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Comparative Study on Polymer Resin Concrete

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Abstract : Polymer concrete was introduced in late 1950's and become well known in 1970's for its use in repair, thin overlays and floors, precast components. Because of it properties like high compressive strength, fast curing, high specific strength, resistance to chemical attack, polymer concrete has found application in very specialized domains. Simultaneously these materials have been used in machine construction also where the vibration damping property of polymer concrete has been exploited. Polymer mortar and concrete are related to new liquid resin such as Polyester, Epoxy as binding material with aggregates. The properties such as setting shrinkage, thermal properties, temperature dependence, lightweight are taken care in respect of light weight porous polymer mortar. This paper investigates the properties of the polymer concrete matrix with different percentages of Epoxy resin binder and light weight particulate fillers.The mixing proportion of particulate filled resin (PFR) was optimized while targeting a specific strength and workability. The content of epoxy resin was varied from 70% to100%, whereas the filler materials ranged from 0% to 30%.The tensile and compression performance of PFR was evaluated using the tensile and compressive strength tests and the most suitable mix proportion of different filler materials are determined based on the experimental results.To study and compare the characteristics of resin concrete containing different filler materials with conventional concrete.
Key words : Epoxy resin, Epoxy hardener, Mineral admixtures, Compressive strength test, Tensile strength test, Acid test.

1.0 Introduction

The most common type of concrete is comprised of three main ingredients; water, aggregate and cement, which are combined with different ratios depending on the characteristics required (Australia, Cement Concrete and Aggregates, 2015).Normal concrete is known to be weak in tensile strength, brittle and easily erodible by chemicals and high velocity water flow[1]. This is becoming an ever growing problem in today's society with the need for the least amount of maintenance and longer lasting structures. In early 1950 research into a different form of concrete was discovered, polymer concrete. Polymer concrete has increased strength characteristics, as well as improved resistance to environmental factors and a faster curing time.With such improved properties, polymer concrete became a fast growing area of research[2]. Moving forward to 2015 and polymer concrete is widely used across the world. There are many different types of polymer concrete, depending on the characteristics required. This report focuses on the development of epoxy based polymer concrete, which is a relatively new area of research and there is still much to learn about the properties and how the specimens will react under different conditions [3].The main area that hasn't been researched is the use of filler material in polymer concrete. Filler materials are being added to the polymer concrete to find if this will have an effect on the strength characteristics of the specimen. There are so many different factors effecting polymer concrete already that the use of filler materials has not been investigated, therefore there is no standard

to follow [4]. This is why it is important to carry out further research into what effect fillers have on epoxy resin polymer concrete.

2.0 Materials and Experimental Procedure

To perform this research, PRC formulations were prepared by mixing aggregate, different filler materials, hardener with thermosetting resins. The aggregate used was foundry sand, which consists in river bed sand, The filler materials are metakaolin, quartz and glass fiber,and epoxy hardener designed by 100/0, 95/5, 90/10, 85/15, 80/20, 75/25 and 70/30, with a uniform granulometry.

The epoxy resin system used is based on a diglycidyl ether bisphenol A and an aliphatic amine hardener with low viscosity (500-700 MPa), which cluster the sand. Epoxy resin produces a high performance polymer concrete, which results in durability, low permeability and fast cure [6]. Resin content used was 12% by weight. Previous studied performed by the author showed the lowest binder concentration that would deliver an optimal cost/performance ratio.

In the acid test, using different acid solutions are distilled water, sulfuric acid, lactic acid and sea water. The pH concentration of the acid solutions are 5.1, 1.1, 1.9 and 8.2 respectively.

Mix proportion of polymer resin concrete: 1:1:2 (resin: hardener: sand)

Resin to filler ratio: 100/0, 95/5, 90/10, 85/15, 80/20, 75/25 and 70/30.

With these binder formulations and mix proportions, polymer concrete were mixed and molded. For compressive strength tests prismatic (70x70x70mm3) cube specimens were manufactured, as illustrated in and cylindrical specimens (ϕ50x100 mm) were produced for tensile strength tests, according to the RILEM standard CPT PC-2. All specimens were allowed to cure for 7 days at room temperature and then postured at 60^{o}C for 4h, before being submitted to corrosive environment.

The test method for degradation followed the procedure presented by the specimens are tested in both compression and tension test for 3days, 5days and 7days after curing process. The final acid test will be conducted in dry state after 7day curing.

Mixing of raw materials

Specimen preparation Curing



Testing

Test

Following equations are used to calculating specimen strength,

Compressive strength □c = (F/A), Tensile strength □t = (2P/□DL) Where, F-applied force, A-area of specimen, P-applied load, D-dia of cylinder, L-length of cylinder

3.0 Test Results and Discussion

Compressive and tensile strength test results in order to obtain polymer concrete mechanical strength are discussed in this section [7]. Table 1 and 2 are represents the compressive and tensile strength test results of polymer concrete subjected to different filler materials are partially adding 0%, 5%, 10%, 15%, 20%, 25% and 30%.

In table 1 comparison we should classify the compressive strength in the different mix of different filler materials such as metakaolin, quartz, glass fiber. If the metakaolin having the maximum strength 32.65MPa, 35.28MPa, 38.16MPa at 10% mixing, quartz having the maximum strength 34.38MPa, 48.57MPa, 51.63MPa at 15% mixing and finally glass fiber having the maximum strength 26.12MPa, 27.75MPa, 29.59MPa at 0% mixing after 3days, 5days and 7days curing respectively.

Table 1 Compressive strength comparison of Polymer Resin Concrete with different fillers

% of Fillers	Compressive strength (MPa)								
	Metakaolin			Quartz			Glass fiber		
	3days	5days	7days	3days	5days	7days	3days	5days	7days
0	26.12	27.75	29.59	26.12	27.75	29.59	26.12	27.75	29.59
5	28.57	30.2	32.5	31.22	33.87	35.71	11.73	25.40	27.75
10	32.65	35.28	38.16	33.67	35.51	40.81	9.7	23.97	25.46
15	20.4	26.73	33.06	34.38	48.57	51.63	4.6	11.83	15.10
20	5.1	6.23	8.77	37.55	46.93	50.61	2.6	9.38	10.61
25	1.63	1.93	2.44	36.52	37.95	40.20	-	-	-
30	0.02	0.1	0.2	34.68	36.73	38.97	-	-	-

Table 2 Tensile strength comparison of Polymer Resin Concrete with different fillers

% of Fillers	Tensile strength (MPa)								
	Metakaolin			Quartz			Glass fiber		
	3days	5days	7days	3days	5days	7days	3days	5days	7days
0	2.2	2.3	2.46	2.2	2.3	2.46	2.2	2.30	2.46
5	2.3	2.89	3.18	2.38	2.76	3.06	4.5	5.27	6.38
10	2.55	2.97	3.48	2.89	3.23	3.48	3.06	3.20	3.31
15	3.82	4.08	4.50	3.83	4.50	5.70	1.10	1.53	1.91

20	0.93	1.53	1.95	0.85	1.06	1.19	0.425	0.68	0.93
25	0.085	0.25	0.425	0.60	0.90	1.02	-	-	-
30	0	0	0	0.09	0.38	0.55	-	-	-

In table 2 comparison we should classify the tensile strength in the different mix of different filler materials such as metakaolin, quartz, glass fiber. If the metakaolin having the maximum strength 3.82MPa, 4.08MPa, 4.50MPa at 15% mixing, quartz having the maximum strength 3.83MPa, 4.50MPa, 5.70MPa at 15% mixing and finally glass fiber having the maximum strength 4.50MPa, 5.27MPa, 6.38MPa at 0.5% mixing.

3.1 Acid test:

In acid test, the 7days curing specimens are taken for the test because high strength achieve in the seventh day.The specimens are dried in the atmospheric temperature after the specimens are immersed in the different acid solution for 1day.after that the specimens are weighted in the weighting machine [9]. The readings are noted and the strength are calculated. The table 3 gives the acid performance of different materials in different solution to the polymer resin concrete

Table 3 – Acid performance of Polymer Resin Concrete

Type of Fillers	**Strength**		**Type of Solution**			
			Distilled water	**H2so4**	**Lactic acid**	**Sea water**
Metakaolin (Reference Com – 38.16 Ten – 4.50) MPa	**Mean Strength(MPa)**	**Com**	37.13	36.97	-	35.10
		Ten	4.38	4.37	-	4.14
	% of Strength loss	**Com**	2.7	3.1	-	8.0
		Ten	2.5	2.85	-	7.95
	% of Weight loss	**Com**	1.2	2.1	2.7	1.4
		Ten	1.05	1.95	2.5	1.25
Quartz (Reference Com – 51.63 Ten – 5.70) MPa	**Mean Strength(MPa)**	**Com**	50.33	50.20	-	47.67
		Ten	5.57	5.55	-	5.27
	% of Strength loss	**Com**	2.5	2.50	-	7.75
		Ten	2.3	2.55	-	7.45
	% of Weight loss	**Com**	0.9	1.9	2.5	1.2
		Ten	0.85	1.75	2.3	1.05

Glass fiber (Reference Com – 29.59 Ten - 6.38) MPa	**Mean Strength(MPa)**	**Com**	28.71	28.59	-	27.07
		Ten	6.20	6.18	-	5.85
	% of Strength loss	**Com**	2.95	3.35	-	8.5
		Ten	2.85	3.15	-	8.3
	% of Weight loss	**Com**	1.4	2.3	2.9	1.6
		Ten	1.35	2.25	2.85	1.55

In the acid test following strength loss will be adopted in these study,

3.2 Compressive strength loss:

When metakaolin, quartz and glass fiber cubic specimens submitted to seawater degradation solution a reduction of 8.0%, 7.75% and 8.5% in polymer concrete compressive strength were measured. A decrease of 3.1%, 2.85% and 3.35% was obtained by specimens submitted to sulfuric acid solution and for specimens degraded in distilled water a 2.7%, 2.5% and 2.95% loss was observed when compared to reference polymer concrete specimens are respectively. Again a severe damage was observed to compressive specimens and tests could not be performed. In lactic acid no strength change for all three specimens [10].

3.3 Tensile strength loss:

When metakaolin, quartz and glass fiber cylinder specimens submitted to seawater degradation solution a reduction of 7.95%, 7.45% and 8.3% in polymer concrete tensile strength were measured. A decrease of 2.85%, 2.55% and 3.15% was obtained by specimens submitted to sulfuric acid solution and for specimens degraded in distilled water a 2.5%, 2.3% and 2.85% loss was observed when compared to reference polymer concrete specimens are respectively. Again a severe damage was observed to tensile specimens and tests could not be performed. In lactic acid no strength change for all three specimens.

4.0 Conclusion

The present study aimed to compare the compressive and tensile strength of polymer resin concrete with different filler materials in the different mix proportion.

4.1 Compressive strength:

Instant increase in Quartz and gradual increase is seen in Metakolin and Glass fiber combinations, all three having different compressive strength after 3 days, 5 days and 7 days.The compressive Strength of Quartz is 157.2% greater than that of Metakolin and 220.4% greater than that of Glass fiber. Glass fiber being the least in compressive strength, equalizes the strength of conventional concrete and is also lighter in self-weight.

Quartz > Metakaolin > Glass fiber

51.63MPa > 38.16MPa > 29.59MPa

4.2 Tensile strength:

Instant increase in Glass fibres and gradual increase is seen in Metakolin and Quartz combinations, all three having different Tensile strength after 3 days, 5 days and 7 days.The Tensile Strength of Glass fiber is

188% greater than that of Metakolin and 68% greater than that of Quartz. Metakolin being the least in tensile strength, equalizes the strength of conventional concrete and is also lighter in self-weight.

Glass fiber > Quartz > Metakaolin

6.38MPa > 5.70MPa > 4.50MPa

4.3 Acid Performance:

In this test above table, the yellow colour represent sea water is highly reduced the compressive and tensile strength of polymer concrete with three type of filler materials. The distilled water and sulfuric acid is small amount reduced the compressive and tensile strength of polymer concrete with three type of filler materials compare to sea water.Finally pink colour represent lactic acid produce the no strength reduction and little variation of specimen weight.

4.4 High performance: Lactic Acid

4.5 Medium performance: H2So4, Distilled Water

4.6 Low performance: Sea Water

5.0 References

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