Polymeric systems for buildings reparation
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ABSTRACT

This paper intends to present some polymeric based materials used in building reparation. It covers the systems for crack reparation, sealing of surfaces and patching. Besides polymeric grouts and mortars, latex modified concretes, and a few other polymeric - concrete systems are discussed.

INTRODUCTION

The reparation of buildings presents a tremendous challenge to the construction industry. To make such projects cost effective, the designer must make innovative use of existing products, as well as special products designed to fit into the building fabrics. New technologies are needed to simulate old materials which are no longer economically produced.

Modern technology has made available many kinds of materials for repair and maintenance of concrete. These range from low-viscosity polymers for the sealing of very fine cracks, very rapid setting cements for repairs in the presence of flowing or seeping water, special concretes for overlays, to portland cement mortar and concrete itself. The engineer will be faced with an array of potential materials to choose from, requiring a specialized knowledge for proper evaluation. A final selection will depend on many factors, such as properties during repair, mechanical response, long-term durability, cost, and prior field experience.

Some examples of materials for concrete reparation are:

- Epoxy polymers for sealing of fine cracks;
- Polymer mortar composites for sealing of large cracks and joints;
- Polymeric coatings for general sealing of surfaces;
- Polymer like epoxies, and polyesters for localized patching of surfaces;
- Fiber-reinforced concretes, latex modified concrete or polymer concrete for overlays and shotcreting.

Cracks reparation

(a) Fine cracks are successfully sealed by injection of polymeric grouts having an acceptable viscosity. After injection and curing (polymerization) such grouts are capable of forming "in situ" a hard polymeric material.

The uses of epoxy polymers and grouts can be classified broadly into:

(a) Remedial work such as strengthening and repair of existing structure (concrete crack repair, bonding concrete to concrete, bonding reinforcements).
(b) New work, where the use of adhesive was envisaged at the design stage [1].

Epoxies are selected for crack injection under pressure because of their good mechanical properties. Epoxy injection is an effective technique for repairing cracks in structural members such as walls, piers, floors, ceilings etc. The process can restore the structure to its original monolithic condition, and to a large measure, structural strength is regained. It will not however, remove the causes of cracking and this should be eliminated in order to effectively repair the crack [2].

Polyepoxides can be used as adhesives, sealants, casting resins, dipping compounds, moulding powders, paints and varnishes, powder coatings, including the matrix in reinforced composites [1].

Most commercial epoxy resin intermediates are derived from epichlorohydrin and bisphenol A. The basic process involves the reaction of epichlorohydrin and bisphenol A at 65°C in the presence of a caustic soda solution. Epoxy prepolymerms can be cross-linked either catalytically or with reactive curing agents (hardeners).

Among the first group of these reactive curing agents are Lewis acids and bases. The most important curing agents are: carboxylic acids, acid anhydrides, primary and secondary amines, dicyandiamide, amido-amines, substituted imidoazoles, ketimines, mercaptan terminated compounds, isocyanates, etc.

The physical properties of a cured epoxy resin depend upon many factors, including type and amount of curing agent, cure history, type of filler,
type of reinforcement, and other modifiers. The relationship between the cure and the resultant properties has been the object of a considerable amount of research work in the last decade [3].

Polyepoxides have proven to be very versatile materials because of a combination of properties such as:

- excellent adhesion to a wide variety of different surfaces;
- chemical stability due to ether linkages in the polymer chains;
- outstanding electrical properties;
- curing without the evolution of noxious by-products;
- curing at low or moderate temperatures;
- low shrinkage, optical clarity;
- good abrasion resistance.

Some of the properties which have made epoxy resins so suitable for cracks reparation and surface coatings have also made these resins applicable for use as adhesives. Since the formulations cure with little shrinkage, they bond well to metals, wood, glass and ceramics.

Their chemical stability prevents breaking of the bond, except under the most severe acidic conditions. Flexibility and toughness are also important when considering the properties of the epoxy polymers.

A significant increase in the use of epoxy adhesives in the civil engineering industry has taken place over the last few years [3].

Epoxy resins are a popular choice, and many proprietary formulations are commercially available. The epoxy is injected under pressure in order to penetrate the very fine and tortuous crack pattern that may exist. The success of pressure grouting depends on proper application to ensure that all cracks are sealed. Epoxy grouting can restore structural integrity as well as seal cracks against seepage. It has been used underwater or in the presence of seeping moisture with good success, but the choice of suitable materials is important [4].

Sealing the surface, with sealers like siloxanes, silanes and poly(methyl methacrylate) is applied for combating pollutants penetration through micro-cracks.

(a) Polymeric grouts based on polyurethane or polyacrylamide which seal with water are used to grout fine cracks in moist environments. In the case of polyurethane one type is a product which foams and is used as a crack sealant, the second one produces a gel similar to polyacrylamide gels. Polyacrylamide grouts contain a mixture of polyacrylamide and glyoxal in water. Similar to polyacrylamide grouts are the polyacrylate
Sealing of Surfaces

Sealants may be in the form of viscous liquids, mastics or tapes. As viscous pourable fluids they are used in horizontal joints where they fill the voids between the substrates and thus provide better adhesion than would be possible with gun-applied sealant. Mastics, which are applied by means of a gun, trowel or knife, contain thixotropic agents to control the flow of the sealant and prevent sagging and flowing out of vertical or near vertical joints. Tapes, cured or uncured, are used as bedding compounds or in glazing work.

Exterior sealants can act in either one-stage or two-stage weatherproofing cracks and joint configurations. The first one uses the seal at the exterior side of the joint, as both a rain and an air seal. Two-stage weatherproofing uses the seal at the interior face of the joint, where it acts as a seal only. Once cracks and joints are repaired, a general protective coat is both beneficial and aesthetic. In cases where little seepage is likely to occur, a general protective coating may be sufficient. Two main polymer concrete systems are used in the restoration of damaged and deteriorated concrete structures; the first one is based on latex modified mortars and the second one on a mixture of fine aggregates in a polymeric matrix, known as polymer-concrete system.

Since World War II, many of the widely used polymers have become available in the latex form. Among the elastomeric latices can be mentioned styrene-butadiene copolymer latices, polychloroprene, butyl and nitrile rubber latices. Non elastomeric latices based on poly(vinyl acetate), polyacrylics, epoxies are already in practice [3,5,6].

Latex modified concrete is produced with the same components as concrete with the addition of a polymeric latex. The polymer enters the structure of concrete providing an extra binding due to the adhesive and cohesive characteristics of the polymer.

Polymer-concrete may be considered as an aggregate filled with a polymeric matrix. The main technique in producing polymer concrete is to minimize void volume in the aggregate mass so as to reduce the quantity of the relatively expensive polymer necessary for binding the aggregate.

A wide variety of monomers, prepolymerers, and aggregates have been used to realize polymer-concrete. The list includes epoxy polymer, polyester-
styrene system, ploy(methyl methacrylate) and furane derivatives, usually in conjunction with cross-linking agents [7,8].

With polymer as the matrix, some of the drawbacks of conventional concrete which can be overcome include:

- formation of internal voids when alkaline Portland cement is used;
- on freezing, can readily crack due to water being entrapped;
- alkaline cement can be chemically attacked by acidic substances and deteriorate.

Curing times and the duration for development of a high proportion of maximum strength can be readily varied from a few minutes to hours.

A great number of macromelecular compounds are hydrophobic and provide polymer-concrete resistance to chemical attack, and can be made compact with a low amount of voids. In order to improve the bond strength between the macromelecular matrix and the aggregate, a silane coupling agent is added to the monomer before the polymerization process.

Bond strengths to substrates are usually high. In spite of high cost, polymer-concrete is particularly useful for maintenance and repairs, especially when delay and inconvenience are important. Thus the cost/benefit ratio is favourable [9].

Patching
Surface patching refers to the restoration of relatively small areas of damage to the profile of the surrounding concrete.

Besides portland cement patching mortars and concretes, latex modified mortars, epoxy, unsaturated polyesters and polyacrylic mortars are used.

Localized patching may involve filling of the holes, bolt holes, prestressing ducts, and so on.

Priming with cement mortar or a polymer bonding agent will help develop additional chemical bond between the old and the new concrete. Alternatively, the use of materials such as polymer concrete or latex-modified concrete will in themselves give a good bond.

Epoxy mortars used for patching are generally prepackaged systems based on the components, the prepolymer and the hardener that are added to a selected blend of aggregates.

Polyester patches are faster than epoxy mortars and are less sensitive to lower temperatures.
Poly(methyl methacrylate) mortars are used for patching sections that are larger or more extensive than those suitable for repair with epoxy mortars.

There are two types of initial components which may lead to the formation of poly(methyl-methacrylate) mortars for patching. Both of them contain neither water nor Portland cement. Instead, the aggregates are held together by the acrylic polymer. Besides and instead of the common methyl methacrylate, recently his oligomer (HMWM) is used. HMWM differs from methyl methacrylate (MMA) in a few important characteristics. MMA has a low flash point, produces a nontoxic but disagreeable odour, and has a short pot life. Its oligomer HMWM has a high flash point and its odour is not strong; less volatile than MMA, it will not evaporate as quickly which means the unfilled oligomer can be poured onto Portland cement concrete decks to weld cracks together, without the monomer evaporating before it has penetrated the cracks and cured. Thus, HMWM has properties which make it easier and safer to use than MMA.

A typical product kit includes:
- the monomer or the oligomer;
- an initiator to activate the polymerization process;
- a promoter to accelerate the polymerization;
- the aggregates.

The product can be used in two ways. All components of the product can be mixed and placed, or the monomer may be poured over a patch area filled with preplaced aggregate. One commercial acrylic concrete system consists of two components; liquid acrylic and a package of premixed fine aggregate, promoters, initiators, and pigments. Polymer concretes are used for patching sections that are generally larger, or more extensive than those suitable for repair with epoxy mortars.

Because the bond to aggregate is affected by water, the aggregate actually used should have a moisture content < 1%, and no water should be added to the mix. Additionally, the substrate to which it is applied should be surface dry. A range of properties such as rapid strength gain, low permeability, and good abrasion resistance is achievable by custom design of the mix [2].

REFERENCES


