GRANITE POWDER CONCRETE

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***Abstract*—Granite is an igneous rock which is widely used as construction material in different forms. Granite industries produce lot of dust and waste materials. The wastes from the granite polishing units are being disposed to environment which cause health hazard. This granite powder waste can be utilized for the preparation of concrete as partial replacement of sand. In order to explore the possibility of utilizing the granite powder as partial replacement to sand, an experimental investigation has been carried out. The percentages of granite powder added by weight to replace sand by weight were 0, 5, 10, 15, 20 and 25. To improve the workability of concrete 0.5% Superplasticiser was added. This attempt has been done due to the exorbitant hike in the price of fine aggregate and its limited availability due to the restriction imposed by the government of Tamil Nadu. Fifty four cubes and 36 cylinders were cast. Compressive strength and split tensile strength were found. The test results indicate that granite as replacement sand with granite powder has beneficial effect on the mechanical properties such as compressive strength and split tensile strength of concrete.**

Keywords-Granite Powder, Compressive strength, Split tensile strength, Optimal replacement percentage.

I. Introduction

Fine aggregate is an essential component of concrete. The most commonly used fine aggregate is natural river sand. The global consumption of natural river sand is very high due to the extensive use of concrete. In particular, the demand of natural river sand is quite high in developed countries owing to infrastructural growth. The non-availability of sufficient quantity of ordinary river sand for making cement concrete is affecting the growth of construction industry in many parts of the country. Recently, Tamil Nadu government (India) has imposed restrictions on sand removal from the river beds due to its undesirable impact on the environment. On the other hand, the granite waste generated by the industry has accumulated over years. Only insignificant quantity has been utilized and the rest has been dumped unscrupulously resulting in pollution problems. With the enormous increase in the quantity of waste needing disposal, acute shortage of dumping sites, sharp increase in the transportation and dumping costs necessitate the need for effective utilisation of this waste. The present work is aimed at developing a concrete using the granite scrap, an industrial waste as a replacement material for the fine aggregate. By doing so, the objective of reduction of cost of construction can be met and it will also help to overcome the problem associated with its disposal including the environmental problems of the region. Accordingly this project work will examine M20, M30 and M40 grades of concrete were cast by varying the percentage replacement of sand with granite powder. The cost difference between the conventional concrete and the granite powder concrete required per m^3 were also found.

II. Review of Literature

Felixkala T and Partheeban P (2010) examined the possibility of using granite powder as replacement of sand along with partial replacement of cement with fly ash, silica fume and blast furnace slag. They reported that granite powder of marginal quantity as partial replacement to sand had beneficial effect on the mechanical properties such as compressive strength, split tensile strength and modulus of elasticity. They also reported that the values of plastic and drying shrinkage of concrete with granite powder were less than those of ordinary concrete specimens.

Oyekan G.L and Kamiyo O.M (2008) studied the performance of hollow sandcrete blocks containing cement, sharp sand and granite fines in varying propositions to determine their structural and hygrothermal properties. The percentage of granite fines by volume of the total fine aggregate was varied in steps of 5% to a maximum of 30%. Results of the tests indicated that the inclusion of granite fines in the sand-cement matrix has a very significant effect on the compressive strength of sandcrete blocks. It was also, observed that for both mix propositions, 15% granite fines content was the optimum value for improved structural performance.

Baboo Rai et al (2011) investigated the effect of using marble powder and granules as constituents of fines in concrete by partially reducing quantities of cement as well as other conventional fines. The values of workability, compressive strength and flexural strengths were found. Partial replacement of cement and usual fine aggregates with varying percentage of marble powder (0%,5%,10%,15%,20%) and marble granules revealed that increased waste marble powder (WMP) or waste marble granule (WMG) resulted in increase in workability and compressive strength of mortar concrete.

Shahul Hameed M and Sekar A.S.S (2009) investigated the usage of quarry rock dust and marble sludge powder as possible substitutes for natural sand in concrete. They also carried out durability studies on green concrete and compared with the natural sand concrete. They found that the compressive, split tensile strength and the durability concrete were good when the fine aggregate was replaced with 50% marble sludge powder and 50% Quarry rock dust (Green concrete).The resistance of concrete to sulphate attack was enhanced greatly.

Bahar Demirel **(2010)** investigated the effects of using waste marble dust (WMD) as a fine material on the mechanical properties of the concrete. For this purpose, four different series of concrete-mixtures were prepared by replacing the fine sand (passing 0.25 mm sieve) with WMD at proportions of 0, 25, 50 and 100% by weight. In order to determine the effect of the WMD on the compressive strength with respect to the curing age, compressive strengths of the samples were recorded at the curing ages of 3, 7, 28 and 90 days. In addition, the porosity values, ultrasonic pulse velocity (UPV), dynamic modulus of elasticity and the unit weights of concrete were determined. It was observed that replacement of the fine material passing through a 0.25mm sieve with WMD at particular proportion has displayed an enhancing effect on compressive strength.

Bouziani Tayeb et al (2011) studied the effect of marble powder content (MP) on the properties self compacting sand concrete (SCSC) at fresh and hardened states. Values of slump flow, the V-funnel flow time and viscosity were found on fresh concrete. At the hardened state, the 28th day compressive strength was found. The obtained test results showed that larger MP content in SCSC (350 kg/m^3) improved the properties at fresh state by decreasing V funnel flow time (from 5s 1.5s) and increasing the slump flow values (from 28cm to 34cm). With the use of 250 kg/m^3 of MP, the highest initial viscosity was obtained while retaining good fluidity at high rotational speeds compared to the MP contents of 150 kg/m^3 and 350 kg/m^3. The 28 days compressive strength decreased with an increase of MP content.

Shirule P.A et al (2012) determined the compressive strength and split tensile strength of concrete in which cement was partially replaced with marble dust powder (0%,5%,10%,15%, 20%).The result indicated that the Compressive strength of concrete increased with addition of waste marble powder up to 10% replaced by weight of cement and further addition of waste marble powder was found to decrease the compressive strength. The optimal percentage replacement was found to be 10%.

Hanifi Binici et al (2007) determined the mechanical properties of concrete containing marble dust (MD) and limestone dust (LD). Seven concrete mixtures were produced in three series with control mixes having 400 kg cement content. Fine aggregate was replaced with MD and LD. The replacement percentage of MD was 5 and 10% and it replacement percentage of LD was 15%. The compressive strengths of concrete cubes were found on 7th, 28th, 90th and 360th day. Sodium sulphate resistance was found after 12 months. Also, abrasion resistance and water penetration of concrete were investigated. Results indicated that MD and LD fine aggregate concrete had good workability and abrasion resistance. Abrasion resistance increased as the rate of fine MD and LD is increased. Furthermore, the results indicated that the increase in the dust content caused a significant increase in the sodium sulphate resistance of the concrete.

Shahul Hameed M et al carried out the durability test on chloride penetration test of self-compacting green concrete (SCGC) made with industrial wastes i.e. marble sludge powder (MSP) from marble processing, units and quarry rock dust (CRD) from stone crushing industries by conducting chloride penetration test. They reported that MSP can be used as filler and helps to reduce the total void content in concrete. Consequently, this contributes to improve the strength of concrete. An experimental investigation was also carried out to study the combined effect of addition of MSP and CRD on the chloride penetration of SCGC. From the result it was observed that CRD with 15% MSP was more beneficial than river sand for manufacturing SCGC.

Kanmalai Williams C et al (2008) examined the performance of concrete made with granite powder as fine aggregate. Sand was replaced with granite powder in steps of 0, 25, 50, 75 and 100% and cement was replaced with 7.5%Silica fume, 10% fly ash and 10% slag. They added 1% superplasticiser to improve the workability. The effects of curing temperature at 32^0 C and 1, 7, 14, 28, 56 and 90 days compressive strength, split tensile strength, modulus of elasticity, drying shrinkage and water penetration depth were found. Experimental results indicated that the increase in the proportions of granite powder resulted in a decrease in the compressive strength of concrete. The highest compressive strength was achieved in samples containing 25% granite powder concrete, which was 47.35 KPa after 90 days. The overall test performance revealed that granite powder can be utilized as a partial replacement of natural sand in high performance concrete.

III. Experimental Investigation

A. Materials Used

Cement

The most commonly available Portland cement of 53-grade was used for the investigation. Cement was bought from the same source throughout the research work. While storing cement, all possible contact with moisture was avoided.

Coarse Aggregate

Hard broken granite stones were used as a coarse aggregate in concrete. Size of the coarse aggregate used in the investigation was 10 mm. The specific gravity of the coarse aggregate was found to be 2.68.

Fine Aggregate

In the present work, the concrete mixes were prepared using locally available river sand. The sand used was confining to zone 3. Fineness modulus and specific gravity of the sand were found to be 2.33 and 2.56 respectively.

Water

Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. In general, water fit for drinking is suitable for mixing concrete. Impurities in the water may affect setting time, strength, shrinkage of concrete or promote corrosion of reinforcement. Locally available drinking water was used in the present work.

Admixture

Superplasticiser was used during investigation to improve the workability of concrete. As per Indian Standards, the dosage of superplasticiser should not exceed 2% by weight of cement. A higher dosage of superplasticiser may delay the hardening process. After trails, the optimal dosage of superplasticiser was found to be 0.5% to produce slump of 100 mm

Granite Powder

Granite belongs to igneous rock family. The density of granite is between 2.65 to 2.75 g/cm^3 and compressive strength will be greater than 200 MPa. Granite powder obtained from the polishing units and the properties were found. Since the granite powder was fine, hydrometer analysis was carried out on the granite powder to determine the particle size distribution. From hydrometer analysis it was found that the coefficient of curvature was 1.95 and coefficient of uniformity was 7.82. The specific gravity of the granite powder was found to be 2.61. Table I gives the chemical composition of granite powder.

TABLE I. Constituent of Granite Powder

S. No	Constituent	% present in Granite powder
1	Alumina (Al_2O_3)	14.42
2.	Magnesium oxide (MgO)	0.71
3.	Calcium oxide (CaO)	1.82
4	K_2O	4.12
5.	Na_2O	3.69
6.	Silica (SiO_2)	72.04
7.	Fe_2O_3	1.22

B. Details of Concrete Mix

Mixes of **M_{20}, M_{30}, and M40** grade were designed as per Indian Standard 10262: 2009 and the specimens were caste. During the present study, the fine aggregate was replaced with GP and the percentages of granite powder added were 0, 5, 10, 15, 20 and 25% of fine aggregate. The details of the specimens cast are given in Table II.

TABLE II. Details of the Specimen Cast

S.No	Grades of concrete	% replace ment	No. of cubes cast	No. of cylinders cast
1.	M_{20}	0	3	2
2.	M_{20}	5	3	2
3.	M_{20}	10	3	2
4.	M_{20}	15	3	2
5.	M_{20}	20	3	2
6.	M_{20}	25	3	2
7.	M_{30}	0	3	2
8.	M_{30}	5	3	2
9.	M_{30}	10	3	2
10.	M_{30}	15	3	2
11.	M_{30}	20	3	2
12.	M_{30}	25	3	2
13.	M_{40}	0	3	2
14.	M_{40}	5	3	2
15.	M_{40}	10	3	2
16.	M_{40}	15	3	2
17.	M_{40}	20	3	2
18.	M_{40}	25	3	2

C. Preparation of Test Specimens

The granite powder collected from polishing units was dried. As per the mix proportions, the quantities of various ingredients were weighed. Initially sand and granite powder were mixed thoroughly. Further cement and coarse aggregate were added to the mix. Once all the materials were mixed well, 0.5% of superplasticiser was added to water and water containing superplasticiser was added to the dry mix to form concrete. Cubes of size 150mmX150mmX150mm and cylinder were cast. The specimens were cured in curing tank for a period of 28 days.

D. Test Results

Compressive Strength

The cured specimens were allowed to dry in air. The dried specimens were centred on a compression testing machine of capacity 2000 kN. The load was applied at a uniform rate of 14 kN/mm^2/min. The test setup is shown in Figure 1

Figure 1 Test setup

Split Tensile Strength

Split tensile strength of concrete is usually found by testing plain concrete cylinders. Cylinders of size 150mm x 300 mm were used to determine the split tensile strength. After curing, the specimens were tested for split tensile strength using a calibrated compression testing machine of 2000kN capacity.

The values of the compressive strength and the split tensile strength are given in Table III, Table IV and Table V respectively for M_{20}, M_{30} and M_{40} concrete.

TABLE III. Test Results of M_{20} Grade Concrete at 28th Day

S.No	Granite Powder Replacement (%)	M_{20}	
		Compressive strength (N/mm^2)	***Split tensile strength (N/mm^2)***
1.	0	25.81	2.05
2.	5	26.96	2.14
3.	10	29.70	2.44
4.	15	32.20	2.95
5.	20	31.30	1.40
6.	25	25.50	1.27

TABLE IV. Test Results of M_{30} Grade Concrete at 28th Day

S.No	Granite Powder Replacement (%)	M_{30}	
		Compressive strength (N/mm^2)	***Split tensile strength (N/mm^2)***
1.	0	31.08	2.62
2.	5	32.11	2.71
3.	10	33.03	2.99
4.	15	35.47	3.39
5.	20	33.51	1.98
6.	25	30.07	1.84

TABLE V. Test Results of M_{40} Grade Concrete at 28th Day

S.No	Granite Powder Replacement (%)	M_{40}	
		Compressive strength (N/mm^2)	***Split tensile strength (N/mm^2)***
1.	0	40	3.39
2.	5	46.67	2.26
3.	10	50.07	2.83
4.	15	53.33	3.51
5.	20	44.00	3.32
6.	25	38.81	3.04

The variations in the compressive strength and split tensile strength of M20 concrete with respect to percentage replacement are shown in Figure 2 and Figure 3 respectively.

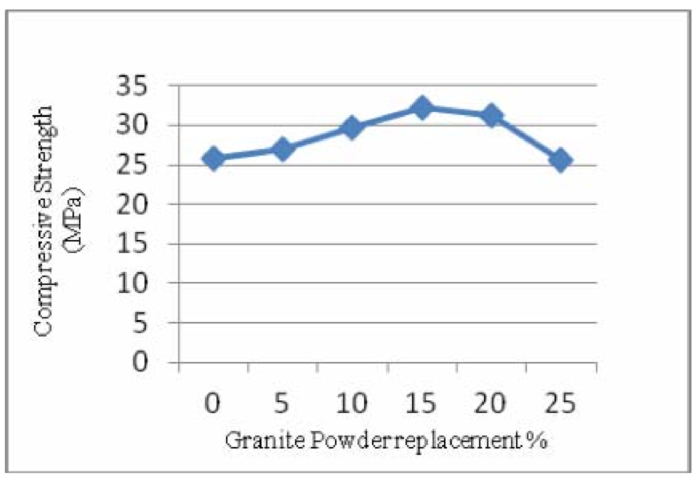

Figure 2 Compressive Strength of M_{20} concrete at 28th Day

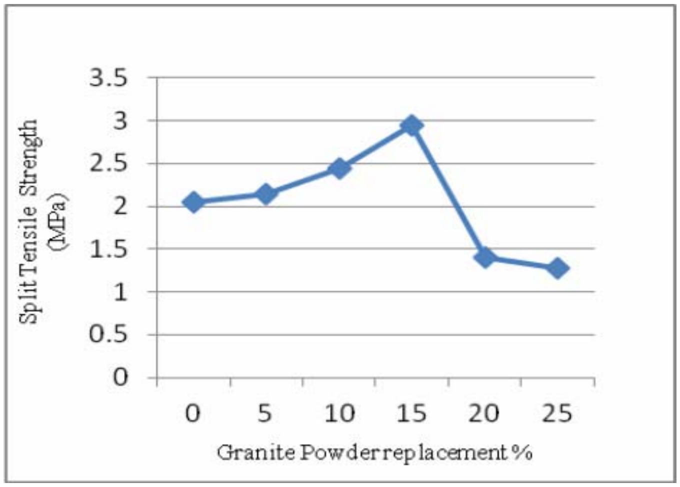

Figure 3 Split Tensile Strength of M20 concrete at 28th Day

The variations in it compressive strength and split tensile strength of M_{30} concrete with respect to percentage replacement are shown in Figure 4 and Figure 5 respectively

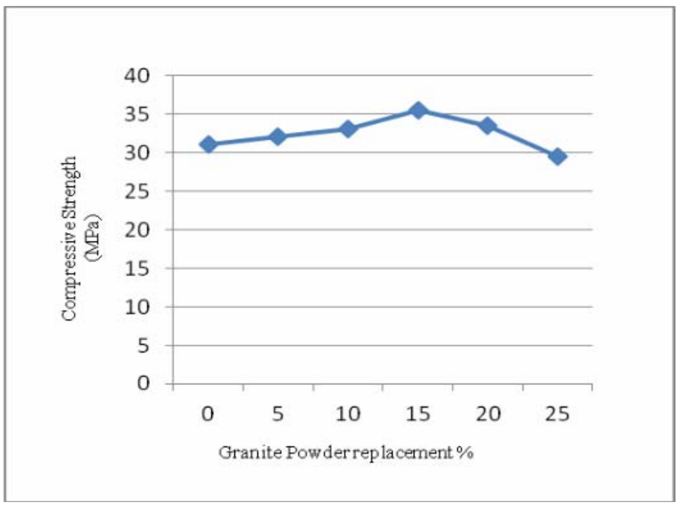

Figure 4 Compressive Strength of M30 concrete at 28th Day

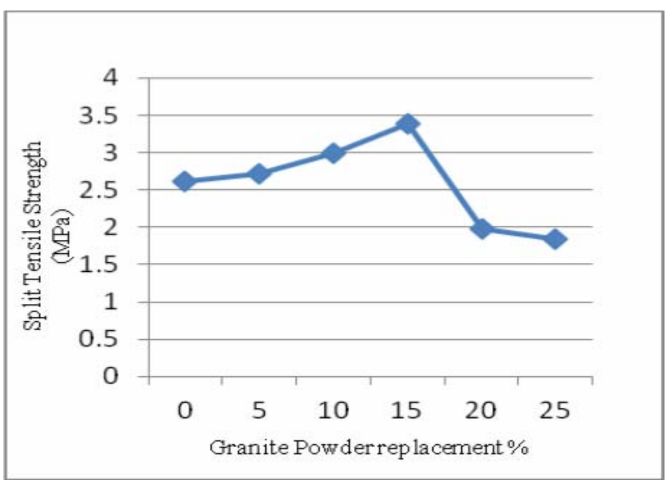

Figure 5 Split Tensile Strength of M30 at 28th Day

The variations in it compressive strength and split tensile strength of M40 concrete with respect to percentage replacement are shown in Figure 6 and Figure 7 respectively.

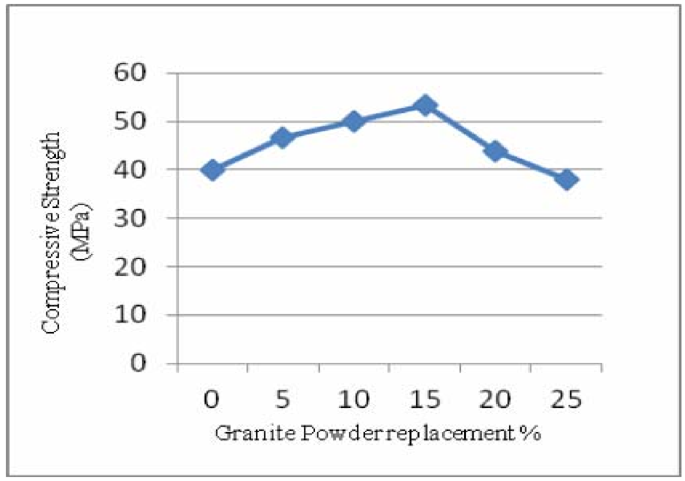

Figure 6 Compressive Strength of M40 concrete at 28th Day

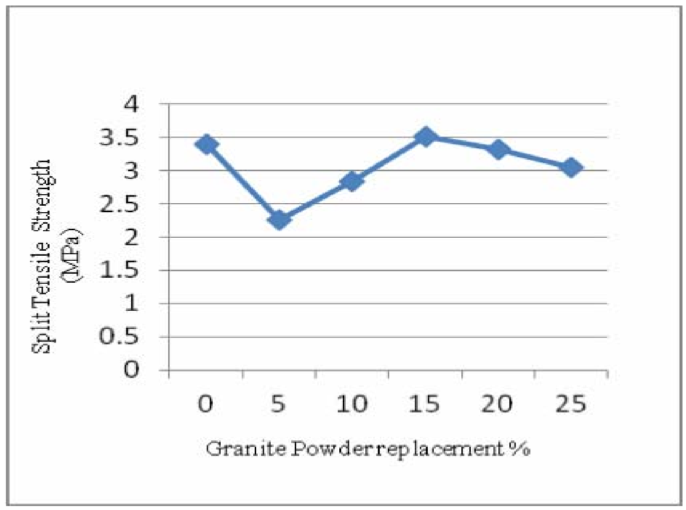

Figure 7 Split Tensile Strength of M40 concrete at 28th Day

From the figures, it can be seen that granite powder improves the compressive and split tensile strengths of concrete. As the percentage replacement of sand with granite powder increases, the compressive and split tensile strengths increase, reach a maximum value and then decrease.

IV. Conclusions

Replacement of fine aggregate with granite powder is found to improve the strength of concrete. The optimal dosage of replacement is found to be 15%. Utilization of granite powder will avoid the disposal problems and related environmental issues. Utilization of granite powder will reduce the usage of river sand and conserve natural resources.

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