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Concrete-Polymer Materials and Polymer-Concrete Composites

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Precast mortar and concrete can be fully impregnated with monomer and polymerized in situ by either Co^{60} gamma radiation or thermal-catalytic techniques. The concrete-polymer material has been found to have substantially improved structural properties and durability compared with those of conventional concrete. The improvement in properties appears to be a function of the polymer loading. Maximum increases in strength are obtained by forming and curing the concrete, subsequently drying, evacuating, and soaking the concrete in monomer, and initiating polymerization by radiation. Increases in strength by as much as a factor of four over that of the control specimens have been obtained. Water permeability, water absorption, and chemical attack by distilled water, sulfate brines, and hydrochloric acid have been reduced to negligible values compared with severe attack observed on the control specimens. The thermoplastic monomers methyl methacrylate, styrene, and chlorostyrene are of value for normal temperature applications. Cross-linked and thermosetting monomers such as 60% styrene-40% trimethylolpropane trimethacrylate, diallyl phthalate, polyester-styrene, and epoxy-styrene impregnated in concrete allow the maintenance of strength and durability properties up to temperatures of the

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order of 150°C. Radiation treated concrete-polymer displays strength properties that are from 12% to 38% higher than in thermal catalytically treated material. Concrete-polymer significantly increases the bond strength and flexural strength of steel-reinforced and fiber-reinforced concrete. Concrete containing light-weight aggregate (foamed glass or volcanic ash) is increased in compressive strength by a factor of 40 when impregnated with polymer. There appears to be little difference between the effects of radiation and thermal treatment on the durability of concrete-polymers except that which can be attributed to polymer loading. Concrete-polymer is being considered for construction of corrosion resistant sewer pipe drain pipe, building block, railroad ties, underwater structures, and large multistage flash distillation vessels. A preliminary comparison between concrete-polymer and other materials of construction indicates reasonable economic potential for certain applications.

The broad definition of a concrete is any material which consists of a solid aggregate bound together with a bonding agent. In the case of portland cement concrete, sand and stone aggregate are bound together with hydrated calcium silicate. An aggregate may also be mixed with a monomer which is subsequently polymerized by either radiation or chemical initiators. This material, containing no hydraulic cement phase may be termed a polymer-concrete. Thus sand-polymer and soil-polymer, soil-cement-polymer and a concrete containing sewage waste and refuse as aggregate can be produced having compressive strengths equal to or greater than ordinary cement concrete

Soil-polymer may be of value as a low cost building material since it makes use of readily available material indigenous to any location. Sewage and refuse-concrete has multiple advantages of recycling and reforming a waste material thus reducing the waste disposal problem and producing a material of possible use in foundation block. The compressive strength and composition of a number of concrete-polymer and polymer-concrete composites formed by radiation techniques are given in Table 1.

Table 1

CONCRETE-POLYMER MATERIAL AND POLYMER-CONCRETE COMPOSITES

Type	Composition, wt %				Compressive strength, psi
	Water	Portland cement	Aggregate	Polymer ⁽¹⁾ loading (% of unloaded)	
Concrete-polymer (5000 psi)	7	14	33 sand 45 rock	6	20,000
High strength concrete-polymer (18,000 psi)	33	66	--	4	25,000
Soil-cement-concrete-polymer	5	10	85 Thailand soil	17	12,500
Soil-polymer	--	--	100 L.I. soil ⁽²⁾	2	6,000
Soil-polymer	--	--	100 L.I. soil ⁽²⁾	6	14,000
Sewage-cement concrete	38 ⁽⁴⁾	46	16 solids ⁽⁴⁾	--	2,200
Sewage-cement-polymer concrete (SPC)	35 ⁽⁴⁾	50	15 solids ⁽⁴⁾	38	12,000
Sewage-cement-polymer concrete	28	60	12 solids ⁽⁴⁾	24	11,300
Refuse-cement-polymer concrete	33	17	50 refuse ⁽⁴⁾	10	4,000
Sewage-refuse-cement-polymer concrete (SRPC)	18	18	54 refuse	10	-- ⁽³⁾
Lt. wt. aggregate-cement-polymer concrete	30	60	10 foamed glass	3	4,000

1) Polymethyl methacrylate

2) Long Island Soil

3) Tests incomplete

4) Content in sewage sludge (contains 70% water - 30% solids)