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An Investigation on Strength and Durability Properties of Self Compacting Geopolymer Concrete with Granite Powder

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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. Most of the works on Granite powder based Self Compacting Geopolymer Concrete (SCGPC) reveals that hardening is due to heat curing. Recent studies on the various properties of heat-cured geopolymer concrete 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 geopolymer concrete suitable for curing at ambient temperature will widen its application to concrete structures.*

SCGPC 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. Geopolymer 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%,20%,30% of fine aggregate in concrete. SCGPC is synthesized by mixing aluminosilicate material with a strong alkaline solution, such as sodium hydroxide and sodium silicate. The Setting mechanism of the SCGPC is depended on the polymerization process. This project will discuss the properties of the SCGPC 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*: Geopolymer Concrete, M-Sand, Granite powder, Alkaline Activator and Fiber**

1. INTRODUCTION

Geopolymer Concrete is an innovative, eco-friendly construction material and it is used as replacement of cement concrete. This Geopolymer Concrete is formed by activating the alumina ad silica-rich materials by the alkali activators. Alumina and Silica from binder materials react with the activator solution to initiate the polymerization process. The demanded for concrete as a construction material has enlarged due to enhance of infrastructure. The production of Portland cement concrete generates problems such as carbon-di-oxide emission, global warming.

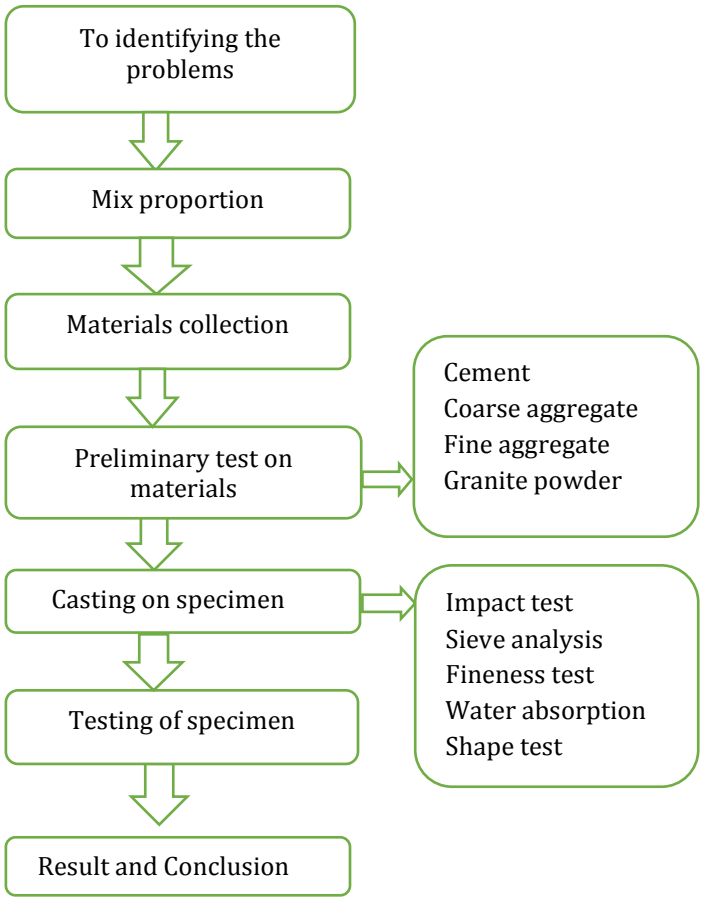
Granite of these raw materials is also causes environmental degradation. Granite tiles manufacturing industries are also producing tones of granite wastes during the manufacturing process. Granite wastes should be dumped on land, these wastes affect the productivity of land. This Granite wastes used in concrete by partially replacement of fine aggregates will reducing the pollution of land. Fly ash is by product of thermal power plants which facing the problem of its disposal. By using fly ash in concrete will help to reduction of CO_2 emission. Granite industry generates different types of wastes such as solid wastes and stone slurry. The semi liquid substance released from the polishing operations was termed as stone slurry or powder. Hence the reuse of waste materials has been emphasized.

2. OBJECTIVES OF INVESTIGATION

i. To known the fresh concrete properties of Granite waste concrete.
ii. Study the effect of Granite waste on compressive strength, flexural strength and split tensile strength of geopolymer concrete.
iii. Comparison of Engineering properties hardened geopolymer concrete by replacement of partially granite waste a fine aggregate.

Fig -1: Geopolymer concrete

3. METHODOLOGY



4. MATERIALS USED

4.1. 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.

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

Fig -2: Cement

4.2. COARSE AGGREGATES

Crushed granite stones of size 20mm aggregates were used as the coarse aggregates in the concrete mixtures. Properties of coarse aggregates were determined as per IS 2386-1997 part III guidelines.

Fig -3: Coarse Aggregate

Table-2: Properties of the 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

4.3. FINE AGGREGATES

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. In the present work crushed stone aggregates was used as fine aggregate and test were conducted as per IS:2386-1997 Part III and IS:383-1970.

Fig -4: Fine Aggregate

Table-3: Properties of the 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

4.4. GRANITE POWDER

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 2.55.

Fig -5: Granite Powder

4.5. ALKALINE ACTIVATORS

Sodium hydroxide and Sodium silicate solution were combined together to form alkaline activators. Sodium hydroxide in flakes form and sodium silicate solution of industrial grades were purchased from SP enterprises, Bengaluru. It is polymerization materials of geopolymer is replacing cement completely with process low calcium which is chemically activated by alkaline activator like sodium silicate and sodium hydroxide.

Fig -6: Alkaline solution

5. EXPERIMENTAL STUDY

This project is to study the GPC mixes using Granite powder as replacement of fine aggregate for 0% , 10% ,20% and 30%. Compressive strength test was conducted on the cubical specimens for all the mixes after 7, 14, 28 days of curing as per IS 516-1959.Three cubical specimens of size 150mm x 150mm x 150mm were cast and tested for each age and each mix. Splitting tensile strength test was conducted on the specimens for all mixes after 28days of curing as per IS 516-1959. Three cylindrical specimens of size 150mm x 400mm were cast and tested for each age and each mix.

Table-4: Mix proportion of concrete

Ingredients,kg/ m^3	0%	10%	20%	30%
Fine aggregate	554	443	333	225
Coarse aggregate	1294	1294	1294	1294
Granite powder	0	110	225	333
Sodium silicate	102	102	102	102
Sodium hydroxide	41 (10M)	41 (10M)	41 (10M)	41 (10M)
Alkaline solution	0.35	0.35	0.35	0.35
Geopolymer solids	0.17	0.17	0.17	0.17
Extra water	100	100	100	100
NaOH /Na_2SiO_3	2.5	2.5	2.5	2.5

5.1. PREPARATION OF ALKALINE LIQUID

Sodium hydroxide flakes were dissolved in distilled water to make a solution of 10M. Sodium silicate solution and sodium hydroxide solution of 10M were mixed together at room temperature. When both solutions were mixed together it starts to react i.e."Polymerization" takes place this liberates large amount of heat. So, it is recommended to leave it for about 24hours.

5.2. PREPARATION OF GEOPOLYMER CONCRETE MIXTURES

Preparation of geopolymer concrete is similarly to that of cement concrete. The M_{50} design mix ratio we have used for this project. Coarse aggregates, two types of fine aggregate like sand and granite powder were mixed in dry state. Then solution which is prepared 24hrs prior to mixing were added along with extra water based on water to geopolymer binder ratio and mixed thoroughly for 3to 4 minutes to obtained homogeneous mix. Longer mixing time yielded lower sump value and increased compressive strength and density of concrete.

5.3. 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.

6. TEST RESULTS

6.1. COMPRESSIVE STRENGTH

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 figure and table-5. In this 58.8 is maximum strength at 28 days.

6.2. 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 5.24 is maximum strength at 28th days.

6.3. 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 4.50 is a maximum tensile strength at 28th days.

Fig -7: Compressive Strength Test

Table-5: Mechanical properties of GPC

	Age	GP 0%	GP 10%	GP 20%	GP 30%
Compressive strength (MPa)	14	46	49	48.7	45.4
	28	52	58.8	58	55.9.
Split Tensile strength (MPa)	14	4.5	4.55	4.11	4.19
	28	4.9	5.24	5.12	5.05
Flexural strength (MPa)	14	3.2	3.60	3.45	3.47
	28	3.6	4.50	3.77	3.96

Fig -8: Split Tensile Strength Test

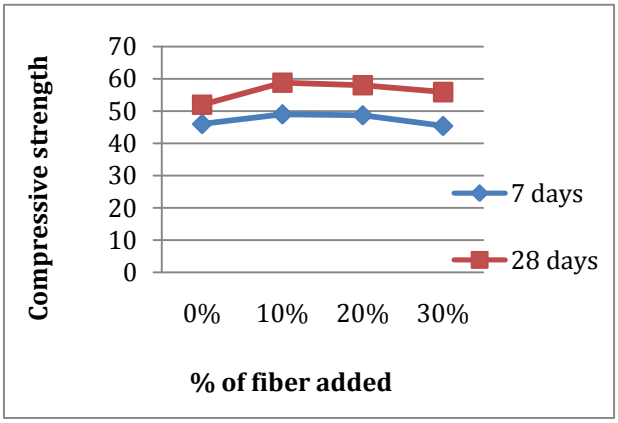


Chart -1: Compressive Strength Test result for different proportion of granite powder of GPC

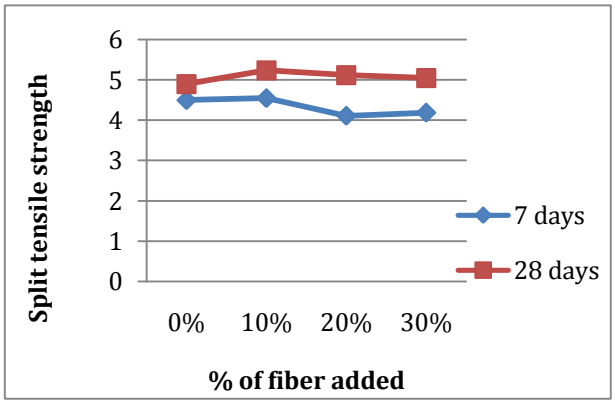


Chart -2: Split Tensile Strength Test result for different proportion of granite powder of GPC

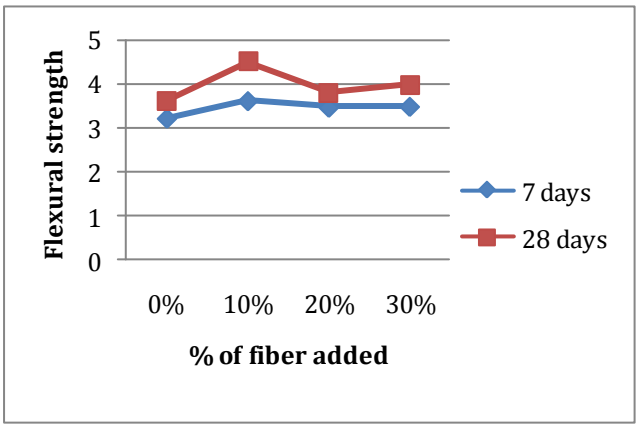


Chart -3: Flexural Strength Test result for different proportion of granite powder of GPC

7. CONCLUSION

Geopolymer concrete is an another material of Portland cement. Its reduce CO_2 emission in the world and eco-friendly for construction. Geopolymer concrete is additional strength after exposure to high temperature. In this project compressive strength is 58.8 at 28th day. Its increase strength and extended durability of concrete. The using waste material is reducing the pollution free environment.

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