 F (300 C) most resins will char and generally volatilize. The resulting fumes may be

toxic.

3.3 -- Susceptibility to chemical attack

3.3.1 -- Epoxies are considered as generally resistant to chemical attack. A general comparison with concrete is given in Table 3.2.

Table 3.2 -- Chemical properties of epoxy and concrete

	Epoxy	Concrete
Wet-dry cycling	Excellent	Excellent
Chloride deicing salts	Excellent	Fair
Muriatic acid (15 percent HCl)	Excellent	Poor
Foods acids (dilute)	Good	Poor
sugar solutions	Excellent	Fair
Gasoline	Excellent	Excellent
Oil	Excellent	Excellent
Detergent cleaning solutions	Excellent	Excellent
Alkalies	Excellent	Good
Sulfates	Excellent	Fair

Epoxy systems used to protect concrete from the effects of food spillage must be compounded for specific end uses. For example, a system resistant to acetic acid may not be resistant to all concentrations of acetic acid. This is because many organic acids have vapor pressures lower than water and, therefore, as spillage evaporates, the acid solution becomes more concentrated. Another note of caution relative to potential failures is that chemical resistance tests are often run at 77 F (25 C) whereas spillage may be much hotter. Food acid absorption by epoxy resins is a function of temperature. Acid absorption at 150 F (66.5 C) may be up to 100 times the absorption at 77 F (25 C). Furthermore, vegetable acid spillage usually contains plant sugars which form a series of organic acids when bio-oxidized. These acids, usually present in small amounts, also may become more concentrated as evaporation of spillage progresses. Therefore, proper selection of the epoxy formulation is important to the success of the substrate protection. Follow the recommendations of the epoxy manufacturer. A typical installation is shown in Fig. 3.2.

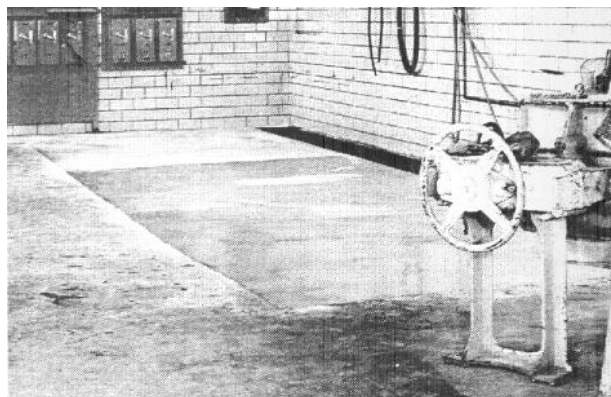


Fig. 3.2 -- Epoxy mortar floor typical in a food processing plant (courtesy Protex Industries)

3.3.2 -- Epoxies are widely used for industrial applications where chemical spillages are the normal environmental condition. Consult with the epoxy manufacturer to determine which formula should be considered.

3.4 -- Electrical properties

3.4.1 -- Epoxies are excellent electrical insulators.

3.4.2 -- Special techniques must be employed to enable an epoxy formulation to be a conductor or partial conductor of electricity. There are places where this is necessary, such as operating room floor surfacings in hospitals, clean rooms and manufacturing areas where static discharge cannot be tolerated. The reader is referred to the instructions from manufacturers specializing in such applications.

3.5 -- Abrasion resistance

3.5.1 -- Epoxies can be formulated to withstand severe abrasion, but conditions of use have to be understood before the best selection of materials can be made. For example, will the surface be dry or wet? Hot or cold? Will abrasion be from rubber wheels, steel wheels, water-borne rocks, etc.? For specific end uses, the epoxy compound manufacturer should be consulted and given a full description of service environmental conditions.

3.6 -- Resilience

3.6.1 -- Epoxies can undergo deformation, and yet recover and return to their original shape providing that their elastic limit has not been exceeded.

3.7 -- Creep

The amount of creep which will occur depends not only on the load but also on how close the service temperature is to the Heat Deflection Temperature (HDT), the amount of inorganic filler in the system, and the degree of confinement of the epoxy system as it is loaded.

3.8 -- Thermal expansion

3.8.1 -- A major difference between epoxy compounds and concrete lies in their coefficients of thermal expansion (see Fig. 3.6).

3.8.2 -- Steel and concrete usually have similar thermal expansions. Combined as reinforced concrete, the difference in their coefficients of thermal expansion does not usually become a problem either in design or use. On the other hand the considerable difference in coefficient of thermal expansion between epoxies and portland cement concrete does require careful consideration.

3.8.3 -- Consider the factors indicated in Fig. 3.3 where (a) is a slab of concrete surfaced with an epoxy (b). Due to the difference in coefficients of thermal expansion as the temperature rises (b) will attempt to grow larger than (a) and, if the concrete were as elastic as the epoxy, the result would be as shown in Fig. 3.4, obviously exaggerated. Conversely, if the temperature drops, (b) will shrink more than (a) and will produce the deformation

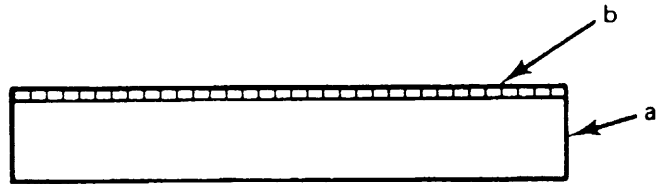


Fig. 3.3 -- A layer of epoxy (b) adhered to a thickness of concrete (a)

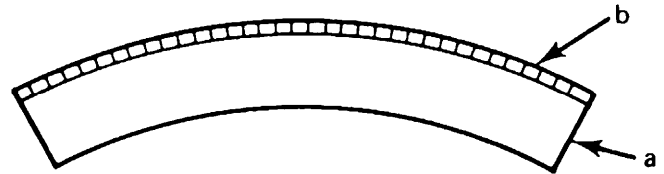


Fig. 3.4 -- The effect of temperature increase in an epoxy-concrete system

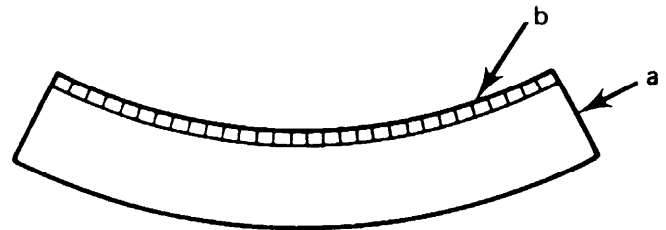


Fig. 3.5 -- Effect of temperature decrease in an epoxy-concrete system

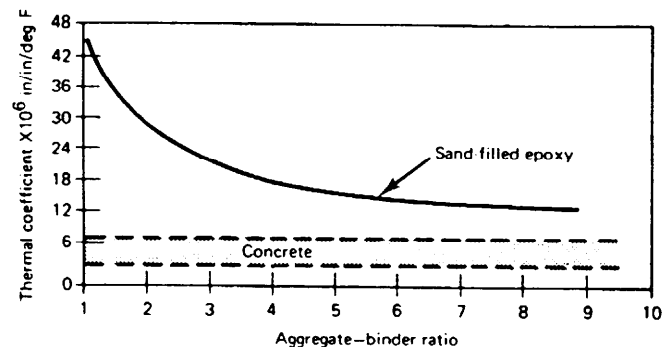


Fig. 3.6 -- The effect of changes in the sand aggregate-binder ratio on the thermal coefficient of an epoxy system

shown in Fig. 3.5.

3.8.4 -- The higher elastic modulus of concrete tends to restrain the movement of the epoxy, thereby causing severe stresses at the interface upon temperature changes. Epoxies yield under stress, and, if properly formulated, they will accommodate relatively larger dimensional changes resulting from thermal effects. Also, the coefficient of thermal expansion of the epoxy can be reduced by the addition of fillers, see Fig. 3.6, with an increase in modulus of elasticity typically resulting.

3.8.5 Thermal coefficient of epoxy-aggregate systems -- The thermal coefficient of an epoxy system will be reduced as the aggregate content of the system is increased as indicated in Fig. 3.6.



Fig. 4.1 -- Application of a thin epoxy mortar floor coating in an area subject to abrasion and chemical attack (courtesy Sika Chemical Corp.)

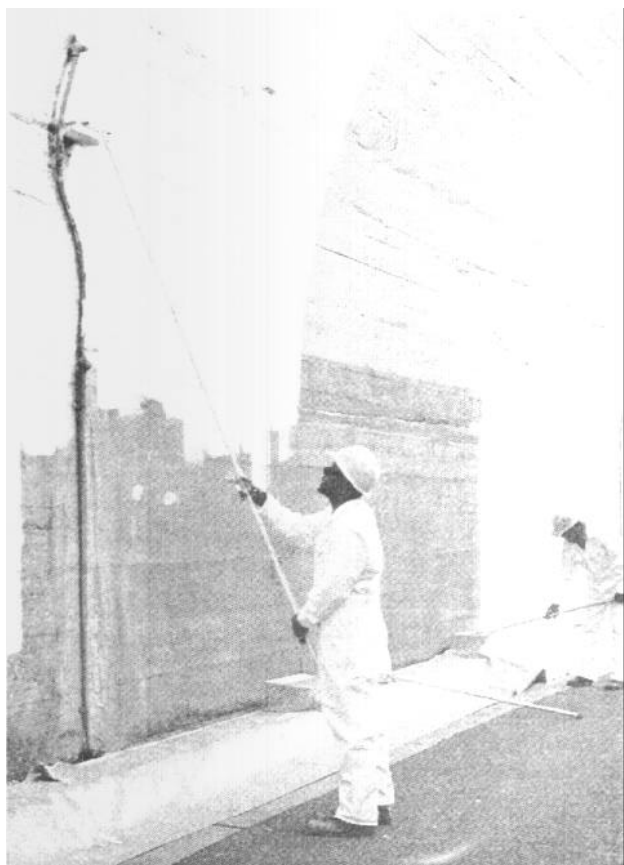


Fig. 4.2 -- An epoxy sealer and light reflector on the walls of a highway tunnel (courtesy Adhesives Engineering)

3.9 -- Exothermic reaction during cure

Epoxyes develop heat during their cure. The temperature rise will depend on mass as well as formulation. To keep this temperature rise to a minimum, it is advisable to maintain a high surface area to volume during mixing



Fig. 4.3 -- Epoxy grouting of keyways in rapid transit bridge (courtesy Adhesives Engineering)

and application, to add the maximum quantity of aggregate consistent with the intended application, or both.

3.10 -- Curing and aging stresses

Curing and aging stresses are developed in epoxies. These stresses can be minimized by correct formulation.

3.11 -- Thermosetting properties

Epoxy resins are thermosetting plastics, i.e., in the process of hardening, they undergo chemical change and cannot be reliquified by heating.

CHAPTER 4 -- USES OF EPOXY RESINS

4.1 -- General

Epoxy resins, meeting ASTM C 881 have good adherence to concrete under all conditions whether wet or dry, and have been found useful for a wide variety of applications with concrete (Fig. 4.1-4.5). For the best performance under each condition of use, the properties of the epoxy resin system should be tailored to meet the specific needs of each type of application. Thus, it is unlikely that a system consisting only of an epoxy resin and pure hardening agent will find wide utility. It is for this reason that the epoxy resin systems sold commercially are generally the products of formulators who specialize in modifying the system with flexibilizers, extenders, diluents, and fillers to meet specific end-use requirements. It logically follows that it is important to adhere to the formulator's recommendations for use.

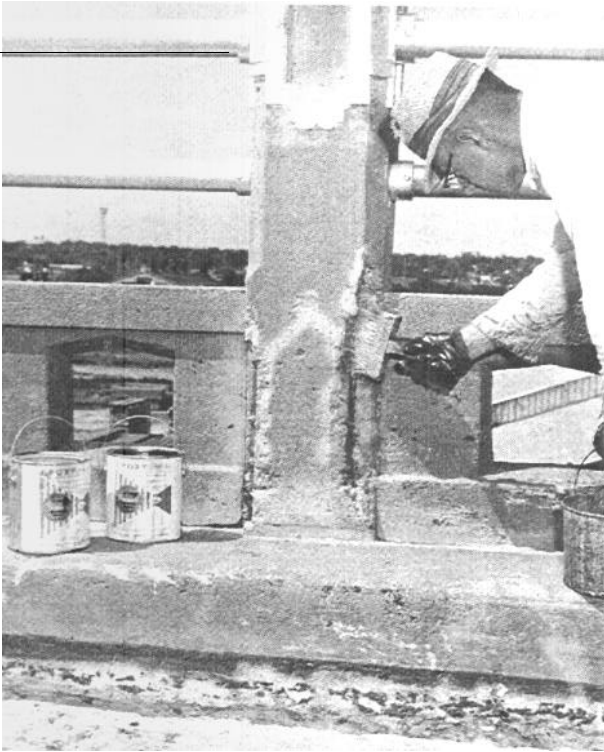


Fig. 4.4 -- Repair of a concrete bridge railing upright (courtesy Protex Industries)

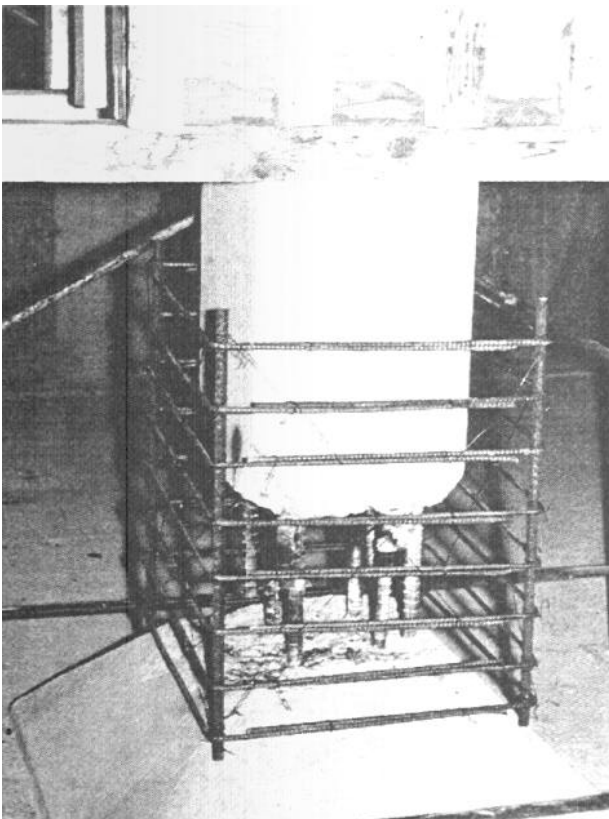
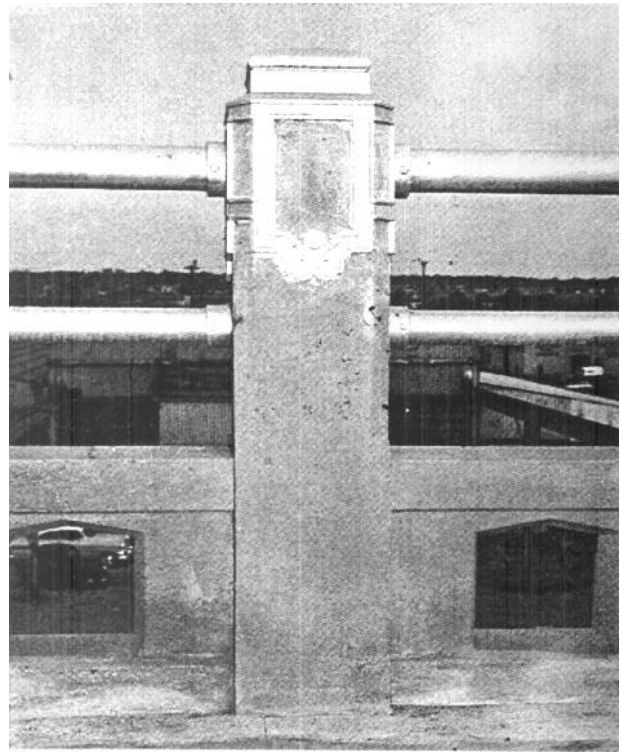


Fig. 4.5 -- Repair of a column-base connection. All exposed surfaces will be epoxy coated prior to casting new concrete (courtesy Protex Industries)

4.2 -- Protective coating

4.2.1 -- Because of their impermeability to water and their resistance to attack by most acids, alkalis, and many solvents, epoxy resin systems have been widely used as protective coatings for concrete. Such coatings may vary from sealers with thin films of 2 or 3 mil (0.05 or 0.08 mm) thickness to high-build coatings amounting to overlays. When used as a coating it is essential that the system be compounded so as to avoid or relieve excessive shrinkage and thermal stresses between the coating and concrete surface in order to prevent delamination of the coating through loss of bond or failure of the concrete.

4.2.2 -- Some of the most severe environments for the protective-coating type of applications are those of the highway bridge deck, industrial floor and parking deck surface for the purpose of preventing penetration of acid rain, chemicals, water and deicing solutions into the concrete. The coating may be used either as the wearing surface itself or may be covered by some type of asphaltic concrete overlay. In either case the coating should have mineral particles imbedded in the surface to provide adequate skid resistance for traffic when it is used as the wearing surface (see Section 4.4), and to provide bond when used beneath a bituminous overlay.

4.2.3 -- Many industrial environments involve exposure of concrete to acid, alkali, or solvents. Floors and walls located in such areas, as well as storage vats, can be made chemically resistant by the use of the epoxy resins.

4.3 -- Decorative coating

Epoxy resins serve exceptionally well as tile-like coatings; however, they surface chalk in outdoor exposure. In the case of wall surfaces, epoxy coatings present a hard, glossy surface and can withstand the abrasive and