Guide for the Selection of Polymer Adhesives with Concrete

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This guide provides the engineer, contractor, and architect with a description of thevarious types of polymer adhesives (epoxy, polyester, acrylic, plyurethane, polysulfide, silicone, vinyl acetate, and styrene butadiene) most frequently used for adhesive bonding of fresh concrete to cured concrete, repair of cracks in concrete, bonding concrete to other materials, and adhesive grouting of bolts and other inserts into concrete.

The guide emphasizes the factors that should be considered where selecting astructural adhesive, including characteristics during installation and in service.The benefits and limitations of adhesive bonding are discussed for each application.

Keywords: acrylic resins; adhesives; bolts; bonding; epoxy resins; fire resistance; fresh concretes; grouting; latex; loads (forces); methacrylate; plastics, polymers, and resins; polyester; polysulfide; polyurethane; repairs; sealing; serviceability; silicone resins; styrene-butadiene resins; toxicity; vinyl acetate; water-borne adhesives.

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CHAPTER 1 — GENERAL

This guide is intended to aid the engineer, contractor, and architect in choosing a proper polymer adhesive for adhesive bonding applications encountered in joining concrete members in construction, repair, and rehabilitation of concrete structures.

1.1- Organization of the Guide

Sections 2 and 3 of the guide describe the properties of the two major classes of polymer adhesives in use (solvent-free adhesives and water-borne adhesives) and identifies the distinguishing features of the specific polymers (e.g., epoxy, acrylic, and polyvinyl acetate) within each class. Section 4 lists the basic criteria that should be used in all adhesive selections. Sections 5 through 9 provide additional guidance specific to the selection of adhesives for bonding fresh or hardened concrete to hardened concrete, repairing cracked concrete, bonding other materials to concrete, and bonding inserts into concrete. Section 10 is a quick reference guide to help narrow the search for a proper adhesive.

This guide includes more data and information on epoxy adhesives than on other types because epoxy adhesives are the most versatile and by far the most widely used with concrete. Information on other types is included where there is a choice.

1.2 - Caution

The Guide presents data on the various polymer and copolymer types (epoxy, polyester, acrylic, polyurethane, silicones, vinyl acetate, and styrene-butadiene) either as typical values, as a range of values, or as relative values. Because of the ease of tailoring polymer products by formulation, some very special products within a group may possess values for a particular characteristic that differ widely from the typical value or fall outside of the range. To include all extremes would lead to a less accurate perception of the true nature of these groups of products as they are commonly used. The cited characteristics of classes of polymer adhesives are only a guide to help narrow the field in a search for an appropriate adhesive.

When using an adhesive, the manufacturer's literature should always be reviewed. Manufacturer's recommendations should be followed because the adhesive may differ from other adhesives in its class.

Many adhesives contain hazardous ingredients. Material Safety Data Sheets (MSDS) and labels should always be consulted before using the adhesive.

1.3 — Advantages/disadvantages of adhesive bonding

The major advantage of adhesive bonding is that it allows distribution of an applied load over much larger areas compared to other methods of fastening, thus reducing the unit stress on the elements that are bonded. It allows attachment without having to alter the shape or deface the elements to be attached. The adhesive bond line can also act as a moisture barrier. [1,2]

The major disadvantage of adhesive bonding is that the bonded elements cannot be disturbed after being joined, because the adhesive cures for hours or days depending on the cure rate of the adhesive used and the temperature of the elements being bonded. Thus, work progress may be slowed down if the other work tasks cannot be scheduled to accommodate the adhesive cure time.

1.4 — Glossary of terms

This glossary gives definitions of some terms which are used in adhesive bonding in the concrete industry. Other terms may be found in ASTM D 907.

Accelerator-A material that increases the rate of a chemical reaction.

Acrylic — One of a group of resins formed by polymerizing the esters or amides of acrylic acid.

Adhesives — The group of materials used to join or bond similar or dissimilar materials; for example, in concrete work, the epoxy resins.

Age hardening — The progressive change in the chemical and physical properties of an adhesive, leading to embrittlement.

Bond line — The interface between two surfaces bonded together with an adhesive.

Catalyst — A substance whose presence increases the rate of a chemical reaction. In some cases the catalyst is consumed and regenerated, in other cases the catalyst seems not to enter into the reaction, but functions by virtue of some other characteristic.

Cohesive — The type of molecular attraction that holds adhesives and other materials together.

Cohesive failure — A failure by separation within the adhesive itself, or within the substrate, rather than in the adhesive's bond to the substrate.

Copolymerization — Polymerization of two or more dissimilar monomers.

Crosslinking agent — A substance that increases the molecular weight of a polymer by chemically linking and bridging the polymer chains.

Cure— To change the properties of a chemical (usually a polymer) by increasing its molecular weight by polymerization or crosslinking, usually accomplished by the action of heat, catalyst, crosslinking agent, curing agent, or any combination, with or without pressure.

Curing agent — A substance that accelerates or participates in the curing of chemicals, sometimes referred to as a hardener.

Elastomeric— Pertaining to a substance which has rubberlike properties.

Emulsion — A two-phase liquid system in which small droplets of one liquid (the internal phase) are immiscible in, and dispersed uniformly throughout, a second continuous liquid phase (the external phase).

Epoxy resins — A class of organic chemical bonding systems used in the preparation of special coatings or adhesives for concrete or as binders in epoxy resin mortars and concretes.

Exothermic -Pertaining to a chemical reaction which occurs with the evolution of heat.

Flexibilizer — A substance that is mixed with a more brittle material to make the latter more ductile.

Gel -A colloid in which the dispersed phase has combined with the continuous phase to produce a viscous jelly-like material.

Glass transition temperature — The temperature or range of temperature at which polymeric materials change from a rigid, glass-like state to an elastomeric-like state.

Heat deflection temperature (HDT) — The temperature at which a plastic material reaches an arbitrary deflection when subjected to an arbitrary load and test condition. It can be an indication of the glass transition temperature, although these two temperatures are not necessarily equal.

Initiator — A substance that causes a chemical reaction (such as polymerization or curing) to start. The term usually applies to free-radical polymerization-type reactions.

Latex — A dispersion of organic polymer particles in water.

Minimum-film-forming temperature (MFFT) — The lowest temperature at which the polymer particles of a latex have sufficient mobility and flexibility to coalesce into a continuous film.

Monomer -An organic liquid, of relatively low molecular weight, that creates a solid polymer by reacting with itself or other compounds of low molecular weight or both.

Plasticizer — A substance added to polymer or copolymer to reduce its minimum film forming temperature and/or its glass transition temperature.

Polyester — One of a large group of synthetic resins, mainly produced by reaction of unsaturated dibasic acids with dihydroxy alcohols; commonly prepared for application by mixing with a vinyl-group monomer and free-radical catalysts at ambient temperatures and used as binders for resin mortars and concretes, fiber laminates (mainly glass), adhesives, and the like.

Polymer — The product of polymerization; more commonly a rubber or resin consisting of large molecules formed by polymerization.

Polymerization - The reaction in which two or more molecules of the same substance (monomer) combine to form a compound containing the same elements, but of high molecular weight.

Polyol - A polhydric alcohol, i.e., one containing two or more hydroxyl groups.

Polysulfide — Synthetic polymers obtained by the reaction of sodium polysulfide with organic dichlorides.

Polyurethane — Reaction product of an isocyanate with any one of a wide variety of other compounds containing an active hydrogen group; used to formulate tough, abrasion-resistant coatings.

Polyvinyl acetate — Colorless, permanently thermoplastic resin; usually supplied as an emulsion or water-dispersible powder characterized by flexibility, stability towards light, transparency to ultraviolet rays, high dielectric strength, toughness, and hardness; the higher the degree of polymerization, the higher the softening temperature; may be used in paints for concrete.

Promoter — Substances, which added in small quanities, increase the activity of catalysts, as well as increase or promote polymerization activity.

Pseudoplastic — Often referred to as thixotropic, a substance whose viscosity decreases with increasing shear.

Rheology — The science dealing with the flow of materials.

Silicone — A resin, in which the main polymer chain consists of alternating silicon and oxygen atoms, with carbon containing side groups; silicones may be used in caulking or coating compounds, admixtures for concrete, or as adhesives.

Substrate — A material upon the surface of which an adhesive is spread for the purpose of bonding.

Surface-active agent — A substance that markedly affects the interfacial or surface tension of solutions even when present in very low concentrations.

Surface energy — The interfacial free energy per unit area of the boundary between the surface of a substrate and the air above it.

Surface tension — A measure of surface energy, arising from molecular forces at the surface of a liquid, which tend to contain the volume to a minimum surface area.

Surfactant — A contraction of the term “surface-active agent".

Thermoplastic — Becoming soft when heated and hard when cooled.

Thermosetting — Becoming rigid by chemical reaction and not remeltable.

Thixotroping agents — A substance incorporated into an adhesive to impart thixotropy.

Thixotropy — The property of a material that enables it to stiffen in a short period of time on standing, but to acquire a lower viscosity on mechanical agitation, the process being reversible; a material having this property is termed thixotropic or shear thinning (see **Rheology).**

Vinyl ester - One of a group of synthetic resins produced by the reaction of acrylic with epoxy resin or Bisphenol A, and commonly prepared for application by mixing with a vinyl group monomer and free-radical catalysts at ambient temperatures, and used as binders for resin mortars and concretes, and fiber laminates (mainly glass) adhesives.

Viscosity — The property of a material which resists change in shape or arrangement of its elements during flow, and the measure thereof. Specifically the ratio of the shear stress existing between laminae of moving fluid and the rate of shear between these laminae.