REMR TECHNICAL NOTE CS-MR-7.1

GENERAL INFORMATION ON POLYMER MATERIALS

PURPOSE: To provide generic information on eight different types of polymer systems and typical applications in the maintenance and repair of concrete structures.

BACKGROUND: Polymers are chemical compounds formed by a chemical reaction in which relatively simple chemical units, called monomers, are reacted together to form larger molecules that contain repeating structural units of the original molecule. Because polymers are relatively expensive, they are often extended by the addition of other lower cost materials to form composite material such as polymer concrete (PC), polymer cement concrete (PCC), and polymer-impregnated concrete (PIC). The use of polymers in industry and in construction has increased phenomenally since 1950. This increase is due to the many desirable properties that can be built into the polymer at a relatively low overall cost.

TYPES OF POLYMERS:

a. Epoxies.

1. Typical applications.

* Bonding fresh concrete to old concrete
* Bonding old concrete to old concrete
* Bonding other materials to concrete
* Patches
* Protective coating
* Overlays
* Sealing water leakage (injection)
* Structural restoration of cracks (injection)
* Anchor grouting
* Grouting preplaced aggregate

2. Physical properties.

* Vary with formulation
* Vary with teiaperature
* Coefficient of thermal expansion greater than that of concrete

3. Advantages.

* Good adhesion
* High compressive/tensile/flexural strength
* Excellent resistance to cycles of freezing and thawing

* Good resistance to chemical attack
* Good wear resistance
* Impermeable
* Minimal shrinkage
• Excellent radiation resistance
* Some formulations are water compatible
• Viscosity can be varied
• Dimensionally stable

4. Disadvantages or limitations.

* Physical properties different from concrete
* Adversely affected by improper proportioning and lack of mixing
* Can cause allergic reaction in workers
* High exothermic reaction when used neat
* Limited thickness
* High coefficient of thermal expansion
* Physical characteristics are reduced at elevated temperature
* Higher creep than that of concrete
* Curing time dependent upon application temperature
* Some systems cannot be used in a moist environment

5. Applicable standards.

* AS@l C 881 - C 884
* ASTM D 1763
* ASTM D 2471, D 696
* ACI 503.1 to 503.4

b. Polyesters.

1. Typical applications.

* Protective coatings
* Anchoring
* Adhesive bonder or sealer
* Floor coatings
* Sealer for epoxy injection
* Binder for polymer mortar
* Binder for fiberglass
* Thin overlays

2. Physical properties.

* Vary with formulation
* Vary with temperature
* Coefficient of thermal expansion greater than that of concrete

3. Advantages.

* Good chemical resistance
* Easy to use
* Good physical properties (some formulations)
* Good wear resistance
* Resistant to staining
* Impact resistance similar to concrete
* Impermeable

4. Disadvantages or limitations.

* Higher shrinkage and expansion than that of concrete
* Relatively poor adhesive properties (some formulations)
* Hydrolysis
* High exothermic reaction
* Strong odor

5. Applicable standards.

* ASTM D 2393
* ASTM D 1338
* ASTM D 838

b. Urethanes.

1. Typical applications.

* Waterproofing
* Water control grouting (moist cured)
* Protective coating
* Insulation
* Floor coating Anchor

Note: Water activated (single component); chemically activated (two components).

2. Physical properties.

* Vary with formulation
* Vary with temperature
* Coefficient of thermal expansion greater than that of concrete

3. Advantages.

* Easy to use
* Good chemical resistance
* Good wear resistance
* Impermeable
* Minimal shrinkage
* Adequate working time

4. Disadvantages or limitations.

* Curing affected by humidity
* Sensitive to temperature differentials
* Stability questionable under certain conditions

5. Applicable standards.

* ASTM D 2393
* ASTM D 1338
* ASTM D 838
* ASTM D 695

c. Methyl-methacrylate (MMA).

1. Typical applications.

* Polymer concrete
* Patches
* Impregnation
* Overlays
* Thin toppings
* Precast elements

2. Physical properties.

* Vary with formulation
* Vary with temperature
* Low viscosity
* Coefficient of thermal expansion greater than that of concrete

3. Advantages.

* Rapid strength gain
* Good bond to dry surface
* Easy to mix
* Available as prepackaged material
* High compressive/flexural/shear/tensile strength
* Impermeable to water
* Excellent resistance to acid
* Good abrasion resistance

4. Disadvantages or limitations.

* Expensive
* Hazardous (flammable)
* Sharp pungent odor
* Moisture sensitive (aggregate or surface must be dry)
* Higher expansion or shrinkage than that of concrete

5. Applicable standard.

* None found

d. High molecular weight methacrylate (HMWA).

1. Typical applications.

* Surface sealer
* Small patches
* Crack filler
* Topping or overlay

2. Physical properties.

* Low viscosity
* Coefficient of thermal expansion greater than that of concrete
* Elastic modulus varies with formulation

3. Advantages.

Concrete sealer or crack repair

* Low viscosity
* Excellent penetration
* Easy to apply

Polymer concrete

* Excellent bond
* High compressive/flexural strength
* Rapid strength gain
* Impermeable to water
* Good acid resistance

4. Disadvantages or limitations.

* Very expensive
* Moisture sensitive
* Excessive shrinkage
* Odor

5. Applicable standard.

* None found

e. Acrylic latex.

1. Typical applications.

* Bond fresh concrete to old concrete
• Floor underlay Patches and overlays
* Cement, plaster, stucco
• Spray coat and fill coat

2. Physical properties.

- Vary according to concentration

3. Advantages.

- Improves flexural/impact/shear/tensile strength
- Good adhesion
* Ultraviolet resistance
* Water resistance
* Good resistance to cycles of freezing and thawing
* Low permeability to salt solutions
* Excellent resistance to discoloration
* Moist curing not necessary
* Chemical resistance good with some materials

4. Disadvantages or limitations.

- Short working life
- Requires special equipment for large application
- May soften under continuous moisture
- Variations on strength development will depend on dosage
- Abrasion resistance varies

5. Applicable standard.

- MIL-B-19235C

f. Styrene butadiene rubber (SBR).

1. Typical applications.

- Bond fresh concrete to old concrete
- Patches and overlays
- Areas subjected to mild chemical attack

2. Physical properties.

- Vary according to concentration

3. Advantages.

* Good adhesion
* Good chemical resistance with some materials
* Improves flexural/compressive/tensile bond strength
* Reduces permeability
* Good stability and aging characteristics
* Unaffected by addition of calcium chloride
* Requires minimal curing

4. Disadvantages or limitations.

- Short working time
- Requires special equipment for dispensing in concrete

- Placing temperature must be above 5° C
* Discolors with age
* May coagulate if subjected to high temperatures
* Not stable with most air-entraining agents
* Wet cure and air dry can give different results
* Addition rates will affect strength
* Requires special finishing skill

5. Applicable standard.

* FHWA RD78-35

g. Polyvinyl acetate (PVA).

1. Typical applications.

* Adhesive for patches or overlays
* Concrete or mortar additive
* Adhesive bond coat
* Bonding agent for plaster

Note: May be either nonreemulsifiable or reemulsifiable.

2. Physical properties.

* Vary according to concentration

3. Advantages.

* Easy to use
* Stable under sunlight
* Improved aging characteristics

4. Disadvantages or limitations.

* Must be protected before drying (some formulations)
* Reemulsifiable (some formulations)
* Poor resistance to cycles of freezing and thawing

5. Applicable standard.

* MIL-B-19235C

ENVIRONMENTAL CONSIDERATIONS: Reasonable caution should guide the preparation, use, and cleanup of polymer materials involving potentially hazardous and toxic chemical substances. Manufacturer's recommendations to protect occupational health and environmental quality should be carefully followed. Material safety data sheets should be obtained from the manufacturers of such materials. In cases where the effects of a chemical substance on occupational health or environmental quality are unknown, chemical substances should be treated as potentially hazardous toxic materials.

REFERENCES: a. American Concrete Institute. "ACI Manual of Concrete Practice," Part 5, Detroit, MI.

b. American Concrete Institute. "ACI Polymers in Concrete," ACI Committee 548, Detroit, MI.

c. Brookhaven National Laboratory. 1974 (Dec). Introductory Course on Concrete Polymer Materials, New York.