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Effect of Granite Powder and Polypropylene Fiber on Compressive, Split Tensile and Flexure Strength of Concrete at High Temperature

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Abstract - *The paper deals with the effects of addition of various proportions of granite powder and polypropylene fibers on the properties of concrete. This paper examines the compressive, split tensile and flexure strength of concrete. River sand is the most commonly used fine aggregate in making concrete. But extensive use and high transportation cost of sand gives rise to expense, so to cut down the cost of sand, granite powder is used as a replacement of sand with variable proportion of 10%, 20% & 30%. Granite powder is an industrial waste which is available in abundance. Fixed proportion of Polypropylene fiber was added to the concrete which is 0.25 percent of the weight of cement. Polypropylene fiber is mainly used for reinforcement of concrete to improve the tensile strength of concrete so as to avoid explosive spalling at elevated temperature, thus making it fire resistant. The main aim of this experimental program is to design concrete of grade M45 and then to study the effect of polypropylene fiber and granite powder at high temperature of 300˚C. After performing the experimental program, the results show that the maximum compressive strength of concrete having 20% proportion of granite powder show improved properties into reference to the plain M45 grade of concrete.*

Key Words: Compressive strength, flexure strength, split tensile strength, polypropylene fiber, granite powder.

1. INTRODUCTION

Most important part of concrete is fine aggregate and almost all construction industries in the whole world, use river sand as fine aggregate. But river sand is quite expensive because of its excessive cost of transportation from natural sources. As it is extensively used in concrete, its consumption is also quite high due to which there is lack of availability of the required amount of sand which is adversely affecting the infrastructure industries, thus creating a void in the development and growth of many parts of the country [1][2][3] Different state governments are imposing ban on the sand removal from the rivers due to its unsafe effects. On the other hand granite powder made from granite stone is treated as a waste material which is present in abundant amount and can be efficiently used as a replacement of sand. Around 17.8 million tonnes of solid granite waste is generated by the Indian granite stone industry out of which 12.2 million tonnes are rejected at the site and 5.2 million tonnes is present in the form of cuttings/ trimmings or undersize materials and there is 0.4 million tonnes of granite slurry present at the processing and polishing units [4].This granite waste is dumped which in turn gives rise to the environmental issues. Thus, the aim is to make use of waste material to create better product, after all that is what engineering is all about. So, by doing so the cost can be cut down and there is no danger to environment also. The test results that are obtained from [1] indicate that if the marginal quantity of granite powder is added as the replacement of sand then it has a beneficial effect on the properties such as the compressive strength, split tensile strength, modulus of elasticity. Furthermore, the test results indicate that both the plastic as well as dry shrinkage in the granite powder concrete mix were also nominal as that of the normal concrete mix.

On the other hand polypropylene fiber is used for reinforcing the concrete. Reinforcement of randomly distributed short fibers into the concrete is a good approach to stabilize the cracks, thus making concrete more ductile and with increased tensile strength. Polypropylene (PP) fiber reinforcement is considered as an effective method that helps in improving the toughness, characteristic shrinkage cracking, and fire resistance of concrete materials [5]. Many research scholars have recommended the use of PP fiber as it results in the reduction of risk of spalling at elevated temperatures. Use of PP fiber results in the formation of high performance concrete (HPC). HPC is a material that is often utilized as a part of the building industry because of its toughness and substantial nature [5][6][7]. In the recent two decades concrete technology all together with the material performance had developed at fast pace. At first, the consideration of the researchers was just centered around high compressive strength [8]. These days, HPC with a compressive strength surpassing 100MPa can be promptly constituted and manufactured. The higher the quality of cement, lower is its ductility. Fiber strands are added to the grid as a reinforcement to control the cracking, thus increasing the ductility [7] [8].

In this study, mixture of different percentage values of the granite powder, PP fiber and cement are used to make

concrete resistive to high temperature [11] a part from high strength of concrete. Different factors like tensile, compressive, and flexure strength are checked to see whether the required characteristics are met or not by comparing the concrete results at elevated temperatures with the experimental results.

2. EXPERIMETAL DETAILS

Materials used

2.1 Cement

• Ordinary Portland Cement 43 grade is used confirming to IS: 8112, 1989.
• All physical properties of Ordinary Portland Cement were determined in the NITTTR lab.
• Specific gravity assumed is 3.15. Initial and final setting time of cement was 125 min and 255 min respectively.
• Soundness value of cement as obtained in the lab was 0.8 mm

2.2 Fine Aggregate

• Natural river sand was used as fine aggregate and Sieve analysis was done to determine the zone of sand as per IS: 383-1970.
• Sieve analysis result exhibited that sand lies between Zone II.
• Specific gravity of sand is 2.63.

2.3 Course Aggregate

• Stones are generally used as coarse aggregates which could be the debris of rocks also. These aggregates normally possess all the qualities of a good building stone that show very high crushing strength, low absorption value and least porosity.
• Coarse aggregate crushed aggregates, angular in shape were used in experimental work. Grading of coarse aggregate was done according to IS: 383-1970 and nominal size was determined.
• Specific gravity of coarse aggregate was found to be 2.76.

2.4 Water

• Potable water that is available in the laboratory was used for mixing and curing. (IS 456- 2000)

2.5 Granite Powder

• Granite powder was obtained from the polishing units and the properties were found.
• The density of granite used was formed to vary between 2.65 to 2.75 g/cm^3.
• Specific gravity of granite powder was found to be 2.93.

2.5 Polypropylene Fiber

• The fiber used was fine polypropylene.
• The fibers used were supplied by Reliance Industry by the name RECRON.
• It is available in various sizes i.e 6mm, 12mm, 18mm and 24 mm. The one that is used in this research is 18mm.
• Specific gravity of polypropylene was found to be 0.90 as per the literature provided by the manufacturers.

3. PROCEDURE

MIX DESIGN FOR M45
The mix design was designed according to the codal provision of BIS: 10262-2009. The proportion of mix design is mentioned as under:

Table -1: MIX DESIGN FOR M45

S.No.	Content	Value per m3 of concrete
1.	Target mean strength	53.25 N/mm2
2.	Water content	0.38
3.	Super plasticizer	1.2%
4.	Cement	450 kg

Table -2: MIX PROPORTION

Water	**cement**	**Fine aggregate**	**Coarse aggregate**	**Super plasticizer**
171	450	637.51	1210.66	0.0061
0.38	1	1.42	2.69	1.2%

The mix design M45 was designed and required quantities were batched by weight as above. During design, different proportions of granite powder were chosen by replacing sand with the variation of 10%, 20%, 30% and fixed proportion of PP fiber of 0.25% by weight of cement was used. After mixing all the ingredients, the obtained concrete mix was poured into the casting moulds in 3 different layers while placing it on vibration table. It was then vibrated for 2 minutes. Demoulding of concrete specimen was done after 24 hours of casting and was immersed in water curing tank for desired curing. After the process of curing, the specimen was tested for its 7, 28 and 56 days compressive strength, split tensile strength and flexure strength.

The systematic approach was followed to make the test specimen with correct measurements as well as exact proportions of the materials. The detailed properties of granite powder were studied. The methodology consisted of following steps for making proposed test specimens. Procedure of carrying out the research, dimensions and number of specimens used in this research study are mentioned below.

• First of all, the selection & testing of ingredients (CA, FA) for concrete mix was done.

• The proportions for designing M45 were calculated according to the codal provisions of BIS: 10262-2009.

• A standard grade M45 concrete sample was prepared as a reference sample casted as 100×100×100 mm size cubes. Total 6 reference samples were prepared.

• Then, the fixed proportion of polypropylene fiber (0.25%) and varying proportion of granite powder (10%, 20%, 30%) was added to the design mix as a replacement for sand For this purpose, total 18 cubes were obtained. The above mixes with varying proportion of Granite powder (10%, 20% & 30%) were designated as GP10 GP20 and GP30.

• The specimens were kept in furnace for 1 hr at desired temperature of 300˚C. After heating the samples for 1 hr time period, the samples belonging to different mix group were checked for its 7 and 28 days compressive strength.

• The proportion of mix which showed the highest value of compressive strength was selected for carrying out the rest of the experimental programme. In our case, GP20 showed the maximum compressive strength.

• Now, Specimens of GP20 were prepared and tested for compressive strength, flexure strength and split tensile strength.

• Total of 18 cubes of size 150×150×150 mm (9 for reference mix and 9 for Gp20) were tested for compressive strength.

• Total of 18 cylinders of size 100x200 mm (9 for reference mix and 9 for Gp20) were tested for Split tensile strength.

• Total of 18 rectangular beams of size 100×100×500 mm (9 for reference mix and 9 for Gp20) were tested for flexure strength.

• The above mentioned tests were conducted for 7, 28 and 56 days strength.

4. RESULTS AND DISCUSSION

4.1 Compressive Strength

Test was conducted on all the specimens (Size: 100x100x100 mm) i.e. plain concrete, GP10, GP20, GP30 for its 7 and 28 days Compressive strength. The results were recorded and comparison was made after representing the recorded results in graphical form as shown in Chart-1.

From all 4 different mixes, GP20 shows the maximum compressive strength i.e. 49 N/mm2. Therefore, GP20 was chosen for our next test procedures.

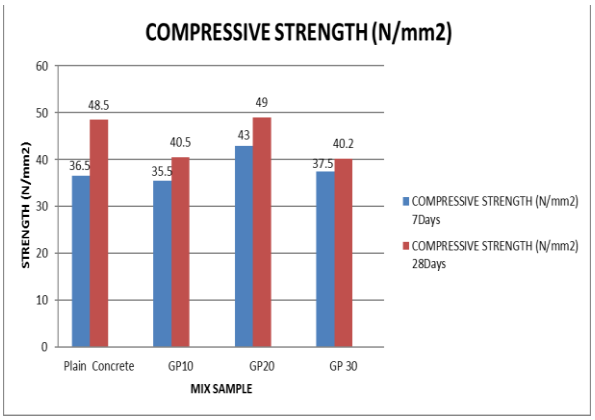

Chart -1: Compressive Strength

Now the specimen (Size 150x150x150 mm) was tested for its 7, 28 & 56 days compressive strength and results were compared with the reference concrete i.e. plain concrete. Results are shown in Chart-2.

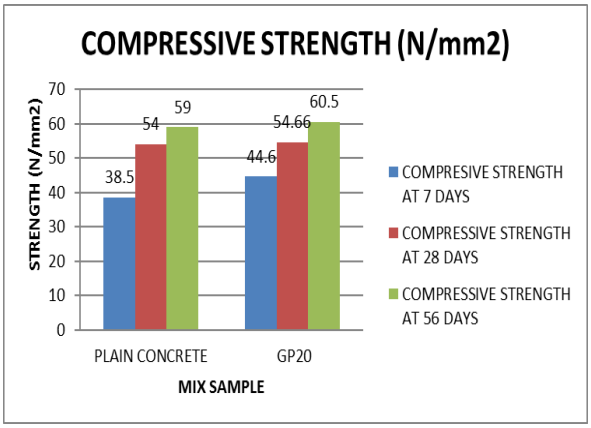

Chart -2: Compressive Strength

Above graphical representation show very little variation in the compressive strength parameter for 28 & 56 days strength but GP20 gains more strength at 7 days.

4.2 Split Tensile Strength

Now the cylindrical specimens of size 100x200mm of GP20 and plain concrete were tested for its 7, 28 & 56 days tensile strength. Results were recorded and represented as below: Chart-3.

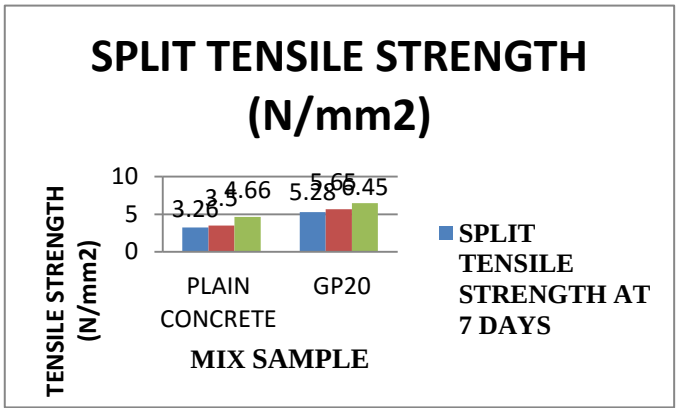

Chart -3: Split Tensile Strength

Above chart shows GP20 gains its tensile strength quickly and the variation between plain concrete and GP20 concrete in their tensile strength is quite reasonable.

4.3 Flexure Strength

The specimens of size 100x100x500 mm when tested for 7, 28 & 56 days flexure strength showed improved results when compared with reference concrete. The results as obtained are represented in graphical form as shown below in Chart-4

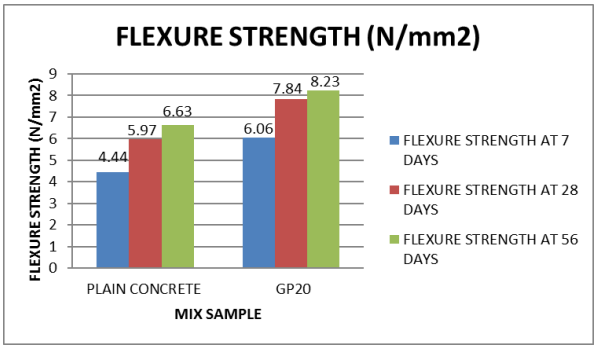

Chart -4: Flexure Strength

5. CONCLUSIONS

The experimental study was carried out by designing a mix of grade M45 and then, adding fixed proportion of PP fiber (0.25% of weight of cement) and replacing sand with Granite powder having proportions of 10%, 20% & 30%. After performing this study and comparison of the results, the interferences that are made from the study are mentioned below:

• As PP fiber is light in weight is result in more bulk density which reflects more positive effect on concrete strength parameter at high temperature of 300^{0}C as it improves due to restricting the widening of concrete micro cracks.

• Granite powder, being the waste material, can be easily found and when added to concrete enhances its strength parameter even at high temperature.

• Among the various mixes, GP20 (20% of granite powder in concrete by replacing sand) was found to be the most superior one as all the strength parameters (i.e. Compressive, split tensile and flexure strength) of GP20 was higher than the plain conventional concrete at evaluated temperature of 300^{0}C.

The present experimental study shows that the strength and fire resistance of concrete could be enhanced by using PP fiber and granite powder which is a waste material obtained from granite industries.

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BIOGRAPHIES

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