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Fatigue Studies on High Performance Fibre Reinforced Concrete

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ABSTRACT - *In contemporary practical world, primarily focuses on infrastructural evolution about functional aspects, modest and artistic in the construction projects. High Performance Concrete plays a very important role in some areas such as hydraulic structures, high rise building and long length bridges and so on. By addition of fibres into the concrete mix, there is an extreme development in the properties of concrete. Here, this research study deals with the exploratory investigation of fibre reinforced HPC for their mechanical properties by replacing the coarse and fine aggregates by crushed concrete waste and foundry sand respectively. Foundry sand is replaced from 0% to 40% with having 5% interval and crushed concrete waste is replaced from 0% to 40% with having an interval of 10%. The mechanical properties like fatigue strength, impact strength, compression strength, flexural strength, split tensile and shear strength of High-Performance Concrete with and without addition fibres are performed. For manufacture of High-Performance Concrete, M-80 Grade concrete has been chosen. According to IRC44:2017 recommendation and guidelines, the mix design process are conducted. Conventional dosage of super plasticizer was managed in the concrete to make a better execution. Here, the poly propylene fibres have been used as of 0.3% by total cement weight used. Mechanical properties are obtained by manufacturing the particular sizes of mould cured for 7, 14 and 28 days for different tests and results were tabulated for respective days and conclusions are discussed.*

Key Words: *High Performance Concrete (HPC), Poly propylene Fibre, Foundry sand, Crushed Concrete Waste, Conventional concrete, Super plasticizer.*

1. INTRODUCTION

The High-Performance Concrete (HPC) becomes one of the most essential concrete materials for the conventional concrete. By taking into consideration its accomplishment and accountability in the particular field of application, the High-Performance Concrete's strength is equal or over of M-80 grade will be applied in large span of construction field. By minimizing the amount of water-cement ratio with the use of special admixtures which leads to improve in the workability, performance and high-strength of HPC. Various types of polymers or steel-based fibres are used in HPC thereby making the concrete into fibre reinforced concrete, to improve its tensile strength, toughness and ductility. Cement is the costliest material, by utilizing base material such as crushed concrete waste powder etc., to replace the cement moderately in concrete is taken as economical and reduces the detrimental effect too. The generation of micro cracks in the concrete structures, buildings or pavements are causes fatigue failure due to periodic application of loads, which ultimately leads to the generation of macro cracks, in the course of time the cracks developed that leads to structure fail. Here we focused to study the function of foundry sand and crushed concrete waste used as a replacement in the High-Performance Concrete also determine the mechanical properties of the Fibre Reinforced High Performance Concrete (FRHPC), by knowing the optimal replacement of material individually and also investigate the compression strength, flexural strength and fatigue behaviour HPC with and without the addition of the fibres.

2. MATERIALS

Ordinary Portland Cement (OPC) 53-Grade have been used for this study as a binding material and basic tests were conducted on the cement to know its properties and the results are enrolled in **Table-1.** River sand and foundry sand shown in Fig-1 has been used also their basic test results are listed in **Table-2.** Natural aggregates are acquired from near vendor and Crushed granite aggregates shown in Fig-2 which passing through 20mm sieve and retained on 12.5mm sieve with specific gravity 2.60 and as recommended in IS: 383-1970 is used for all the specimens and their basic tests are tabulated in the **Table 3.** The water which is used for the preparation of concrete should be free from organic matter and dirt. Here, Poly Carboxylic Ether is taken as a super plasticizer of specific gravity 1.08. Poly propylene fibres are also used and it is a form of linear polymer synthetic fibres shown in Fig-3.

Table-1: Results of basic tests on Cement

SI No	Properties	Results
1.	Normal Consistency	29.0%
2.	Initial Setting	38 mins
3	Final Setting	375 mins
4	Specific Gravity	3.1

Fig-1: River Sand and Foundry Sand

Fig-2: Natural aggregates and Crushed Concrete Waste

Fig-3: Poly-Propylene Fibres

Table 2: Properties of Fine Aggregate

SI No	Properties	Result
River Sand		
1.	Specific Gravity (g/cm^3)	2.6
2.	Silt Content	4.4 %
3.	Bulking Of Sand	6%
4.	Particle Size Distribution	3.2 (Coarse)
Foundry sand		
1.	Specific Gravity	2.5
2.	Silt Content	Nil
3.	Bulking Of Sand	4%
4.	Particle Size Distribution	2.7 (Medium)
5.	Abrasion Test In Wt. Loss(G)	0.235

Table 3: Properties of Coarse Aggregate

SI No	Properties	Results
Natural Aggregate		
1	Specific Gravity	2.63
2	Compression Strength (%)	32.3
3	Flakiness (%)	6.30
4	Elongation (%)	14.73
5	Impact Value	17.82
6	Water Absorption	2.35 %
Crushed Concrete Waste		
1	Specific Gravity	2.58
2	Compression Strength (%)	17.39
3	Flakiness (%)	11.40
4	Elongation (%)	14.58
5	Impact Value	5.57
6	Water Absorption	2.70%

Table 4: Mix proportions and materials obligations of M-80 grade concrete

Materials	Weight of materials	Mix proportion
Cement	450kg/m^3	1
Fine Aggregate	565 kg/m^3	1.26
Coarse aggregate	1330 kg/m^3	2.94
Water	123 Liter	W/C ratio = 0.27
Super plasticizers	6.0	0.0052

3. CASTING OF SPECIMENS

It is necessary to examine the strength properties of the concrete. Hence, Concrete cubes of size 150*150*150mm, are casted for 24 hours and then de-moulded. The specimens are manufactured in two ways such as, by using concrete mixtures accommodate with crushed concrete waste as Coarse aggregate and waste foundry sand as Fine aggregate and also concrete mixture with crushed concrete waste as Coarse aggregate and without waste foundry sand as Fine aggregate as partial substitutes in the High Performance Concrete having different varying proportional such as foundry sand with 10%, 20%, 30% and 40% and crushed concrete waste with 5%,10%,15% and 20% of concrete cubes at room temperature. Polypropylene fibres have been used to achieve the properties of High-Performance Concrete, then compared with conventional concrete and replaced concrete without fibres.

Fig-4: Concrete casted in mould and de-moulded cubes

4. RESULTS

4.1 Compression Strength Test

All the concrete cubes were tested to determine their resistivity to compression loads. Compression testing machine having 3000 KN capacity was used to test the concrete specimens.

The test results of all the specimens are listed below and conclusions are discussed based on the obtained result.

Table 5: Compression Strength Test Results

SI. No	Samples	Average Compression strength			
		7 days (Mpa)		28days (Mpa)	
		With fibre	Without fibre	With fibre	Without fibre
1.	Normal M80	65.33	61.92	101.03	96.74
2.	10% CCW	63.55	61.48	101.03	95.11
3.	15% FS	67.25	65.62	106.22	100.14

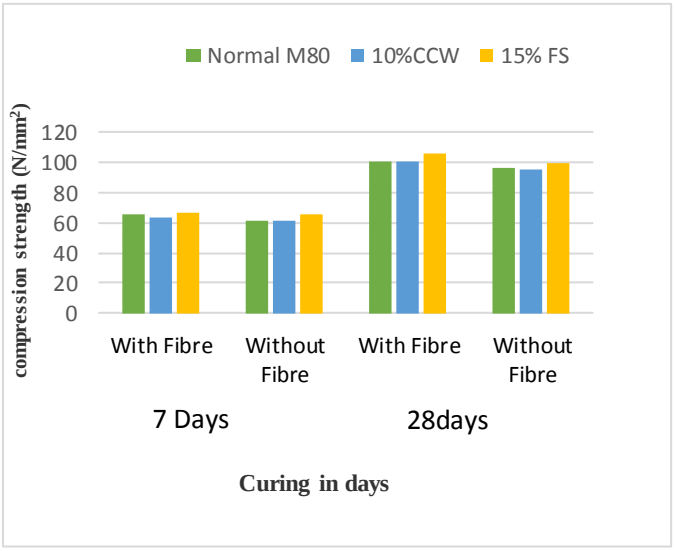

Fig-5: Graph of Compression Strength Results

4.2 Flexural Strength Test

Flexural strength is used to determine tensile strength indirectly. The mould of size 100mm x 100mm x 500mm was prepared and cured with respect to curing periods. Test may do through one point or two points loading to analyze the flexural behavior of the concrete. The flexural strength test results are listed below.

Table 6: Flexural Strength Test Results

SI.No	Samples	Average Flexural strength	
		7 days (Mpa)	28 days (Mpa)
1	Conventional M80 with fibre	8.5	13
2	10% CCW with fibre	7.5	12
3	15% FS with fibre	8	12.5

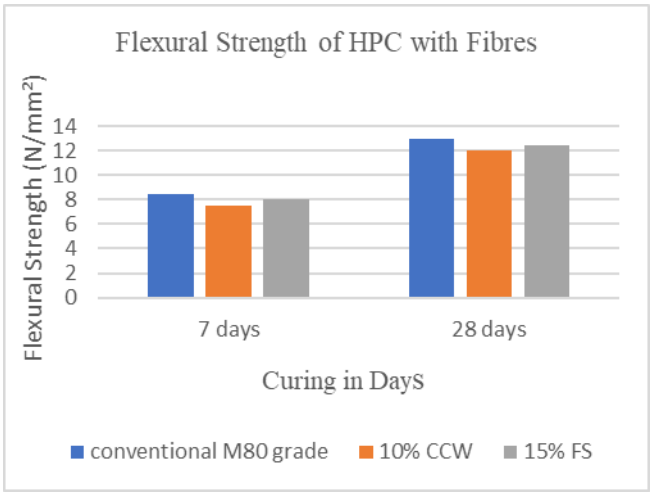

Fig-6: Graph of Flexural Strength Results

4.3 Fatigue Strength Test

To conduct fatigue test, it is essential to know the static flexural strength of concrete. Based upon the obtained static flexural strength, the required load to conduct the fatigue test was calculated. Fatigue test was conducted for different stress ratios like 0.95, 0.85 and 0.75. The frequency of 3Hz remains kept constant till the end of the experiment. The number of cycles sustained by the specimens was recorded and S-N curve is designed.

Table 7: Number of Cycles for Different Stress Ratios converted into Log Values

Type of concrete	Number of Cycles for different Stress Ratios		
	0.95	0.85	0.75
FS+C&D M 80 Grade with fibre	1.602	2.401	3.398
Conventional M80 grade without fibre	1.698	2.307	3.477

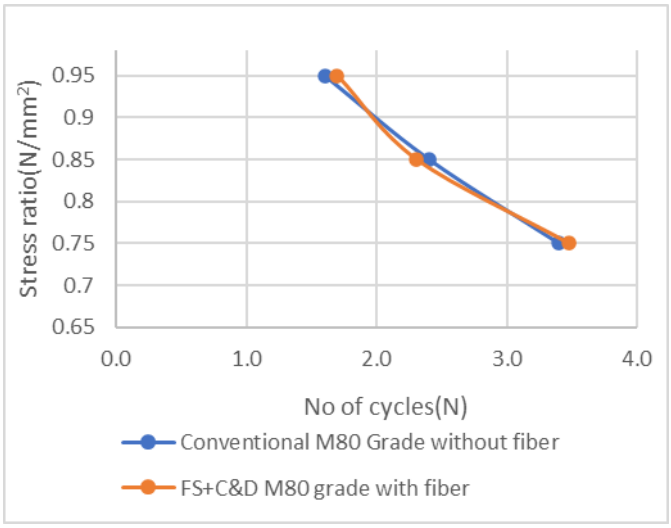

Fig-7: Graph of Fatigue test result

5. CONCLUSIONS

1) By providing the poly- propylene fibres of 0.3% dosage by volume of cementitious material to the HPC, there is a considerable increase in both compression strength and flexural strength of the composite section compared to conventional concrete.

2) In compression strength test the maximum replacement of foundry sand is 15% and crushed concrete waste is 10%.

3) In Compression Strength Test, once the sample concrete cube without addition of fibre reaches the ultimate load, the internal stress of the concrete cube will get fail and specimen sample breaks by blasting with immense sound. On other side, the sample concrete cubes are accommodating with poly-propylene fibre, the stress load would transfer to the fibres from the concrete and strain in the concrete cube is less and it will take time to fail.

4) In Flexural Strength Test, the failure section of the specimen precisely about the point, where the load applies also called shear zone. Hence, the concrete cube did not get break due to the presence of fibre, but ability of a material to receive forces will get fail by brittle failure. Compared to conventional concrete, the value of flexural strength of FRHPC increased by 5-10% due to the better aspect ratio of fibres.

5) As compared with IRC 58-2002 values, all the concrete sections resist a greater number of load repetitions. One of all, composite sections (FS+C&D M80 with fibre) withstand more repetitions of fatigue.

6) In fatigue test, the maximum replacement of foundry sand is 15%, by providing poly-propylene fibre of 0.3% dosage by volume of cemetitious materials to HPC. For stress ratio 0.95, FS+C&D M80 with fibre can sustain 19.8% more repetitions than Conventional M80 grade concrete without fibre.

7) For stress ratio 0.85, FS+C&D M80 with fibre can sustain 7.12% more repetitions than Conventional M80 without fibre.

8) For stress ratio 0.75, FS+C&D M80 with fibre can sustain 5.45% more repetitions than Conventional M80 without fibre.

9) From these studies and based on test results, it is noticed that the composite concrete section FS+C&D M80 with fibre is a good solution for the structures, also it has the power of resisting a more number of cyclic loads as compared to single layer of normal or conventional concrete.

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