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Study on utilisation of granite powder waste in concrete

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Abstract

Granite industry cuts the granite rock to slabs based on the requirement of the client, using metal saws, and the fine powder is produced during cutting is considered as solid waste and is being collected. Granite mine industry generates huge amount of waste, during the process of sawing. The granite saw dust comprises of calcium and iron which has the compatibility to acid soils. Use of granite waste found to be effective in the production of concrete for civil construction. In this project work, Granite waste was used as partial substitute in fine aggregate proportions varying from 20% to 40% by weight to cement in concrete. Experiments have been conducted with the collection of materials required and data required for mix design are obtained. The M40 grade concrete is designed as per Indian standard code. The water cement ratio is maintained for this mix design is 0.40. The granite powder wastes was partially replaced with 20%, 30% and 40% in concrete. Cubes, beams and cylinders were casted with these concrete mixes and subjected to curing of 28 days. The effects of Granite Powder waste on mechanical properties of concrete were evaluated through compressive strength, split tensile strength and flexural strength tests. The compressive strength test of concrete showed better results for 30% replacement of granite powder by fine aggregate whereas, the split tensile strength and flexural strength tests of concrete showed better results for 20% replacement of granite powder by fine aggregate.

Keywords: *Granite industry waste, Special concrete, mechanical properties of concrete, industry recycling waste, Granite saw dust, compressive strength, powder.*

1. Introduction

Granite powder is a powdered byproduct obtained from the crushing of granite stones and the polishing of granite stones. It's a prospective pozzolanic substance for usage in concrete, similar to silica fume, fly ash, slag, and other pozzolanic minerals. These items can be used as a filler material (instead of sand) in concrete to reduce void content. It is also generated from recycling marble tops, terrazzo, granite pavers, and stone scraps and discards.

In India about 960 million tons of solid waste is generated annually as bi-product from different industrial processes out of which approximately 350 million tons are from organic agricultural sources, 290 million tons inorganic wastage from industrial mining and 4.5 million tons are hazardous waste. Part of the waste from different industries has been recycled in construction industry as well as other industries. The granite saw dust comprises of calcium and iron which has the compatibility to acid soils, granite waste powder is used as a suitable means to neutralize acid soils. Use of granite and marble rock waste found to be effective in the production of concrete for civil construction. Use of municipal solid waste incinerated fly ash is found to be effective up to 20%, as cement substitute in concrete.

2. Objectives and Methodology

The main objective of this study is to experimentally investigate the suitability of granite powder waste as a substitute material for fine aggregate in concrete production and to enhance the mechanical properties of the concrete. Aimed to study the Physical properties such as Specific gravity, and water absorption test of the granite powder waste as well. The experimental parameter was percentage of granite powder substitution in fine aggregate by weight of cement in concrete. Accordingly, this Project work, has examined M40 grade of concrete cube, beam and cylinder with 20%, 30%, and 40% as replacement of natural sand with granite powder (GP) waste. The effects of GP waste on mechanical properties of concrete were evaluated through compressive strength, split tensile strength and flexural strength tests.

The primary process entails the gathering of raw resources. After that, the IS 10262 – 2019 method is used to apportion the combination. In the next phase, concrete specimens are cast to investigate compression, split, and flexural behavior. In the final step, the results and discussions were carried out.

3. Experimental Program

3.1 Materials

Cement: Cement is the most significant ingredient in concrete manufacture. Changing the cement content of concrete has a substantial impact on its qualities. According to IS 12269 – 1987, ordinary Portland cement of grade 53 was used.

Coarse aggregates: 20 - 10 mm size aggregates are used in this work confirming to IS 383-1970.

Fine aggregates: Fine aggregates with a size of less than 4.75 mm that conform to grading zone II and are certified to IS 383-1970 are used.

Granite Powder: Granite powder waste which is less than 90 microns was collected from BNR stone crushers nearby Vignan institute of technology and sciences. Table 1 summarizes the material qualities.

Table 1 Preliminary tests on materials

Material	Specific gravity	Bulk density	Water absorption
Cement Initial setting time: 98 minutes Final setting time: 4 hours 20 minutes	3..14	-	-
Coarse aggregate	2.70	1700 kg/m^3	0.72%
Fine aggregate River Sand	2.50	1602 kg/m^3	1%
Granite Powder	2.65	1000 kg/m^3	1.5%

3.2 Mix Proportion Quantities and Casting of Specimens:

Concrete mix design is the process of determining which elements to use and how much of each to use in order to produce concrete with the desired strength and characteristics. Every difficulty that emerges in concrete during placement, curing, or other processes will be solved by using the proper mix design. The mix design also aids in the production of cost-effective concrete. Cement is generally more expensive than other concrete elements.

The mix in this project must be designed to provide the requisite grade of concrete with prescribed workability and characteristic compressive strength that are not less than the appropriate values as per IS 10262-2019. The appropriate mix design will be obtained by adjusting the corresponding variables with the different areas in this project. Then we'll be able to get the required mix design.

Table 2 Material proportion for M40 grade concrete (kg/m^3)

Cement	Fine aggregate	Coarse aggregate	Water	Water/cement ratio
465	500	1198	192	0.40

The trail mixes are prepared For M40 grades. For each grade the replacement of materials is stipulated as follows and Shown in Table 3

Table 3 Percentages of Material replacements

Material	Percentage of Replacement
Granite Powder with Sand	0%, 20%, 30% and 40%

Table 4 Shows the mix designations of Trials

Mix	Cement (Kg/m^3)	FA (Kg/m^3)	GP (Kg/m^3)	CA (Kg/m^3)	Water (Lit)
NC	465	0	503.08	1198	192
20% GP	465	100.61	402.46	1198	192
30% GP	465	150.92	352.15	1198	192
40% GP	465	201.23	301.84	1198	192

4. Results and Discussions

The compressive strength of hardened concrete is considered one of the most important properties and is often used as an index of the overall quality of concrete. we have calculated the compression strength, split tensile strength and flexural strength for four samples i.e., normal concrete, 20%, 30% and 40% of granite substituted by fine aggregate concrete in 28 days of curing.

4.1 Fresh Properties of Concrete

The slump cone test, which is in accordance with Indian Standards, is used to measure the workability of fresh concrete. The results of slump cone tests on various mixes are shown in Table 5.

Table 5 Variation of Slump

Mix	Slump (mm)
Normal Concrete	100
20% GP	96
30% GP	92
40% GP	90

4.2 Hardened Properties of Concrete

4.2.1 Compressive Strength

On obtain compressive strength, a crushing load is applied to the cube surface. It's also known as Crushing Strength as a result of this. Below are the compressive strength test results for 28 days of testing. The

moisture content of the water cured specimens is eliminated by surface drying before testing in the CTM. The detailed test findings are provided in Table 6 and are summarized below.

Table 6 Compressive strength of Concrete

S.NO.	% of Granite powder	Load KN	Compressive strength (N/mm²)	% Change
1.	0%	904	40.2	-
2.	20%	1050	46.7	16.2 %
3.	30%	1075	47.8	18.9 %
4.	40%	1032	45.9	14.2 %

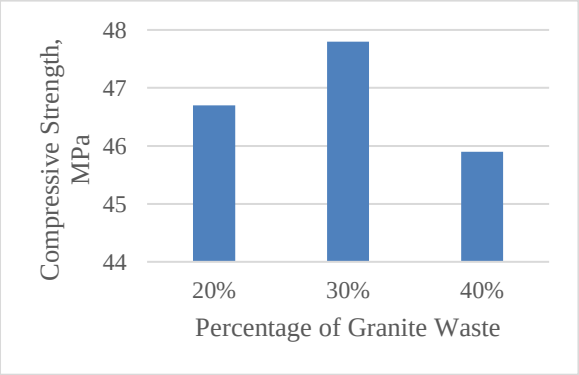

Fig 1 Compressive Strength of concrete

4.2.2 Split Tensile Strength

One of the most important characteristics of concrete is its tensile strength. Tensile strength is measured using cylindrical specimens of 300mm in height and 150mm in diameter. In this lab, each pair of specimens is evaluated for 28 days of curing. The test findings are summarized in detail in Table 7.

Table 7 Split Tensile Strength of Concrete

S.NO.	% of Granite powder	Load KN	Split Tensile strength (N/mm²)	% Change
1.	0%	187	2.64	-
2.	20%	223	3.61	37 %
3.	30%	212	3.0	14 %
4.	40%	197	2.79	6 %

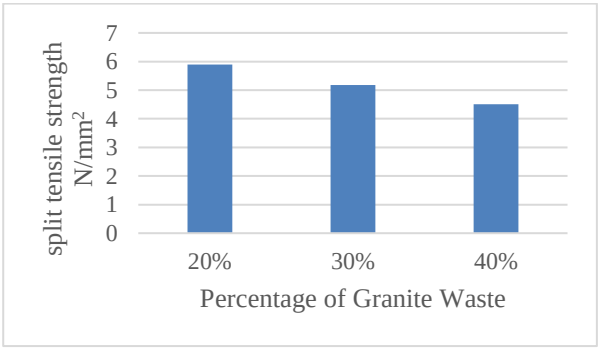

Fig 2 Split Tensile Strength of concrete

4.2.3 Flexural Strength

The rupture modulus of flexural members is the most essential property. Improving the flexural strength of concrete is one of the most essential tasks in today's construction activity. The results of concrete's flexural strength are shown in Table 8.

Table 8 Flexural Strength of Concrete

S.NO.	% of Granite powder	Load KN	Flexural strength (N/mm²)	% Change
1.	0%	31	4.18	-
2.	20%	44	5.89	41%
3.	30%	38	5.18	24%
4.	40%	33	4.51	8%

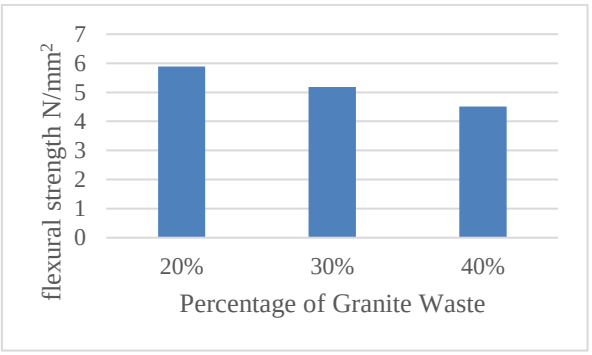

Fig 3 Flexural Strength of concrete

Conclusions

1) The percentage increase of compressive strength of Conventional concrete to 20%, 30% and 40% of partial replacement of granite powder concrete is increased by 16.2%, 18.9% and 14.2% respectively.
2) The percentage increase of split tensile strength of Conventional concrete to 20%, 30% and 40% partial replacement of granite powder concrete is increased by 37%, 14% and 6% respectively.
3) The percentage increase of flexural strength of Conventional concrete to 20%, 30% and 40% partial replacement of granite powder concrete is increased by 41%, 24% and 8% respectively.
4) The compressive strength test of concrete showed better results for 30% replacement of granite powder by fine aggregate.
5) The split tensile strength and flexural strength tests of concrete showed better results for 20% replacement of granite powder by fine aggregate.
6) It was recommended that the replacement of fine aggregate by granite powder waste up to 30 % is favorable for concrete.

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