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STUDY ON BEHAVIOUR OF CONCRETE BEAMS CONTAINING GRANITE POWDER

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Abstract - Granite powder is an industrial by-product generated from the granite polishing and milling industry in powder form respectively. These by-products are left largely unused and are hazardous materials to human health because they are airborne and can be easily inhaled. An experimental investigation has been carried out to explore the possibility of using the granite powder as a partial replacement of sand in concrete. Twenty cubes and ten beams of concrete with granite powder were prepared and tested. The percentages of granite powder added to replace sand were 5%, 10%, 15%, and 20% of the sand by weight. It was observed that substitution of 15% of sand by weight with granite powder in concrete was the most effective in increasing the compressive and flexural strength compared to other ratios. The test resulted showed that for 15% ratio of granite powder in concrete, the increase in the compressive strength was about 15% compared to normal concrete. Similar results were also observed for the flexure.

***Key Words*: Granite powder, Granite Powder concrete, Granite Polishing Wastes, Sustainable Concrete.**

1. Introduction

Fine aggregate is a vital constituent of concrete. Natural river sand is the most frequently used fine aggregate. The worldwide exploitation of river sand is excessive due to the widespread use of concrete. The sufficient quantity of ordinary river sand for making cement concrete is not available, thus affecting the development of construction industry in various parts of the country. The demand of natural river sand is increasing in developed countries owing to infrastructural development. Of late, Tamil Nadu government of India has imposed limitations on sand excavation from river beds due to its undesirable impact on the environment. In contrast, the granite waste generated by the granite industry has accumulated over many years. Only an insignificant quantity has been utilized and the rest has been dumped resulting in pollution problems. With the huge increase in the amount of waste needing disposal, severe shortage of disposal sites, sharp increase in the conveyance and disposal costs demand the need for effective application of this waste. This work is aimed at developing a concrete using the granite scrap wastes as a replacement material for the fine aggregate. So, the objective of reduction of cost of construction can be met and it will also help to solve the problem related to its disposal including the ecological problems of the region. Consequently, this project work will examine M35 grade of concrete that were cast by changing the percentage replacement of sand with granite powder.

2. Research Objectives

- To recommend the use of waste materials like granite powder to reduce land pollution.
- To replace fine aggregate in concrete with granite powder and to find out their Compressive strength, Split tensile strength and Flexural strength.
- To compare the strength of regular concrete and partially replaced concrete.

3. Materials and Methods

3.1 Cement

In this research study, most commonly available Penna Power PPC Cement, Pozzolona Portland Cement of Grade 53 is used. PPC is a superior blend of cement as per BIS requirement, IS: 1489, and is manufactured by inter-grinding Ordinary Portland Cement clinker with superior processed fly ash together with gypsum. Due to its intrinsic characteristics, PPC helps in producing corrosion resistant concrete that is better to concrete made with OPC. The use of blended cement in concrete decreases crack formation, increases workability, constrains sulphate attacks and lessens the heat of hydration. Besides, its 28 days strength shows to be much improved than OPC 53 Grade.

3.2 Fine Aggregate

The river sand was used as fine aggregate conforming to the requirements of IS: 383. The river sand was washed and screened, to eliminate deleterious material and over size particles. The fineness modulus of sand is 2.31 and confirms to Zone II grading and the Specific Gravity of sand is 2.62.

3.3 Coarse Aggregate

Crushed granite coarse aggregate of 20mm size were used, the specific gravity was 2.67.

3.4 Granite Powder

Sieve analysis was carried out for the sand and granite powder at different sieve sizes. It is shown from the Sieve analysis carried out for the sand and granite powder at different sieve sizes that the quantity of fine particles present in granite powder is considerably higher when compared to the river sand.

Table 1: Sieve analysis results of fine aggregate

Sieve Size	Sand % Passing	Granite Powder % Passing
4.75mm	95	100
2.36mm	89	97
1.18mm	60	89
600µm	21	57
300µm	4	46
150µm	1	22

3.5 Water

Generally, water fit for consumption is suitable for mixing concrete. Impurities in the water may influence concrete setting time, strength, shrinkage or promote corrosion of reinforcement. Therefore, locally accessible purified drinking water was used in this project.

3.6 Concrete mix details

For replacement of Granite powder in concrete there is no typical proportioning. Thus, it was determined that finding the better ratio for aggregate and cement by testing various proportions was necessary. In 1:1.6:2.907 (reducing 5%, 10%, 15% and 20% of fine aggregate) keeping water cement ratio as constant. The w/c ratio is kept as 0.43.

3.7 Compressive Strength Test

The compressive test on both conventional concrete and granite powder concrete is carried out. The concrete specimens of size 150mm x 150mm x 150mm are used to conduct the test. The compressive strength of the cube specimen is computed as follows

Compressive strength

= p/a (N/mm^2).

Where, p – Load applied (N) a – Surface area of cube under loading (mm2).

3.8 Split Tensile Test

The split tensile test on both conventional concrete and waste glass concrete is carried out. The test is conducted on 150mm x 300mm. Cylinder is kept under the testing machine and the load is applied till the cylinder fails. The compressive strength of the specimen is calculated as follows,

Split tensile strength = (N/ mm2). Where, P – Applied load in N, D – Diameter of cylinder in mm, L – Length of cylinder in mm.

3.9 Flexural Test

The flexural test on both conventional concrete and waste glass concrete is carried out. In a conventional test, flexural strength expressed in MPa is equal to $2PL/bd^2$. Specimen size 100x100x500mm. Where, P = the load applied to a sample of test length L, width b and depth d.

4. Results and Discussions

4.1 Comparison of Compressive Strength Test Results of Cube

The Compressive Strength Results of Concrete Cube Specimens for 7, 14 and 28 days are presented in the Table with the comparisons of the results.

Table 2: Compressive strength test results

Addition of granite powder	Compressive strength (f_{ck}) N/mm2		
	7th day	14th day	28th day
0%	23.5	32.3	36.1
5%	24.1	33.4	37.6
10%	24.3	34.7	38.4
15%	27.8	36.8	40.6
20%	24.2	34.6	38.1

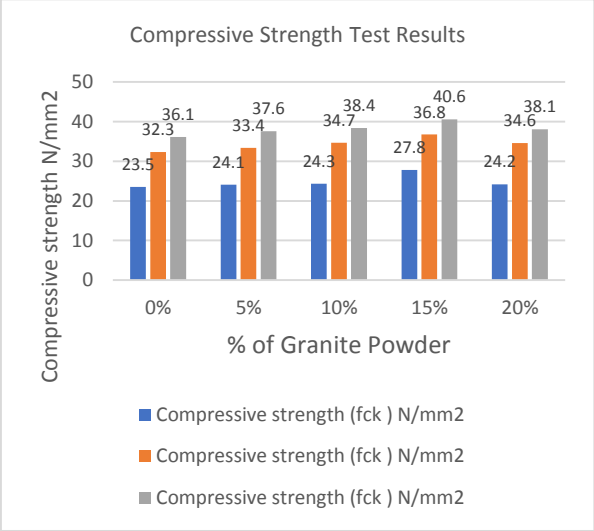

Figure 1: Compressive strength test results

4.2 Comparison of Split Tensile Test Results of Cylinder

The Split Tensile Results of Concrete Cube Specimens for 7 and 28 days are presented in the Table with the comparisons of the results.

Table 3: Split tensile strength test results

Addition of granite powder	Split tensile strength (f_{ck}) N/mm2	
	7th day	28th day
0%	2.90	4.50
5%	2.84	4.50
10%	2.76	4.45
15%	2.75	4.40
20%	2.75	4.40

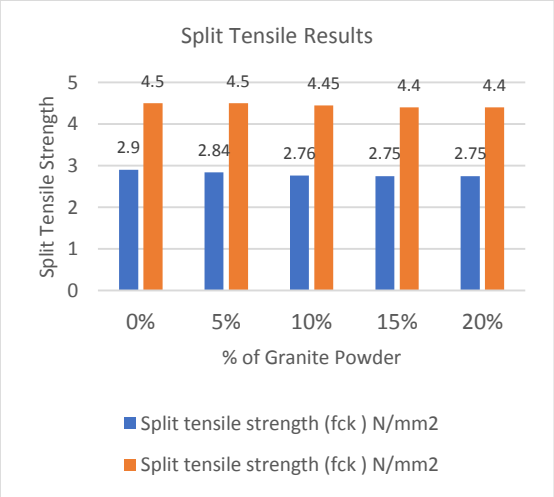

Figure 2: Split tensile strength test results

4.3 Comparison of Flexural Strength Test Results of Prism Beam

The Flexural Strength Test Result of Concrete Cube Specimens for 7 and 28 days are presented in the Table and the comparisons of the results.

Table 4: Flexural strength test results

Addition of granite powder	Flexural strength (f_{ck}) N/mm2	
	7th day	28th day
0%	2.70	4.52
5%	2.81	4.55
10%	3.05	4.6
15%	3.12	4.72
20%	2.31	4.1

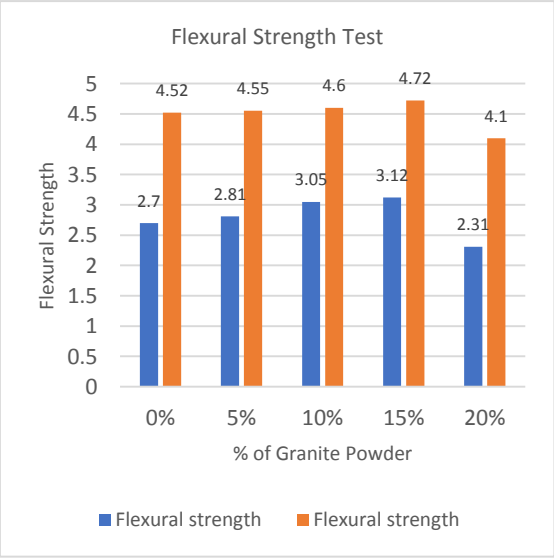

Figure 3: Flexural strength test results

4.4 Result Discussions

The experimental investigation carried out in this study showed that partial replacement of sand in concrete with granite powder improves its compressive strength, flexural strength, and tensile strength. The particle size is vital for the physical and chemical contributions of granite powder in concrete. As the particle size of granite powder is smaller than sand, they were able to fill the voids between sand particles comparable to the way sand particles fill the void among coarser aggregates thus resulting in less voids and higher density and strength. Moreover, because the particle size is smaller than sand, the surface area will be greater. Because of the greater surface area of granite powder compared to sand, the concrete is anticipated to have greater strength due to more bonded areas with hydrating cement. Even though the granite powder normally has a reduced amount of silicon oxide content as compared to sand and not all granite powder may react chemically with cement, the filler effect will bring improvements in the concrete. The test results showed that the greatest gain in compressive strength and flexural strength was with 15% granite powder concrete ratio. Beyond 15%, the increase was less. It appears that beyond this percentage, the filling effect of granite powder is not optimized and hinders the strength of concrete. It means that as the surface area expands, additional hydrating cement is needed to bond these areas. If the water-cement ratio and added admixtures are not enough to hydrate sufficient cement, then the enlarged surface area of granite powder would not all be bonded and consequently less strength was observed with increased ratios of granite powder.

5. Conclusions

Based on the results of this study, the following conclusions can be drawn:

- The concrete mix created using granite powder as partial replacement of sand displayed good workability and fluidity similar to normal concrete mixes.
- The compressive strength of concrete improved when it is added with granite powder as partial replacement of sand. Using 15% granite powder as replacement in concrete gave the top result (maximum increase in compressive strength) compared to other ratios.
- Similar to the observations in the compressive strength, the flexural strength of concrete increased with the addition of granite powder as partial replacement of sand. The maximum increase was observed for 15% GP ratio.
- For the split-cylinder tensile strength, the optimum value of the percentage of in concrete was 15% like flexural and compressive strength. For 20% granite powder in concrete the split tensile strength was actually lower than that of the control mix.
- This study was limited to the evaluation of the mechanical properties of concrete with granite powder as well its workability and fluidity. The longer-term performance of concrete with granite powder was not part of this study. Durability is important for the proper use of this material in structural as well as non-structural applications and will be investigated in a future study.
- This study as well studies in other countries have shown the viability of producing concrete with granite powder byproducts. This will encourage producers and environmental groups to continue collecting and storing these hazardous airborne fines. Life-cycle cost analysis for the use of these materials compared to current concrete material also needs to be addressed in future research.

6. References

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