Lecture Notes in Civil Engineering

Md. Abdul Mannan
R. Sathyanathan
N. Umamaheswari
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Emerging Trends in Composite Structures

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About the Editors

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Structural Engineering and Health Monitoring

Strength of Concrete with Partial Replacement of Aggregate with Granite

S. Suresh Babu and T. Abishek

1 Introduction

Rapid expansion can be seen in the building trades. On the other hand, the world's supply of raw materials required to make concrete is dwindling, while industrial waste is rising. So, these countries are exploring alternatives to cement in order to meet demand. The purpose of this research was to find a way to partially substitute fine aggregate with granite quarry refuse. Compressive strength more than 200Mpa is characteristic of the igneous rock family of which granite is a member because it is created by the crystallisation of magma. Granite powder can be used as a partial replacement for fine aggregates since its physical properties are similar to those of natural river sand. Using granite demolition debris has various benefits, including lowering construction costs and easing the environmental crisis. Due to its high silica and fledspar content, granite powder is a potential material. As a result of silica, cement-like pozzolanic behaviour is seen. It also aids in forming a consistent blend by binding the basic materials together. The pozzolanic quality is claimed to increase concrete's durability. Granite powder is useful for packing and filling the matrix of concrete because of its small particle size. Cement, coarse aggregate, fine aggregate, water, and admixtures (if any) make-up the matrix of a concrete slab. The goal of the task is to adjust the granite powder content by switching out the coarse aggregate. The performance characteristics of concrete can be altered by the addition of granite powder. Concrete's workability, compressive strength, and split tensile strength have all been compared to standard concrete since they contribute to a building's stability. It is hoped that the findings would aid in solving the issues of granite quarry solid waste management and a lack of available natural sand. High performance concrete was studied by Kanmalai Williams et al. (2008) [6], who reported on the impact of using

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granite powder as a partial replacement of fine aggregate. According to the findings, adding more granite powder lowers the material's compressive strength. Dr. Flexi Kala (2013) [3] found that using small amounts of granite powder to partially replace sand in concrete with admixtures improved the material's durability and strength. The weight percentages of granite powder and the other admixtures were 0, 25, 50, 75, and 100. Not only did the concrete have a larger plastic strain value, but the drying shrinkage strains were also greater than normal concrete's. According to a 2013 study by M. VijayaLakshmi et al., [4] adding granite powder to concrete not only increases its mechanical characteristics but also its pozzolanic property by efficiently filling the concrete matrix. When compared to the strength of the control mixture and higher, which decreased significantly when granite powder was replaced by sand at a rate of more than 15%. An extensive experimental research on compressive strength, split tensile strength, and comparison with regular concrete was given by A. Arivumangai et al. in 2014 [5]. The use of granite powder in concrete was shown to increase both its strength and its durability. Granite powder was investigated by Makarla Susmitha Kumari et al. (2018) [9] as a potential fine aggregate replacement. The amounts of granite powder applied ranged from 10 to 25 per cent. In addition, 20% fly ash can be substituted for cement in any percentage of granite powder. The revealed results were encouraging for using fly ash to replace 20% of the cement and granite powder to replace 20% of the fine aggregate. Concrete with 60% sand replacement, as suggested by Yuvraj Patil et al. (2018) [11], has high compressive strength. Kavya B R et al. (2019) [10] showed what would happen if fine aggregate was replaced with varying percentages of granite slurry (10%, 15%, 20%, 25%, and 30%) found that the concrete containing 20% granite slurry performed relatively well. According to Grzegorz Prokopski et al. (2020) [12], the average density of concrete increases when granite powder is used as a partial replacement for sand because the microstructure of the cement matrix is compacted. Concrete with granite powder added to it is the subject of an attempt by Danish Shaikh et al. (2021) [8]. Using granite powder as a partial replacement for sand in the concrete matrix was found to be successful, as evidenced by the test results.

2 Research Significance

From the literature study, it is known that the granite powder is one of the promising materials for replacing fine aggregate. Studies revealed the technogenic materials can be used as fillers, which also solves the environmental problem to a certain extent. However, optimizing the percentage of granite powder to replace fine aggregate is an important consideration to obtain high concrete strength. The aim is to optimize the percentage of granite powder in concrete and to determine the physical properties of concrete. Thus, this research was conducted to experiment the potential use of granite powder as a replacement for fine aggregate together with admixtures.

3 Experimental Programme

3.1 Materials

Portland Pozzolana Cement, a type of cement. In this research, fly ash served as the foundation. Fly ash can make-up anywhere from 15 to 35% of Portland Pozzolana Cement by weight. Components Necessary for Portland Pozzolana Cement conforms to the requirements of IS 1489:2015, parts 1 and 2 [15, 16]. Table 1 lists the cement's physical qualities, whereas table 2 lists its chemical properties.

Nearly 60%–75% of the total volume of concrete is occupied by aggregate. Coarse aggregate is the larger variety, whereas fine aggregate is the smaller. The coarse aggregate employed in this investigation was an everyday blue metal with a nominal size of 20 mm. To make practical concrete, proper gradation of aggregates is the most crucial factor. The coarse aggregates for the course have been sieved. Table 3 provides the percentages passing via various sieve sizes as specified by IS 2386(1):1963 [1]. The characteristics of coarse aggregate that meet the requirements of IS 2386(3):1963 [13] are given in Table 4.

Table 1 Physical properties of cement

Properties	Experimental value	Values as per IS 1489: 2015
Specific gravity	3.13	3.15
Finesses (blaine) m^2/kg	356	300 (minimum)
Normal consistency (%)	30	-
Initial setting time (min)	56	30(minimum)
final setting time (min)	245	600(maximum)
Soundness(le chatelier expansion (mm)	3	10(maximum)
Compressive strength (MPa) A) 3 days B) 7 days C) 28 days	16 25 34	16(minimum) 22(minimum) 33(minimum)

Table 2 Chemical properties of cement

composition	Experimental value	Values as per IS 1489: 2015
Insoluble residue (%)	2.3	3 (maximum)
Magnesia (%)	1.65	6 (maximum)
Sulphuric anhydride (SO_3) (%)	2.6	3.5(maximum)
Loss of ignition, (%)	3.06	5(maximum)
Chloride content, (%)	0.06	0.1(maximum)
Sodium oxide (Na2O + 0.658 K2O) (%)	0.1	0.6(maximum)

Table 3 Sieve analysis of coarse aggregate

Sieve size (mm)	% passing
25	100
20	96
16	85
12.5	62
10	24
6.3	01
4.75	00

Table 4 Properties of coarse aggregate

Properties	Experimental value	Values as per IS 2386(3):1963
Specific gravity	2.67	2.6–2.9
Bulk density kg/m^3	1790	-
Water absorption (%)	1.35	Less than 2
Fineness modulus	6.85	6.75–8
Impact value (%)	19	10–20(strong)
Crushing test	12.5	-
Flakiness test	20.1	-
Elongation test	26	-

Fine aggregate used to meet zone II grading requirements is often natural river sand. The qualities of granite powder that was obtained from a crushing unit were investigated. The particle size distribution curves of river sand and granite powder are shown in Fig. 1. The characteristics of river sand and granite powder are given in Table 5. The chemical make-up of river sand and granite powder is given in Table 6.

Water: IS 3025–1988 [17] and IS 456–2000 [14] compliant drinking water were used in this study.

Additive chemistry: The local superplasticizer (conplast SP-430) was employed at a concentration of 1% to attain the appropriate workability. Table 7 gives some of the characteristics of superplasticizers.

3.2 Mix Combination and Casting

In the present investigation, four mix combination of granite powder was involved. The percentage replacement of granite powder (20%, 25%, 30%) is given in Table 8, which was compared to the conventional concrete mix. In the laboratory, the cement, coarse aggregate, fine aggregate, and granite powder were initially mixed to form

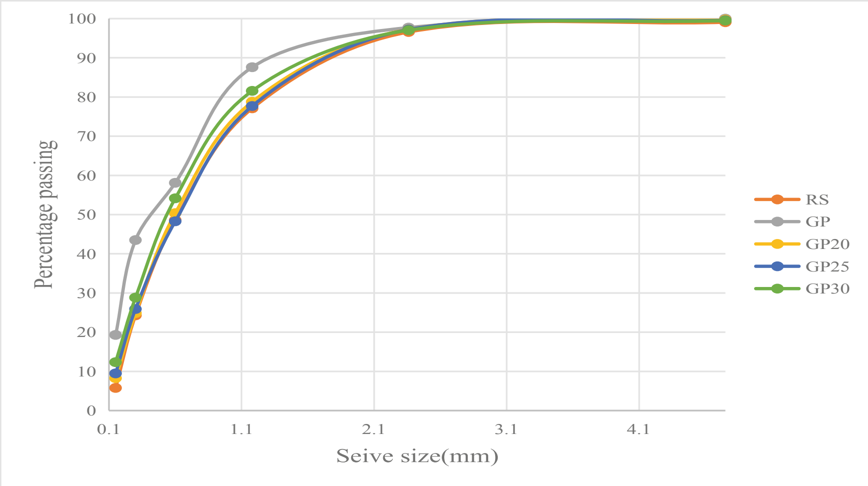

Fig. 1 Particle size distribution curve of river sand and granite powder

Table 5 Physical properties of river sand and granite powder

Properties	Experimental value		Values as per IS 2386(3): 1963
	River sand	Granite powder	
Specific gravity	2.668	2.653	2.65–2.67
Bulk density kg/m^3	1602	1598	-
Water absorption (%)	3.2	5.4	2–6
Fineness modulus	2.5	3.8	2–4

Table 6 Chemical composition of river sand and granite powder

Composition	River sand (%)	Granite powder(%)
SiO_2	73.46	74.39
AL_2O_3	10.78	13.5
Fe_2O_3	3.38	0.86
MnO	0.09	0.02
MgO	1.33	0.38
CaO	3.58	0.41
Na_2O	2.25	4.16
K_2O	2.06	4.79
TiO_2	0.45	0.17
P_2O_5	0.08	0.02

Table 7 Properties of superplasticizers

Properties	Values
Brand	Conplast SP-430
Specific gravity	1.2
Density kg/m^3	1260
Colour	blue
Base chemical	SNFC

Table 8 Percentage replacement of granite powder

Specimen designation	FA%	GP%
CC	100	0
20GP	80	20
25GP	75	25
30GP	70	30

homogeneous mixture. Then, the liquid components were added to the dry mix and continued the mixing for another 4 min.

Cubes of size 150 mm x 150 mm x 150 mm and cylinder of diameter 150 mm and length 300 mm were casted for each mix to determine the hardened properties of concrete. For each mix proportion, minimum of three cube and three cylinder were casted to obtain the average test results.

4 Results and Discussion

Workability: The test results shown in Fig. 2 explain the effect of GP on the workability as per is code IS 1199–1959 [18]. The workability of concrete decreases with increase of GP. Lowest workability was observed for the substitution of 30% GP (30GP). This is because workability and water demand depends on the partials size and shape of the materials added. From Fig. 1, it is clear that particle size of GP is finer then river sand. The uneven and angular texture of GP is the reason behind the decrease of workability.

Compaction Factor: The test was conducted as per IS 1199–1959 [18]. The mix 30GP shows the highest compaction factor when compared to other mix as shown in Fig. 3. The smaller size of GP has effectively contributed to the packing and filling of concrete matrix which in turn showed a gradual increase in the compaction factor from CC to 30GP.

Compression Strength: The compressive strength of different mix proportion having 20%, 25%, 30% GP as a replacement to river sand is tested at ages of 7, 14, 28, and 56 days. The compression test results are shown in Fig. 4; from the graph, it is clear that the compression strength of 25GP is maximum when compared to the other mix (Fig. 5 and Fig. 6).

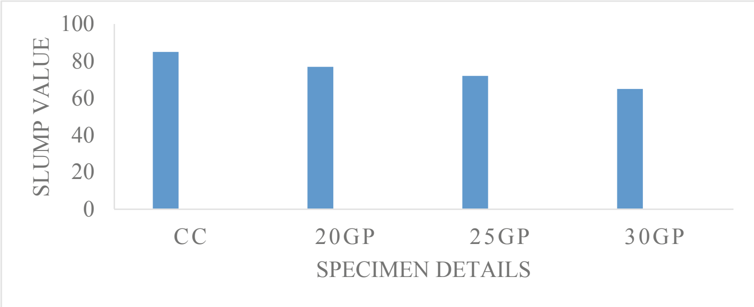

Fig. 2 Slump value

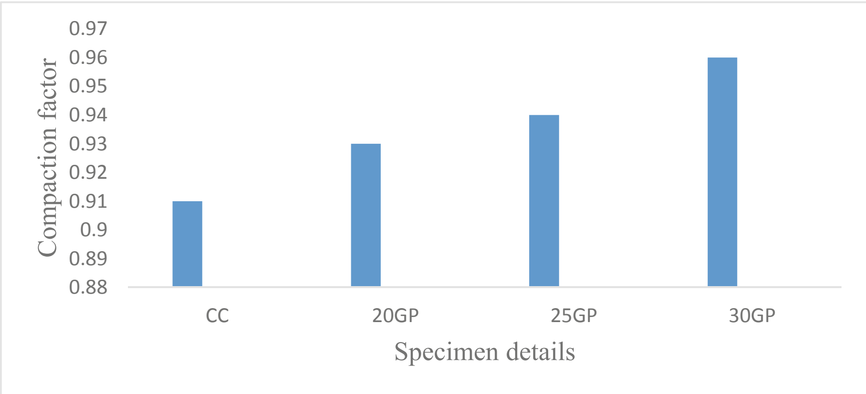

Fig. 3 Compaction factor

Fig. 4 Casting of cube and cylinder

Fig. 5 Testing of cube and cylinder

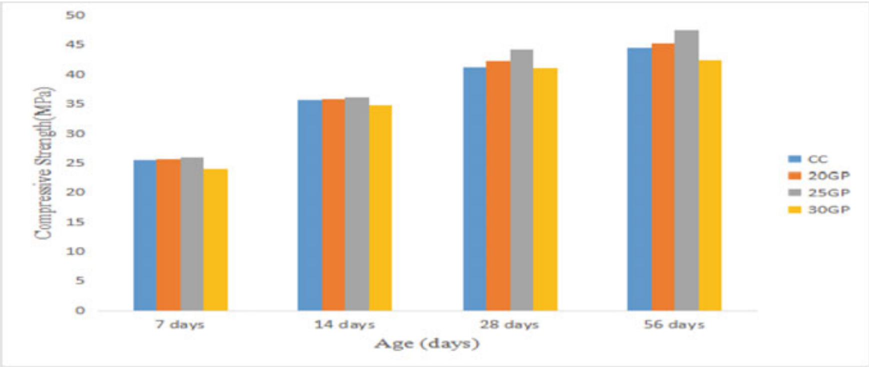

Fig. 6 Compression test

Cylinder specimens were examined for split tensile strength at 20%, 25%, and 30% GP and 7, 14, 28, and 56 days. Figure 7 displays that the tensile strength increased up to a 25% replacement rate, and then suddenly dropped for the 30GP blend. The results indicate that the best tensile strength was achieved with a 25% GP substitution.

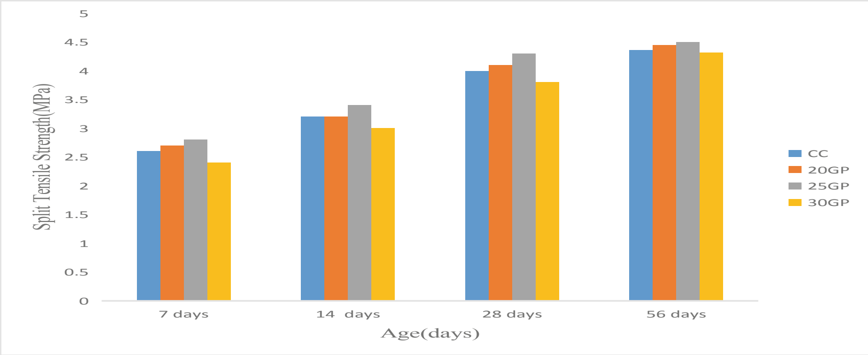

Fig. 7 Split tensile test

5 Conclusion

Concrete qualities like workability, compressive strength, and split tensile strength are investigated in a research of concrete made with GP as a partial replacement to river sand. When added to concrete, GP improves the material's mechanical qualities, as was observed empirically. When compared to the other mix proportions and across all ages of curing, concrete with 25% GP (25GP) had the strongest strength of the four studied. Based on these findings, it can be concluded that GP can be used to partially replace river sand to produce concrete with increased strength while also reducing environmental impact.

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