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Performance of Self Compacting Concrete with Replacement of Granite Powder as Fine Aggregate

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Abstract - *Concrete is the most predominantly used construction material in the world. The main binding ingredient of concrete that is ordinary Portland cement is a major contributor to global warming. The cement industry is the second-largest producer of greenhouse gas. The total world production of cement is expected to be around 4800 Mt by 2030, which indicates the like impact on global warming indicates. In this regard, Utilization of industrial by-products from various industries as a supplementary cementitious material in concrete along with cement has been well recognized for its enhanced properties and potential to reduce environmental impacts. Most of the works on Granite powder based Self Compacting Concrete (SCC) reveals that hardening is due to heat curing. Recent studies on the various properties of heat-cured have shown its suitability for applications such as precast concrete members. The heat curing process requires special arrangements, which is energy consuming and may not be feasible to apply in cast-in-situ concreting. Therefore, the development of self-compacting concrete suitable for curing at ambient temperature will widen its application to concrete structures.*

SCC is a special type of concrete which can be placed and consolidated under its own weight without any vibration and which at the same time is cohesive enough to be handled without segregation or bleeding. It is a relatively new binder, which can be a sustainable and economical binding material as it is produced from a combination of industrial by-products such as Granite powder replacing 10% of fine aggregate in concrete. The Setting mechanism of the SCC is depended on the polymerization process. Nowadays, the demand for natural sand is very high. This project will discuss the properties of the SCC when the fine aggregate is partially replaced with fine aggregate. It is not only cost effective but, also facilitates the safe disposal of industrial waste, hence protects the valuable land from pollution and ambient curing also save the energy required for oven curing. Greenhouse gas emission potential will be reduced as much as 90 percent when compared with Ordinary Portland Cement.

***Key Words*: Granite Powder, Self-Compacting Concrete, Compressive Strength, Spilt Tensile Strength, Flexural Strength.**

1. INTRODUCTION

Concrete is a composite construction material, composed of cement (commonly Portland cement) and other cementitious materials such as fly ash and slag cement, aggregate generally a coarse aggregate made of gravels or crushed rocks such as limestone, or granite, plus a fine aggregate such as sand, water, and chemical admixtures. Unlike the conventional concrete, self- compacting concrete doesn't require compacting using external force from mechanical equipment such as an immersion vibrator; instead SCC is designed in such as way that it gets compacted using its own weight and characteristics. Once applied, the self-compacting property enables the concrete to fully reinforce around the steel structures and completely fill the space within the framework. The self-compacting of concrete is achieved without losing any kind of strength or change in properties.

Since its introduction in the later years of 1980's Self Compacting Concrete(SCC) has brought a revolutionary change in construction industry. Since the production process is much easier than the conventional concrete, it is widely used in mass concreting works, bridge constructions, metro rail constructions. The quality of produced with SCC is much better than the ordinary concrete. SCC mixes always contain a powerful superplasticizer and often use a large quantity of powder materials and/or viscosity-modifying admixtures. The superplasticizer is necessary for producing a highly fluid concrete mix(low yield value). Self-Compacting Concrete is considered to be a concrete which can be placed and compacted under its own self weight with little or no vibration effort and which is at the same time cohesive enough to be handled without any segregation or bleeding. Granite is an igneous rock which is widely used as construction materials in different forms. Granite industry produce lot of waste materials. According to this study the replacement of granite powder for sand and the addition of admixtures to make self-compacting concrete.

1.1 Need for this study

Granite belongs to igneous rock family. Granite powder is used as a secondary material for fine aggregate. Granite powder is obtained from the granite cutting industry. The semi liquid substance released from the polishing process was termed as granite slurry, which will be stored in tanks and allowed for evaporation. Granite powder is a waste product obtained during the process of sawing of granite rocks in granite industries. As this granite dust is creating many environmental hazards, its disposal is a great problem. Self-compacting concrete contains a large quantity of powder materials which is required to maintain sufficient yield value of the fresh mix and hence reducing bleeding, segregation and settlement. Hence, it is worthwhile to investigate the influence of granite powder in SCC as filler.

1.2 Objectives of the study

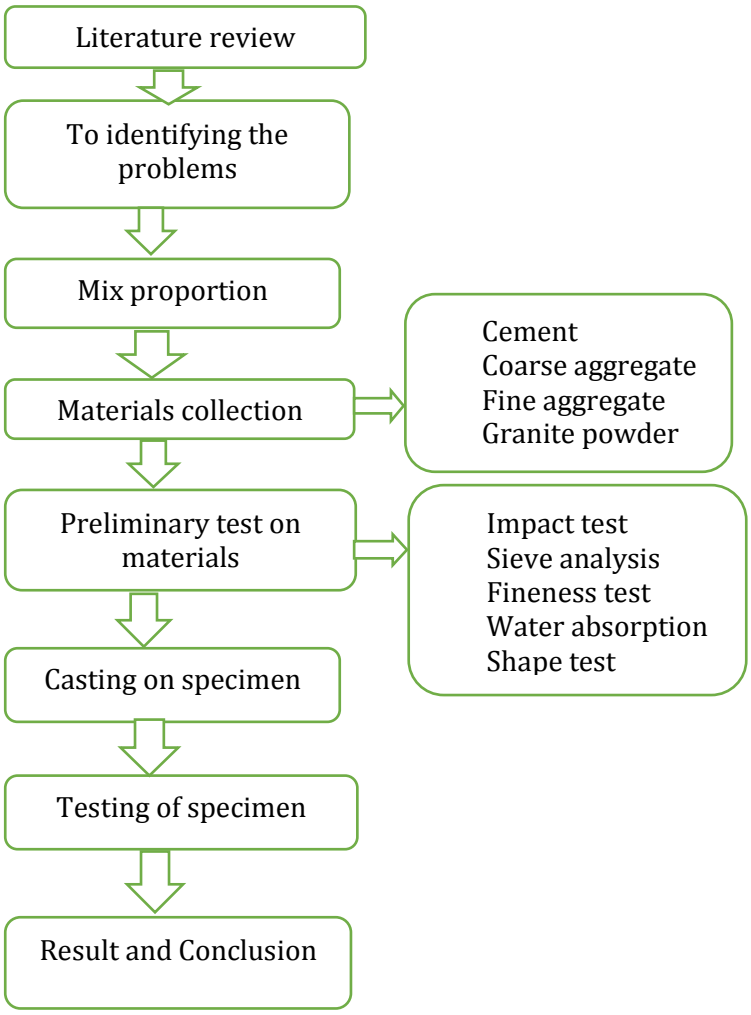
The main objective of this experimental investigation is to study

- To known the fresh concrete properties of Granite waste concrete
- Physical properties of granite powder waste for its possible use as powder in SCC.
- To analyze and forecast the size of the global self-compacting concrete market, space in term of value.
- To identify significant trends and factors that may drive or restrains the growth of the market.
- The influence of Granite powder on fresh and hardened properties of SCC.

1.3 Scope of the work

- According our test result we can replace ordinary concrete to self compacting concrete.
- The use of SCC has been gaining momentum and the SCC market is expected to grow 5.7% annually.
- SCC gives flexibility to both the engineers as well as architects to design and construct complicated structures, without having to compromise on quality and durability.
- With the increasing population, the need for high rise building would be inevitable which in turn would make SCC a necessity.

2. METHODOLOGY



3. Material used

3.1 Cement

A cement is a binder, a substance used for construction that sets, hardens, and adheres to other materials to bind together. Some tests were conducted such as consistency test, specific gravity test and setting time tests.

Fig -1: Cement

Table -1: Properties of Cement

Property	Test results
Normal consistency	28%
Specific Gravity	3.15
Initial setting time	110 minutes
Final setting time	300 minutes

3.2 Coarse Aggregate

Aggregate is a granular material, such as sand, gravel, crushed stone, crushed hydraulic cement concrete used with a hydraulic cementing medium to produce either concrete or mortar. The aggregate of each type is further sub-divided into many types of classification based on its size. Crushed stones of size 20mm aggregates were used as the coarse aggregates in the concrete mixtures.

Fig -2: Coarse Aggregate

Table -2: Properties of Coarse Aggregate

Characteristics	Test results
Specific Gravity	2.68
Water Adsorption	0.55%
Bulk density in loose state	1450 kg/m^3
Bulk density in compacted state	1670 kg/m^3

3.3 Fine Aggregate

Fine aggregates is used an artificial material of M-Sand. The manufacture sand is crushed aggregate products from granite stone it to be used as a replacement of river sand. Now-a-days good sand is not readily presented. The Fine Aggregates day by day demand in construction sector. Natural sand is an alternative material for M-Sand. Fine aggregate used in this experimental work is locally available river sand, care is taken to see that the sand is free from impurities, waste stones and to remain clean. Sand used is confirming to the requirements of IS: 383-1970.

Fig -3: Fine Aggregate

Table -3: Properties of Fine Aggregate

Characteristics	Test results
Specific Gravity	2.69
Water Adsorption	0.65%
Fineness modulus	2.60
Bulk density in loose state	1420 kg/m^3
Bulk density in compacted state	1650 kg/m^3

3.4 Granite Powder

Granite stone is highly demanded by construction sector. In the processing stage, great amounts of waste powder are produced that can be used as fine aggregate in concrete. Granite belongs to igneous rock family. Granite powder is used as a secondary material for fine aggregate. Granite powder is obtained from the granite cutting industry. The semi liquid substance released from the polishing process was termed as granite slurry, which will be stored in tanks and allowed for evaporation. The material obtained after evaporation will be termed as granite powder. The specific gravity of granite powder determined is 2.50.

Fig -4: Granite Powder

4. Experimental study

Concrete was first designed by absolute volume batching method, which assumes that the volume of compacted concrete is equal to the sum of the absolute volumes of all ingredients.

The mix is designed for M50 grade concrete with a w/c ratio of 0.43 to get a minimum slump of 550mm. In this study trial mixes are done for different paste volumes to achieve SCC and also to get an ideal mix with good strength. Superplasticizer is used to achieve good slump. In this study granite powder is used as filler for good bonding in concrete. In each varying VP (Volume of Paste) the cement and water is kept constant but only the granite powder is varied. Use of GP help to achieve SCC easily and also arrests segregation and bleeding in this process.

Table -4: Mix proportion of concrete

Ingredients (kg/m^3)	***0%***	10%	***20%***	***30%***
Fine aggragate	554	443	333	225
Coarse aggragate	1294	1294	1294	1294
Granite powder	0	110	225	333

4.1 Specimen testing

After the curing period, specimen testing is performed 7days, 14 days and 28 days. Test will be conducted for compression strength for cubes (150mmx150mmx150mm), split tensile test for cylinders (150mm diameter x 300mm height) and flexural test for prisms (100mmx100mmx400mm) as per IS 516-1959.

Fig -5: Casting on specimen

5. Test Result

5.1 Compressive Strength

Compressive strength is the capacity of a material or structure to withstand loads tending to reduce size, as opposed to tensile strength, which withstands loads tending to elongate. Compressive strength is the ability of material to carry the loads on its surface without any crack or deflection. The cube specimen as tested in compressive testing machine having 2000kN capacity. The strength of the concrete increases with age. The test result of 7 day,14 day and 28 day compressive are shown in Table-5. In this 59.9 is maximum strength at 28 days.

Fig -6: Compressive strength test

5.2 Split tensile strength

Splitting tensile strength test on cylinder is a way to determine tensile strength. Determine the load concrete may crack. Concrete was tested on 150mmx300mm cylinder at the period of 7 day,14 day and 28 day. The split tensile strength of the concrete shows a similar behavior like the compressive strength. Replacement of sand with granite powder improves the spilt tensile strength of the concrete. The cylinder specimen as tested in compressive machine having 2000kN capacity. The result of 7th day,14th day and 28thday determines that the load concrete may crack will happen are shown in Table-5. In this 5.65 is maximum strength at 28th days.

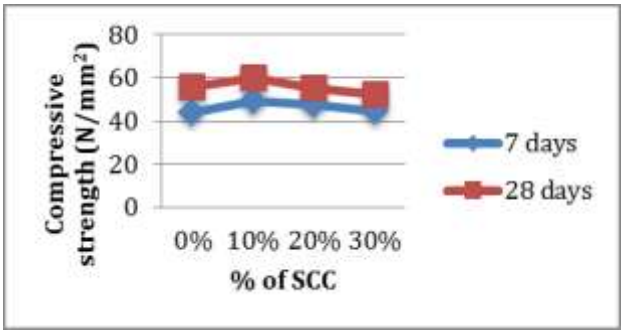
Fig -7: Split tensile strength test

Table -5: Mechanical properties of SCC

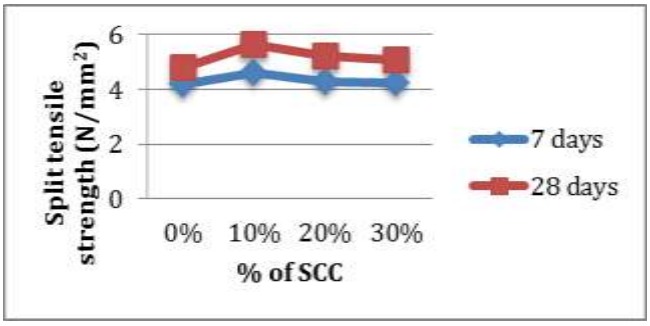
	Age	SCC 0%	SCC 10%	SCC 20%	SCC 30 %
Compressive strength (MPa)	7	44	49	47.6	44.3
	28	56	59.9	55	52
Split Tensile strength (MPa)	7	4.2	4.6	4.3	4.25
	28	4.8	5.65	5.21	5.09
Flexural strength (MPa)	7	3.90	3.66	3.43	3.85
	28	3.62	4.85	3.69	3.99

5.3 Flexural strength

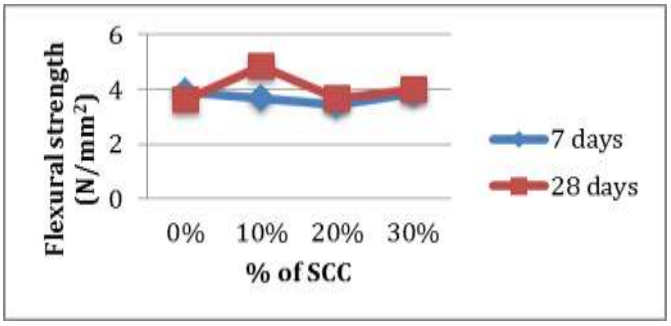
Flexural strength is one measure of the tensile strength of concrete. It is a measure of an unreinforced concrete to resist failure in bending. Very few use flexural testing for structural concrete. Flexural strength of concrete was tested on 100mmx100mmx400mm prisms at the age of 7 day, 14 day and 28 day. The test result shows that there will be an increase in the flexural strength as the percentage of granite powder increase in geopolymer concrete at 7day, 14 day and 28 day. The result of 7th day, 14th day and 28th day are flexural tensile strength is shown in Table- 5. In this 4.85 is a maximum tensile strength at 28th days.



Graph -1: Compressive strength



Graph -2: Split tensile strength



Graph -3: Flexural strength

6. Conclusion

- The available waste product from granite industry i.e. granite powder can be used successfully to achieve SCC properties in fresh state. As it is a finer material helps in avoiding segregation and promotes sustainability of natural resources.
- Increase in granite powder content beyond a certain limit is likely to increase the viscosity of the mixes and hence less flowable.
- There is a significant increase in strength at 1 & 3days when granite powder is used as filler. This is very helpful to early opening of roads to traffic and can be explored to produce SCC.
- An optimum content of 260kg/m3 of granite powder gives maximum strength than higher content, as it is evident from compressive strength, flexure strength and split tensile strength results.
- Among the volume of pastes examined, paste of 0.38 appears to be optimal and gives superior performance both in fresh and hardened state.

- From the study, we can conclude that among the CA:FA ratios, 55:45 appears to be an optimal ratio for the characteristics of aggregates used.

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