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Experimental Investigations on the Effective Utilization of Granite Powder in Self Compacting Concrete

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Abstract: ***Concrete is most widely used construction material. Traditionally concrete is made up of cement, river sand as fine aggregate, crushed stone aggregate as coarse aggregate and potable water. Concrete has to be heavily vibrated for flow into very intricate forms or forms that have a lot of reinforcing bars. Hence to overcome these defects the self-compacting concrete is used. The self compacting concrete is a flowing concrete mixture that is able to consolidate under its own weight. The self compacting concrete flows easily at suitable speed into formwork without blocking through the reinforcement without being heavily vibrated. A well designed SCC mix does not segregate, has high deformability and excellent stability characteristics. River sand is one of the main ingredients used as a fine aggregate in concrete production. Nowadays, river sand is not readily available for use in many places. Instead of natural river sand, crusher sand or manufactured sand obtained from stone aggregate quarries is widely used as fine aggregate in concrete. Granite powder is a waste material obtained from granite processing industries. These materials have potential application as the replacement of fine aggregate in concrete. This study deals with the self compacting concrete where fine aggregate (M-Sand) is partially replaced with granite powder. Here M-Sand is partially replaced with 10%, 20% and 30% of granite powder. Experimental work on various proportions of concrete mixes was done and the Fresh and Hardened properties of self compacting concrete are obtained.***

Keywords: Granite Powder, River Sand, M-Sand, Concrete, Percentages, self compacting concrete, Replacement

1. Introduction

Granite it is the plutonic igneous rock because it is formed due to solidification of magma at great depths. The word "granite" comes from the Latin granum. It is a holo crystalline and leucocratic rock because it is completely crystalline and light colored rock. It is acidic rock because it is very rich in silica content (nearly 72%). Granite is compact, dense, massive and hard rock. Granite is mainly composed of only primary minerals such as feldspar and quartz. Granite is generally medium to coarse grained rock. The granitic rocks which are of deep seated origin are seen on the earth's surface because of long, continued erosion for millions of years of overlying rocks or tectonic activity Concrete is the single most widely used construction material in the world today. It is used in buildings, bridges, sidewalks, highway pavements, house construction, dams, and many other applications. The key to a strong and durable concrete are the mix proportions between the various components. Less cement paste can lead to more voids, thus less strength and durability while more cement paste can lead to more shrinkage and less Durability. The gradation and the ratio of fine aggregates to coarse aggregates can affect strength and porosity. The mix design should also achieve the desired workability of concrete so as to prevent segregation and allow for ease of placement. Granite powder is an industrial byproduct obtained from crushing of granite stone and granite stone polishing industry in a powder form. It is also generated from recycling marble tops, terrazzo, granite pavers, and stone scraps and Discards. If left on its own and is not properly collected and stored, the fine granite powder can be easily be airborne and will cause health problems and environmental pollution. Inhalation of granite powder fine particles is a health hazard and is a cause of lung diseases especially for people living near granite mills. In this present work, granite powder is used as partial replacement of sand in concrete in different percentage and the associated compressive strength, and splitting tensile strengths of concrete have been evaluated. By doing so, natural resources of sand can be preserved and the health hazards of these industrial wastes are minimized. Granite waste powder is obtained from the crusher units in the form of finer fraction in slurry form. This is a physical mechanism owing to its spherical shape and very small in size, granite powder disperses easily in presence of super plasticizer and fills the voids between the quarry sand, resulting in a well packed concrete mix.

2. Objectives

- ❖The objective of this project is to assess the feasibility of utilizing a granite industry waste as a replacement for fine aggregate/ M- sand in normal concrete production and to evaluate the durability properties to ensure the reliability of its usage in aggressive environments.
- ❖The main objectives of this investigations is to determine the suitable percentages of granite powder replacement and influence of different proportioning of super plasticizer in SCC that gives the highest values of concrete.
- ❖To arrive a design mix for SCC with M sand as fine aggregate.
- ❖The influence of granite powder on fresh and hardened properties of a Self Compacting Concrete.

3. Experimental Program

In this investigation, 24 cubes, 12-cylinder are tested to investigate concrete compressive strength and split-tensile strength of SCC with fly ash and different proportioning of granite powder with the replacement of fine aggregate (M-Sand). All test specimen of cube with 100mm x 100mm size and cylinder with diameter of 100mm and 200mm in length.

3.1 Materials and their Properties

3.1.1 Material Used

1. Cement
2. Coarse aggregate
3. Fine aggregate
4. Granite powder
5. Fly Ash
6. Super plasticizer – PCE, Water

3.1.2 Cement

Cement acts as a binding material in concrete. Ordinary Portland cement of 53 grade confirming to IS: 12269-1987 is used in this experiment. The physical properties of the cement obtained on conducting appropriate tests as per IS: 269/4831 and the requirements as per IS 12269-1987 are given in table 1.

Figure 1: Cement

3.1.3 Coarse Aggregate

Aggregates are composite material. The coarse aggregate used in the nominal size of 12 mm, crushed angular and free from saw dust. The tests conducted on coarse aggregates are given in table 1.

Figure 2: Coarse aggregate

3.1.4 Fine Aggregate (M-Sand)

In the present work, the concrete mixes were prepared by using locally available manufactured sand. The sand used was confining to zone 2 (IS 383). The tests conducted on Fine aggregates (M-Sand) are given in table 1.

Figure 3: Fine aggregate

3.1.5 Granite Powder

Granite powder is a general type of igneous rock. It is a waste material from the granite polishing industry, which forms during the sawing, shaping and polishing processes of granite. The wet granite sludge was dried up prior to the preparation of the samples. It has been used in this experimental work. It can be used as a filler material (partial replacement of sand) to reduce the void in concrete. The tests conducted on Granite Powder (GP) are given in table 1.

Figure 4: Granite Powder

3.1.6 Fly Ash

The flow ability of self compacting concrete depends on the powder and paste content. Hence, in order to increase the flow ability, mineral admixtures such as fly ash (class –F type). The tests conducted on Granite Powder (GP) are given in table 1.

Figure 5: Fly Ash

3.1.7 Water

Portable water is used for both concrete mixing and curing. The most recommended water should be free from salts, organic matter, oils, saw dust and other Impurities materials. The pH value should be lies in between 6 to 8.

3.1.8 Super Plasticizer (SP)

The super plasticizer used in our project is Poly carboxylate–ether (Glenium 8233), it is a high performance super plasticizer intended for applications where increased workability and high fluidity is required. Table-2 gives the properties of PCE.

Figure 6: PCE

Table 1: Properties of Materials

Materials	Properties	
Cement	Specific gravity	3.15
	Initial setting time	30 min
	Final setting time	288 min
M-Sand	Specific gravity	2.76
	Fineness modulus	2.62
	Water Absorption	0.80%
	Bulk density	1800 kg/m^3
Coarse aggregate	Specific gravity	2.72
	Fineness modulus	6.075
	Water Absorption	0.60%
	Bulk density	2200 kg/m^3
Granite powder	Specific gravity	2.66
	Fineness modulus	2.71
	Water Absorption	1.01
	Bulk density	1750 kg/m^3
Fly ash	Colour	Whitish Grey
	Bulk density	1.2 g/cc
	Specific gravity	1.9 to 2.0
	Fineness	2000 to 2200 cm/g

Table 2: Properties of PCE

Appearance	Values
Basis	Polycarboxylate-ether(glenium 8233)
Density	Approx. 1.10
pH	Approx. 6.5
Dosage limit	0.6 – 2.0% by weight of cement

4. Mix Proportioning Procedures for SCC

Several methods exit for the mix design of SCC. The general purpose mix design method was first developed by Okamura and Ozawa (1995). The mix design is done as per the EFNARC guidelines. In this study, the key proportions for the mixes are done by volume. The Detailed steps for the mix design are described as follows.

- ❖Designation of desired air content
- ❖Determination of coarse aggregate content
- ❖Determination of mortar content
- ❖Determination of fine aggregate content
- ❖Determination of paste content
- ❖Calculation of water binder ratio and super plasticizer dosage
- ❖Determination of powder content.
- ❖Determination of water content
- ❖Trial Mix Proportion

Table 3: Mix proportions of SCC

Materials	CC	10%	20%	30%
Water	196	196	196	196
Total powder	551	551	551	551
Cement	386	386	386	386
Fly ash	165	165	165	165
M-Sand	841	756.9	672.8	588.7
Granite powder	0	84.1	168.2	252.3
Coarse aggregate	785	785	785	785
SP (PCE)	0.7%	0.7%	0.7%	0.7%
W/P ratio	1.02	1.02	1.02	1.02
Coarse aggregate volume of ratio	47%	47%	47%	47%

be struck off, and any concrete remaining on the base plate should be removed. After a short rest (no more than Table 4 gives the list of test methods for workability properties of SCC based on the EFNARC Specifications and guidelines. Table 5 gives the typical acceptance criteria for SCC.

Table 4: EFNARC Specifications and guidelines

S. No	Methods	Property
1	Slump flow	Filling ability
2	T_{50cm} slump flow	Filling ability
3	V funnel	Filling ability
4	L box	Passing ability
5	j- ring	Passing ability

Table 5: Typical acceptance criteria for SCC

S. No	Method	UNIT	Range of Value	
			Min	Max
1	Slump flow	mm	600	800
2	T_{50cm} slump flow	Sec	2	5
3	V funnel	Sec	8	12
4	L box	Sec	0.8	10
5	j-ring	mm	0	10

5. Testing of Fresh and Hardened Concrete

5.1 Testing of Fresh Concrete

5.1.2 Slump Cone Test

The slump flow measures the flow spread. It indicates the free, unrestricted deformability within a defined flow distance. The slump cone has 20 cm bottom diameter, 10 cm top diameter and 30 cm in height. Fill the cone with the sample from the bucket without any external compacting action such as rodding or vibrating. The surplus concrete above the top of the cone should 30 seconds), lift the cone perpendicular to the base plate in a single movement, in such a manner that the concrete is allowed to flow out freely without obstruction from the cone. The subsequent diameter of the spread is blocking and/or segregation do not take place the flow time of the V-funnel test is to some degree related to the plastic viscosity. Fill the funnel completely with a Measured in two perpendicular directions. The tests results on slump cone are given in table 6.

Figure 7: Slump Cone

5.1.3 T_{50} CM Slump Flow Test

The procedure for this test is same as for slump flow test. When the slump cone is lifted start the stop watch and find the time taken for the concrete to reach 500 mm mark. This time is called T50 time. This is an indication of rate of speed of concrete. A lower time indicates greater flow ability. The tests results on T50 cm slump cone are given in table 6.

5.1.4 L-Box Test

Fill the vertical part of the L-box with fresh concrete. Now the sliding gate is lifted and the concrete flows from the vertical part to the horizontal part. The height of the section at the end of the horizontal section represents h2 (mm) and the height of the vertical section represents h1 (mm). The ratio of h2/h1 is known as blocking ratio. The tests results on L-box are given in table 6.

Figure 8: L –Box

5.1.5 V-Funnel Test

The V-funnel flow time is the period a defined volume of SCC needs to pass a narrow opening and gives an indication of the filling ability of SCC provided that representative sample of SCC without applying any compaction or rodding. Remove any surplus of concrete from the top of the funnel using the straight edge. Open the gate after a waiting period of (10 ± 2) seconds. Start the stopwatch at the same moment the gate opens. Look inside the funnel and stop the time at the moment when clear space is visible through the opening of the funnel. The stopwatch reading is recorded as the V-funnel flow time. Do not touch or move the V-funnel until it is empty. The tests results on V-funnel are given in table 6.

Figure 9: L –Box

5.1.6 J-Ring Test

The J-Ring test, in conjunction with the Slump- Flow test, is one way to determine the passing ability of SCC, defined as the ability of the concrete to flow under its own weight to completely fill all spaces within the formwork. Depending upon the procedure selected, a modified slump cone is positioned either inverted or upright in the middle of the J-Ring and filled with concrete in a single lift. The cone is then lifted straight up and the diameter of the resulting circular flow of concrete is measured. A similar test is then run without the J-Ring in place and the difference in the flow diameters is recorded as the passing ability. Additional measurements or visual classifications may also be determined at the conclusion of the test. The tests results on J-ring are given in table 6.

Figure 10: J-Ring

Table 6: Fresh property test results of SCC

Name of the Mix	Slump Cone mm	T_{50} CM SC sec	L-Box mm	V-F sec	J-Ring mm
C.C	670	4	0.8	9	9
C.C+10%	650	4.56	0.8	11.45	7
C.C+20%	680	3.54	0.9	10.23	5
C.C+30%	660	5	0.82	9.54	6

6. Preparation of Specimens

6.1 Casting

Mix is tested in fresh state to suit the requirements of SCC and Specimens are casted for normal SCC and various replacements of Granite Powder for M-Sand with 10%, 20%, 30% respectively. Specimens are casted in the mix satisfying the conditions of SCC in the fresh state and are allowed for a curing period of 28 days. As casting of specimens were done soon as mixing was completed, For every different mix 2 set of specimens such as cubes, cylinders were cast. After casting, all the specimens were stored at the laboratory environment and de moulded after 24 hours.

Figure 11: Casting

6.2 Curing

Cube Specimens were cured in water for 7 and 28 days and Cylinder Specimens were cured in water for 28 days. The water used for curing should be in a PH value of 7.

Figure 12: Curing

6.3 Testing of Hardened Concrete

After curing for three cubes were tested in 7 and 28 days and three cylinders were tested in 28 days only. The tests include Compressive Strength Test, Split Tensile Strength Test.

6.3.1 Compressive Testing Machine

Compressive strength test is the most common test conducted on hardened concrete. Cube specimens of size 100mm x 100mm x 100mm were cast for finding the compressive strength after curing for 7 and 28 days. Then the specimen was placed between the jaws of compression testing machine of 2000kN capacity. Compressive load was given till the specimen failed. The failure load was noted as shown in the display of CTM. The compressive strength of three cubes was calculated from the average failure load of cubes.

Figure 13: Compression Strength Test

6.3.2 Split Tensile Strength Test

Split Tensile Strength was used to determine the tensile strength of concrete. Cylindrical specimens of size 150 mm diameter and 200 mm height were used in this test. For each mix 3 specimens were cast and cured for 28 days. Tensile strength test was carried out in a 2000 kN capacity compression testing machine in which the specimens were placed in such a way that its axis was horizontal. The load was applied uniformly at a constant rate until failure by splitting along the vertical diameter took place. The failure load was recorded and the splitting tensile strength was computed.

Figure 14: Tensile – Strength Test

7. Results and Discussions

7.1 General

The test results of compressive strength, split tensile strength results are given below;

7.2 Compressive Strength Test

Chart 1 show the results of various compression tests. The compression test was conducted on various specimens with different replacement(10%, 20%, 30%). Compressive strength of concrete cubes at an age of 7 and 28days.

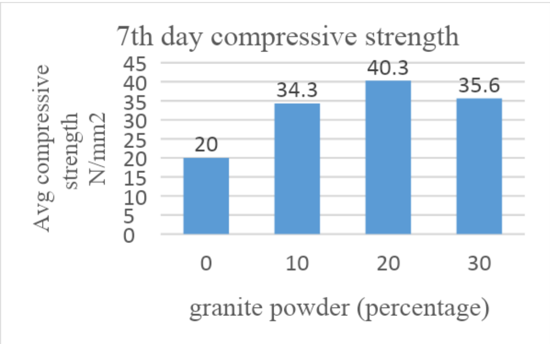

Figure 15: 7th day compressive strength

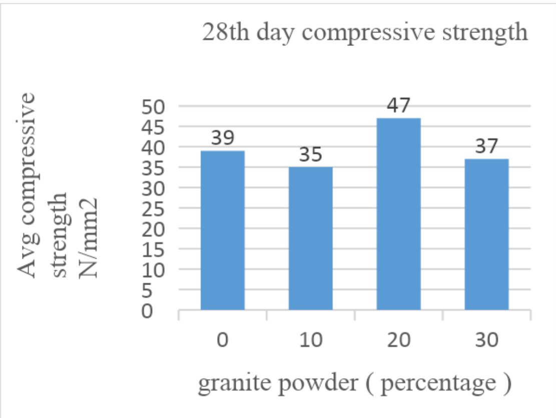

Figure 16: 28th day compressive strength

7.3 Split Tensile Strength Test

Chart 2 shows the results of split tensile strength for various specimens with different proportions. Split tensile strength results at an age of 28 days.

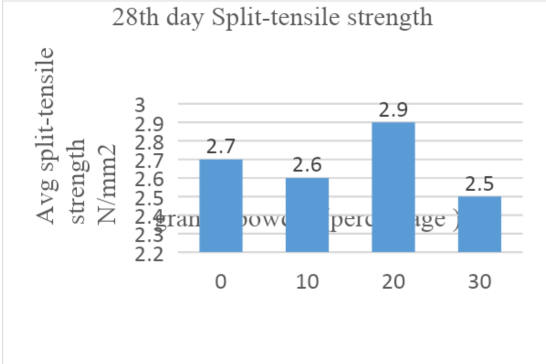

Figure 17: 28th day Split-tensile strength

8. Conclusions

- ❖M-Sand can be effectively used as fine aggregate to produce self compacting concrete.
- ❖Effect of granite powder on fresh property and hardened properties of concrete.
- ❖The slump value of concrete mixture was decreased when M sand was replaced with Granite powder compared to control concrete mix. The slump was maintained as constant value of 800 mm by increasing the dosage of super plastizers to get the medium workability for pumped concrete.
- ❖Passing ability and segregation resistance are good for replacement of 20% of granite powder and they are within the limits of EFNARC guidelines.
- ❖The compressive strength and Split tensile strength of concrete for the replacement of 20 % Granite powder (GP10) was more than the control mix (GP 0) at all the ages. The strength for the remaining mix proportions was reduced slightly compared to control mix due to the presence of fine particles.
- ❖Compared to conventional concrete 20% of replacement granite powder with M-Sand shows increases in strength at 28 days and SCC with 10%, 20% and 30%.
- ❖ Hence based on the above conclusions, the replacement of granite powder in M-sand up to 20% was appropriate to produce Self Compacting Concrete.

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