Experimental Investigation on Mechanical Properties of Latex Polymer Modified Concrete

Dr.N.Pannirselvam[1], Dr.K. Chandramouli[2]
[1]Associate Professor, Department of civil engineering, SRM Institute of Science and Technology, Kattankulathur, Chennai, India
[2]Professor & Head, Department of civil engineering, NRI Institute of Technology,Guntur, AndhraPradesh, India

Abstract

Experimental Investigation is carried out to evaluate the mechanical properties of latex polymer modified concrete. The work estimates for different grades of concrete such as M20, M30 and M40 with varying percentage of 5, 10, 15 and 20 of polymer. The addition of latex polymer shows the better workability in low water cement ratio in designed mix concrete and also reduces the water content in polymer concrete. The addition of polymer by 5, 10, 15 and 20% results that there is slight reduction of compressive strength in latex polymer modified concrete for various grades of concrete such as M20, M30 and M40. The mechanical properties are analyzed and the results show that the optimum percentage of addition of latex polymer is 5% in compression. There is a marginal increase for split, modulus of rupture and flexural strength.

Keywords: *Compressive strength, Flexural strength, Latex Polymer, Modulus of elasticity, Split tensile strength.*

I. INTRODUCTION

Concrete is a widely used construction material for various types of structures due to its structural stability and strength. The construction is the largest industry in the nation and encompasses projects of all scales like, highways, tall buildings, industrial projects, etc. Cement concrete is the most extensively used versatile material for the construction of large infrastructure facilities. Ordinary Portland cement is recognized as the most widely used construction material even though it has a number of limitations such as low flexural strength, susceptibility to frost damage and low resistance to chemicals these properties can be improved by using polymer modified concrete.

Modification of Portland cement mortars and concretes by addition of polymer latex, results in composites with improved engineering properties. These composites (known also as polymer modified cements or polymer cement concretes) have higher tensile and compressive strength, modulus of rupture, abrasion resistance, ductility, bond strength and reduced permeability. An important advantage of these materials is that they can be produced by conventional concrete technology, i.e. the polymer latex which is a dispersion of about 50% solid polymer particles in water is mixed with cement, aggregates and water in ordinary mixers and the fresh mix can be easily placed and compacted. The latex usually applied is specially formulated styrene-butadiene, acrylics, Polyvinylidene chloride and Polyvinyl acetate.

In practice, polymer latex-cement composites are mainly used for repair of damaged concretes and resurfacing of roads and floors, thus taking advantage only of two of their improved properties: bond strength and abrasion resistance. However, the other characteristics of these composites make them a potentially suitable building material for structural thin elements or matrix which could be compatible with various reinforcing fibres.

Principles of Polymer Modification

Although polymer-based admixtures in any form such as polymer latexes, water-soluble polymers and liquid polymers are used in cementitious composites such as mortar and concrete, it is very important that both cement hydration and polymer film formation (coalescence of polymer particles and the polymerization of resins) proceed well to yield a monolithic matrix phase with a network structure in which the cement hydrate phase and polymer interpenetrate. In polymer-modified mortar and concrete structures, aggregates are bound by a matrix phase, resulting in superior properties compared with conventional cementitious composites.

II. OBJECTIVE OF THE STUDY

1. To design for M20, M30 and M40 grade of concrete with and without polymer.
2. To study the workability of concrete.
3. To optimize the dosage of polymer.
4. To investigate the mechanical properties of concrete with and without polymer in varying percentage such as 5%, 10%, 15% and 20% in each grade of concrete.

III. EXPERIMENTAL INVESTIGATION

In the present experimental investigation properties of Latex Polymer Modified concrete has been studied. Studies have been carried out on properties like compressive strength, split tensile strength, flexural strength, modulus of rigidity and modulus of elasticity of both ordinary concrete and latex polymer modified concrete mixes with varying percentages.

a. Cement The cement used has been tested for various properties as per IS 4031-1988 and found to be conforming to various specifications of are 12239-1987. The details of physical properties of cement are given in Table 1.

Table 1 Physical Properties of Cement

Sl No.	Description	Values
1	Consistency	31%
2	Initial setting time	110 minutes
3	Final setting time	235 minutes
4	Specific gravity	3.20
5	Fineness of cement	4%
6	Compressive strength at 28 days	57.90 N/mm^2

b. Coarse aggregate The coarse aggregate is also tested for its various properties and presented in Table 2 and 3. The specific gravity and fineness modulus are found to be 2.84 and 7.63.

Table 2 Sieve Analysis for Coarse Aggregate

Sl. No.	Sieve Size(mm)	Percentage of Passing
1	40	100.00
2	20	49.34
3	12.5	5.64
4	10	0.94
5	4.75	0
6	Less than 4.75	0

Table 3 Specific Gravity and Bulk Densities for Coarse Aggregates

Sl.No.	Size of Coarse Aggregate	Specific Gravity	Bulk Density,(Kg/m^3)	
			Loose	Rodded
1.	20 mm	2.80	1426	1671

c. Fine aggregate The fine aggregate is tested for its various properties like specific gravity, fineness modulus, bulk density etc., in accordance with IS: 2386. Sieve analysis is carried out and results are shown in Table 4 and 5. The locally available river sand was used as fine aggregate in the present investigation.

Table 4 Sieve Analysis of Fine Aggregate

Sl. No.	Sieve Size (mm)	Cumulative Percentage of Passing	Remarks
1	10.0	100.00	The tested sand belongs to Zone – II category.
2	4.75	95.76	
3	2.36	89.24	
4	1.18	62.60	
5	0.600	35.94	
6	0.300	4.31	
7	0.150	0	

Table 5 Specific Gravity and Bulk Densities of Fine Aggregate

Sl. No.	Fineness Modulus	Specific Gravity	Bulk Density (Kg/m^3)	
			Loose	Rodded
1.	2.76	2.60	1598	1732

d. Latex Polymer The locally available Sika-Latex Power is used throughout the work. It is a synthetic multifunctional rubber emulsion which when added to cement mortar or concrete provides good adhesion and water resistance properties. The specific gravity of the polymer at 30ºC is 1.02 and its colour is white liquid.

e. Water Potable water is used for mixing concrete.

IV. DESIGN MIX

The concrete mix design is a process of selecting suitable ingredients for concrete and determining their properties which would produce concrete having certain minimum compressive strength, workability and durability with economically. The following mix designs were designed for M20, M30 and M40 grades of concrete was done according to IS 10262 and the final proportions achieved are given in the Table 6.

In this experimental investigation programme, the specimens were cast to determine the compressive strength, split tensile strength and modulus of elasticity.

Table 6 Mix Proportion (by weight) for M20, M30 and M40 Grade of Concrete

Grade of concrete	Cement Kg	Fine Aggregate Kg	Coarse Aggregate Kg	Water Kg	Water Cement Ratio
M 20	395.75	815.76	1266.69	186.00	0.47
M 30	502.70	609.33	1117.31	186.00	0.37
M 40	529.41	557.68	1165.83	180.00	0.34

V. RESULTS AND DISCUSSION

The data obtained from experimental investigations on the compressive strength, split tensile strength, modulus of elasticity, modulus of rupture, rapid chloride permeability test results are presented in the following sections.

a. Compressive Strength The compressive strength for M20, M30 and M40 grades with different percentage of polymers fibres for 7 days and 28 days are presented in Table 7 and 8. The variation of compressive strength is shown in Fig. 1.

Table 7 Test Results of Conventional Concrete for Different Grades

Grade of concrete	Compressive Strength, N/mm^2	
	7 Days	28 Days
M20	17.50	37.10
	18.00	37.70
	18.50	39.80
M30	23.60	35.10
	21.50	48.40
	21.60	46.40
M40	34.20	51.00
	33.90	48.90
	36.00	49.10

Table 8 Test Results of Various Grades of Concrete with various % of Polymer

Grade of concrete with polymer (%)		Workability	Compressive Strength N/mm^2	
			7 Days	28 Days
M 20	0%	65	18.00	38.20
	5%	22	24.70	38.10
	10%	25	23.36	41.17
	15%	30	21.33	37.23
	20%	35	20.60	31.87
M 30	0%	56	22.23	43.30
	5%	18	28.30	41.20
	10%	20	28.80	42.70
	15%	26	28.95	38.70
	20%	30	25.25	38.40
M 40	0%	45	34.70	49.70
	5%	16	32.60	42.20
	10%	18	31.70	40.33
	15%	20	33.20	44.07
	20%	26	32.90	36.43

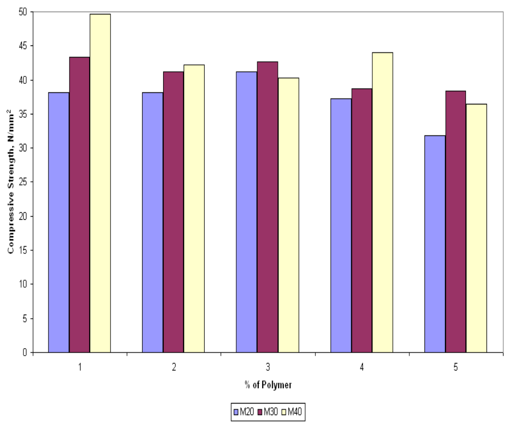

Fig.1 Compressive Strength for various Grades of Concrete with various % of Polymer

b. Split Tensile Strength The split tensile strength for M20, M30 and M40 grades with different percentage of polymers at 28 days are presented in Table 9 and Fig. 2.

c. Modulus of Rupture of Beams

The modulus of rupture of beams for M20, M30 and M40 grades with different percentage of polymers at 28 days are presented in Table 9 and Fig. 3.

d. Modulus of Elasticity

The modulus of elasticity for M20, M30 and M40 grades with different percentage of polymers at 28 days are presented in Table 9 and Fig. 4.

Table 9 Test Results of Split Tensile Strength, Flexural Strength and Modulus of Rupture for Various Grades of Concrete with Various Percentage of Polymer (28 days)

Grade of concrete with polymer (%)		Split Tensile Strength, N/mm^2	Flexural Strength, kg/mm^2	Modulus of Elasticity, x10^4 MPa
M 20	0%	0.60	1.79	3.28
	5%	0.62	2.05	3.25
	10%	0.54	1.88	2.96
	15%	0.62	1.73	2.80
	20%	0.52	1.79	2.64
M 30	0%	0.64	1.62	3.17
	5%	0.72	1.50	2.32
	10%	0.70	1.34	2.42
	15%	0.62	1.32	2.61
	20%	0.62	1.59	2.99
M 40	0%	0.88	1.57	3.83
	5%	0.90	1.54	2.55
	10%	0.88	2.37	3.41
	15%	0.80	1.75	3.34
	20%	0.62	1.59	3.54

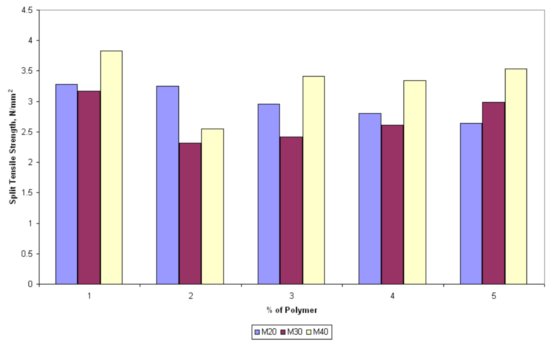

Fig.2 Split Tensile Strength for various Grades of Concrete with various % of Polymer

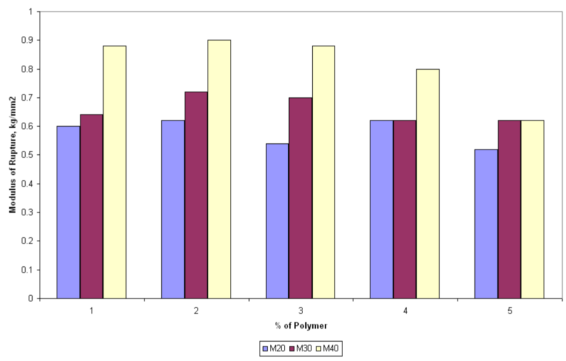

Fig.3 Flexural Strength for various Grades of Concrete with various % of Polymer

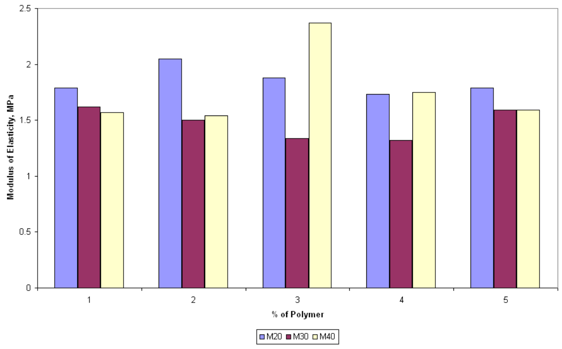

Fig.4 Modulus of Elasticity for various Grades of Concrete with various % of Polymer

V. CONCLUSION

1. In addition of latex polymer, the workability of latex polymer modified concrete is greatly improved.
2. The compressive strength is increased by 7.77% for addition of 10% in M20 grade of concrete.
3. The compressive strength decreases for 5, 15 and 20% of addition of polymer in the range of 0.26 to 16.57% at 28 days for M20, M30 and M40 grade.
4. There was a marginal increase in split tensile strength for addition of polymer when compared to conventional concrete.
5. Flexural strength and Young's modulus of latex polymer concrete is improved when compared to conventional concrete.
6. The mechanical property has been increased in 5% of addition of Polymer irrespective of their grades.

REFERENCES

[1] Abdel-Mohsen O. Mohamed and Maisa El Gamal, (2009), Hydro-Mechanical Behavior of a Newly Developed Sulfur Polymer Concrete, Cement and Concrete Composites, 31, 186–194.

[2] Adnan C, (2005), Properties of Plain and Latex Modified Portland Cement Pastes and Concretes with and without Superplasticizer, Cement and Concrete Research, 35, 1510–1521.

[3] Aggarwal. L.K., Thapliyal. P.C., Karade. S.R., (2007), Properties of polymer-Modified Mortars using Epoxy and Acrylic Emulsions, Construction and Building Materials, 21, 379–383.

[4] Atzeni. C., Cabiddu. M. G., Massidda. L. and Sanna. U., (1994), Crystallization of Sodium Sulphate in Polymer Impregnated Plasters, Cement and Concrete Composites, 17, 3-8.

[5] Bijen. J., (1990), Study on Improved Mechanical Properties of Glass Fibre Reinforced Cement by Polymer Modification, Cement & Concrete Composites, 12, 95-101.

[6] Bing Chen and Juanyu Liu, (2005), Mechanical Properties of Polymer-Modified Concretes Containing Expanded Polystyrene Beads, Construction and Building Materials, 21, 7–11.

[7] Bing Chen and Juanyu Liu, (2007), Mechanical Properties of Polymer-Modified Concretes Containing Expanded Polystyrene Beads, Construction and Building Materials, 21, 7–11.

[8] Byung-Wan, Seung-Kook Park and Jong-Chil Park, (2008), Mechanical Properties of Polymer Concrete made with Recycled Pet and Recycled Concrete Aggregates, Construction and Building Materials, 22, 2281–2291.

[9] Cheng-Hsin Chen, Huang. R., Wu. J.K., Chien-Hung Chen, (2006), Influence of Soaking and Polymerization Conditions on the Properties of Polymer Concrete, Construction and Building Materials, 20, 706–712.

[10] Dionys Van Gemert, Lech Czarnecki, Matthias Maultzsch, Harald Schorn, Anne Beeldens, Paweł Lukowski and Elke Knapen, (2005), Cement Concrete and Concrete–Polymer Composites: Two Merging Worlds, A report from 11th ICPIC Congress in Berlin, 2004, Cement & Concrete Composites, 27, 926–933.

[11] Gao. J.M, Qian, C.X, Wang, B, Morino, K, (2002), Experimental Study on Properties of Polymer Modified Cement Mortars with Silica Fume, Cement and Concrete Research, 32, 41–45.

[12] Gorninski, J.P, Dal Molin, D.C and Kazmierczak, C.S., (2007), Comparative Assessment of Isophtalic and Orthophtalic Polyester Polymer Concrete: Different Costs, Similar Mechanical Properties and Durability, Construction and Building Materials, 21, 546-555.

[13] Hassan, K.E Robery, P.C and Al-Alawi, L, (2000), Effect of Hot-Dry Curing Environment on the Intrinsic Properties of Repair Materials, Cement & Concrete Composites, 22, 453-458.

[14] Hughes. B.P.and Lubis. B., (1995), Mechanical Properties of Nano-MMT Reinforced Polymer Composite and Polymer Concrete, Cement and Concrete Composites, 18, 41-46.

[15] Jae-Ho Kim, Richard E. Robertson and Antoine E. Naaman, (1999), Structure and Properties of Poly (Vinyl Alcohol)-Modified Mortar and Concrete, Cement and Concrete Research, 29, 407–415.

[16] Joao A. Rossignolo and Marcos V.C. Agnesini, (2002), Mechanical Properties of Polymer-Modified Lightweight Aggregate Concrete, Cement and Concrete Research, 32, 329–334.

[17] Kostas Komnitsas, Dimitra Zaharaki and Vasillios Perdikatsis, (2008), Effect of Synthesis Parameters on the Compressive Strength of Low-Calcium Ferronickel Slag Inorganic Polymers, Journal of Hazardous Materials, 161, 760–768.

[18] Kostas Komnitsas, Dimitra Zaharaki and Vasillios Perdikatsis, (2009), Effect of Synthesis Parameters on the Compressive Strength of Low-Calcium Ferronickel Slag Inorganic Polymers, Journal of Hazardous Materials, 161, 760–768.

[19] Nele De Belie and Joke Monteny, (1998), Resistance of Concrete Containing Styrol Acrylic Acid Ester Latex to Acids Occurring on Floors for Livestock Housing Cement and Concrete Research, Vol. 28, No. 11, 1621–1628.

[20] Novoa, P.J.R.O. Ribeiro. M.C.S., Ferreira. A.J.M., Marques. A.T., (2004), Mechanical Characterization of Lightweight Polymer Mortar Modified with Cork Granulates" Composites Science and Technology, 64, 2197–2205.

[21] Ohama. Y. and Kan. S. (1982), Effects of Specimen Size on Strength and Drying Shrinkage of Polymer Modified Concrete, The International Journal of Cement Composites and Lightweight Concrete, Volume 4, Number 4.

[22] Reis. J.M.L., (2009), Mechanical Characterization of Polymer Mortars Exposed to Degradation Solutions Construction and Building Materials, 23, 3328–3331.

[23] Sedat Kurugo, Leyla Tanac and Halit Yasa Ersoy, (2008), Young's Modulus of Fiber-Reinforced and Polymer-Modified Lightweight Concrete Composites, Construction and Building Materials, 22, 1019–1028.

[24] Shaker. F.A., El-Dieb. A.S and Reda. M.M., (1997), Durability of Styrene-Butadiene Latex Modified Concrete, Cement and Concrete Research, Vol. 27, No. 5, 711-720.

[25] Tomas San-Jose, Inigo Vegas and Find Meyer, (2006), Structural Analysis of Fibre Reinforced Polymer Concrete Material, Cement and Concrete Composites, 18, 41-46.

[26] Walter O. Oyawa, (2005), Steel Encased Polymer Concrete under Axial Compressive Loading Analytical Formulations, Construction and Building Materials, 21, 57–65.