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Performance of Polymer Concrete Seeded with Steel Fibres and Stone Powder

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Abstract: ***This paper presents the fiber effect in the polymer concrete. The concrete is prepared with 10% Bethemcharla stone powder as replacement to cement and 10% of Bisphenol-A polymer to the concrete mixes. The fibers were incorporated to the concrete in the proportion of 0,1 and 2% by volume of specimen. The study mainly focused to evaluate compressive, split, shear and flexural strengths of concrete. Tests conducted on cube, cylinder and beam specimens and from the results it is found that, the fiber seeding to mixes enhances the strength properties. In addition to the mixes, plan cement concrete mix without stone powder and polymer is prepared and tested for the same strengths, this mix is considered as reference mix for comparison purpose. For present experimental work few mathematical models are established to assess strengths in association of cube compressive strength.***

Key words: Fibres, Bisfinol-A epoxy, Stone powder, models

I. INTRODUCTION

The discovery of Portland cement for construction industry becomes turning point in the history. Products readily utilized before the conception of Portland cement such as lime and clay, though malleable and easy to work, did not achieve a high strength when cured. Now days the research works are moving to improve the strengths of the concrete with addition of available materials such as fly ash, silica fume, rice husk ash etc. however few materials are came to lime light and some are in still under process to know the behavior after addition of those to cement concrete mix. In this way few polymers are also using to enhance the strength and durability of cement concrete. In the varieties of polymers, epoxy is one of the polymers in greater use at present days. The curing response in epoxy resin is exothermic in nature but is of small magnitude. Hence, in the preparation of epoxy based concrete, epoxy can be poured deeply in a mould, without overheating. Epoxy polymer concrete shows good bonding between concrete and metal surfaces and also shows high physical strength. Due to these qualities, epoxy can be used for different types of concrete works where heavy loads and chemical exposure are present paper

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II. REVIEW OF RECENT PAST WORKS

In this view herein recent past research works were happened on concrete with addition of polymers have been discussed in brief. Y. Ohama and K. Demura [1], Studied the strength development of polyester resin concrete under different curing conditions. The polyester resin concrete was mixed with regular mix proportions containing binders. The cured specimens were subjected to compressive strength test and the outcome showed that the optimal pre curing period before heat curing for polymer concrete is about 10 hours, water cure is applicable for resin concrete without damaging hydrolysis of polyester resin used, the compressive strength of heat cured resin concrete were high than that of water cured and dry cured concrete O. Elalaoui et al. [2], carried out an investigational program on mechanical and physical properties of epoxy. The compressive strengths for epoxy concrete with 0.4 mm of aggregates were found to be 60 ± 9MPa and the values of flexural strengths for same mixes is 17.57 MPa. It has been declared by the author that the above mechanical properties were attained by the use of 24% epoxy resin. The average particle size of Fine, medium and coarse silica powder is of 50 to 60µm, 600µm and 1100µm, respectively, had been used as filler in the making of epoxy polymer concrete. Dolomite is used as filler; the particle size of dolomite is less than 4.75 mm. The compressive strength of resulting epoxy concrete was quite high (128.9 MPa) compared to reference concrete (32.5 MPa). Golestaneh et al.[4] conducted experimentations on epoxy polymer concrete and the author predicted that the high compactness of the aggregate and filler in the mixture was most likely the reason for such a high value for epoxy polymer concrete. The maximum value for flexural strength is noted as 22.5 MPa. Haidar et al.[5] studied about the epoxy resin with reinforcement, coarse and fine aggregate named as micro polymer concrete (MPC). It observed that the MPC concrete designed with a polymer content of 9% showed the maximum physical and mechanical properties such as strengths and rigidity. Also for the formation of MPC the percentage of epoxy resin taken was slightly lower than for conventional epoxy polymer concrete.

III. OBJECTIVES

From the Vinay Babu and N.Venkata Ramana [6] paper it is observed that, the optimum dosage of polymer for stone powder concrete is 10%. Hence in continuing of the previous work, the present study is focused on to known the performance of fibers in the polymer concrete mixes. For this study total four mixes are consider.

The first mix prepared M20 concrete (1:1.59:3.01 and with water cement ratio of 0.5) without any additives and it is referred as reference mix (RM). The second, third and fourth mixes are prepared with 0, 1 and 2% of fiber dosage. For these mixes 10% Bethemcharla stone powder as partial replacement to cement and 10% Bisphenol-A (by cement content) is added mix.

The second, third and fourth mixes are nomenclature as PC0%, PC1% and PC2%. The first two letter indicated polymer concrete and third letter indicates percentage of fibers provided for the concrete. For all four mixes laboratory tests are conducted to know the compressive, split, shear and flexural strengths of corresponding mixes.

IV. MATERIALS

Cement: OPC grade 53 was used which is conforming to IS 8112:1989. The specific gravity of the cement was observed as 3.10. The initial and finial setting times noticed as 45 and 360 minutes respectively.

Fine Aggregate: Locally available fine aggregate is used, which is passing through 4.75 mm. The specific gravity of fine aggregate found to be 2.58.

Coarse-Aggregate: 20mm maximum size of coarse granite aggregate was used and the specific gravity of the aggregate is 2.75.

Fibers: 50mm length crimpled fibers were used and these fibers having diameter of 0.75mm.

Bethamcharla stone powder: It is obtained from the stone polishing industry, which is nearby Nandyal, Kurnool district, Andhra Pradesh (state).

Water: Portable water was used for the experimental work.

Bisphenol-A epoxy: Which is obtained from the company of Vruksha omposites, Valasalavakkam, Chennai.

V. CASTING AND CURING OF TEST SPECIMENS

The concrete is designed for M20 grade as per IS10261-2009 procedure and mix proportion noticed as 1:1.59:3.01. The mix provided with a water cement ratio of 0.5.The fibers are weighed separately and these were added to the concrete during mixing stage and also care has been taken to avoid balling action (figure1). The cubes, cylinders and beams are cast in the laboratory and after 24 hours the respective specimens are taken out from the corresponding moulds. Later the specimens were exposed to 7 days water curing and immediately they were exposed to dry curing for 21 days. Here it shows the specimens are subjected to both wet and dry curing. During wet state the hydration process is effective and during dry curing the polymerization is effective, this type of process has been noticed in the previous research work, hence here also same procedure adopted for curing. After curing process the specimens are tested to corresponding test so as to arrive required material strength properties. The compressive and split tensile strengths are arrived from the cube and cylinder specimens and tests are conducted according IS specifications. To obtain shear strength, the cylinder was slotted for a length of 50mm and load applied over the cylinder, from this shear stress is obtained. The shear stress is obtained from the failure load and shearing area of the cylinder specimen. To obtain flexural strength the beam was tested under third point loading. The results of the various tests have been presented in the next section along with the detailed discussion.

Fig 1: Concrete mix with fibers

VI. DISCUSSION OF TEST RESULTS

The results for various tests have been presented in the Table 1. In this table all the test results are depicted and each of test discussing below.

Compressive strength:

The compressive strengths are increasing as the fiber dosage increases for the mix. The compressive strength ranges from 38.50 to 47.74MPa for 0 to 2% fiber volume fraction. The 0, 1 and 2% fibers the compressive strengths are increased by 23.08, 46.45 and 52.62% when compared with reference concrete. Among the fiber mixes the mix with 2% fiber showed maximum value and this exhibited 4.21% compared with 1% fiber volume mix.

In the present study, cylinder compressive strength also found along with cube compressive strength. Here also same trend is following towards compressive strengths. When compared with reference mix, the 0, 1 and 2% mixes are showing 32.75, 58.40 and 66.72% higher strengths. Here also the 2% fiber mix has performed superiority than 1% and showed as 5.1% higher strength. The tested cubes and cylinders can be viewed in figure 2.

Fig 2: Cube and cylinders under compressive test

Split Tensile strength:

The split tensile strengths are evaluated for all mixes. From the results it is observed that, the mixes with 0,1 and 2% fiber dosage the strengths are increasing by 103.00,128.13 and 142.42% respectively when compared with reference mix**.** The fiber provided more split tensile strength; these fibers are act as energy absorber.

During testing, by visual observation it is stating that, the samples with fibers showed fewer cracks and intact of concrete mass was observed.. The tested cylinders under split tensile test can be seen in figure 3.

Fig 3: Tested specimens under split tension.

Shear Strength:

The shear strength is also one of the most important parameter during design of structural elements. Hence herein the text has been conducted with the help of cylinders to access direct shear strength. The shear strength is increasing as the dosage of fibers increases for the mixes. The shear strength for the steel reinforced polymer mixes are 5.30, 5.77 and 6.05MPa respectively. There is a marginal increment between the 1 and 2% of polymer mixes. The percentage of shear strength for 0,1 and 2% mixes are 21.0,31.73 and 38.12% respectively. The failed sample under shear can be notice in figure 4.

Fig 4: Direct Shear test

Flexural Strength:

This strength is important during design of elements very particularly for flexure. Most of the times the beams are subjected to flexure, if we are aware of the resistance stress, then we can judge the safety of the element. Hence here it is found the flexural strength for various mixes, which were prepared by the Epoxy polymer, Bethemcharla stone powder and steel fibers. . The mixes with 0, 1 and 2% fibers the flexural strengths are increased by 25.64, 31.83 and 39.31% respectively with compared with mix of reference mix (4.68MPa). In this section also the higher dosage of fiber mix showed superior performance than the other mixes. The testing of beam under flexure is shown in figure 5.

Fig 5: Flexural test

Regression models

In most of the structural design codes (IS, ACI, BS etc) the various strengths are correlated with cube or cylinder compressive strength. In IS 456-200 code, the strengths have been correlated with cube compressive strength. Hence here it is decided that, the cylinder compressive, split, shear and flexural strengths to make the relation with cube compressive strength. By using the statistics and with the principle of least square, models are generated and same were presented below.

$$f_{cylinder} = 0.84 f_c$$

$$f_{spilt} = 0.44 (f_c)^{0.65}$$

$$f_{Shear} = 0.86 \sqrt{f_c}$$

$$f_{flexure} = 0.87 \sqrt{f_c}$$

in the above equations

f_c indicates the 28 cube compressive strength in MPa

The performances of models are tested and the results are presented in Table 2. In same table few values are indicated in the bracket/s, those are indicate the ratio between experimental and regression model strengths of corresponding mixes with respective different strengths. From the table it is noticed that the compressive, split, shear and flexure strength ratios are varying 1.02 to 1.03, 0.99 to 1.03, 0.99 to 1.01 and 1.04 to 1.09 respectively. The models are at most varied about 9%. Hence the proposed models possess the good compatibility with the experimental results.

Table 1: Strength Tests

Sl.No	Steel fiber Percentage(%)	Compressive Stress (MPa)	Cylinder compressive stress (MPa)	Split tensile stress (MPa)	Shear stress\ (MPa)	Flexural stress (MPa)
1	RC	31.28	24.88	2.31	4.38	4.68
2	PC0%	38.50	33.03	4.69	5.30	5.84
3	PC1%	45.81	39.43	5.27	5.77	6.17
4	PC2%	47.74	41.48	5.60	6.05	6.52

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Table 2: Strength results based on model

Sl.No	Steel fiber Percentage (%)	Cylinder compressive stress (MPa)	Split tensile stress (MPa)	Shear stress (MPa)	Flexural stress (MPa)
1	PC0%	32.34(1.02)	4.72(0.99)	5.33(0.99)	5.33(1.09)
2	PC1%	38.48 1.02)	5.28(0.99)	5.82(0.99)	5.88(1.04)
3	PC2%	40.10(1.03)	5.42(1.03)	5.94(1.01)	6.01(1.08)
Note: The value in the bracket indicates the strength ratio between experimental to regression model					

VII. CONCLUSIONS

1. The stone powder polymer concrete showed good performance in mechanical properties than the conventional concrete.
2. As the incorporation of fibers dosage increases for the concrete the strengths are increased and max strengths are noticed for 2% mix.

3. Few mathematical models are generated to assess the strengths and the models are provided good compatibility with experimental results.
4. The strength increment is in the ascending order of RC, PC0%, PC1% and PC2%.
5. The addition of polymer, Bethemcharla stone powder and fibers to the conventional mix is viable.

REFERENCES

1. 1 Yoshihiko Ohama and Katsunori Demura,Relation between curing conditions and compressive strength of polyester resin concrete The International Journal of Cement Composites and Lightweight Concrete, Volume 4, pp 241-244,1982.
2. O. Elalaoui, E. Ghorbel, V. Mignot, and M. B. Ouezdou, Mechanical and physical properties of epoxy,Construction And Building Materials, Vol. 27, No. 1, pp 415–424, 2012.
3. I.-T. Roh, K.-C. Jung, S.-H. Chang, and Y.-H. Cho,Characterization of compliant polymer concretes for rapid repair of runways Construction And Building Materials, Vol. 78, pp 77– 84, 2015.
4. 4.M. Golestaneh, G. Amini, G. D. Najafpour, and M. A. Beygi,Evaluation of mechanical strength of epoxy polymer concrete with silica powder as filler,World Applied Sciences Journal, Vol. 9, pp. 216–220, 2010
5. M. Haidar, E. Ghorbel, and H. Toutanji, Optimization of the formulation of micro-polymer concretes,Construction And Building Materials , Vol. 25, No. 4, pp 1632–1644, 2011.
6. S.Vinay Babu and N.Venkata Ramana, Performance of Bisphenol-A epoxy in concrete, International conference on recent trends in engineering, applied science and humanities, Pune, 28Sep2019, pp142-147.

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