ISSN XXXX XXXX © 2018 IJESC

Research Article Volume 8 Issue No.3

A Review Paper on Cost Analysis of Self Compacting Geopolymer Concrete Using Waste Foundry Sand With Self Compacting Cement Concrete (SCC) and Geopolymer Concrete (GPC)

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Abstract:
Preparation of Self Compacting Geopolymer Concrete (SCGC) using waste foundry sand is an approach to make concreting technique economical and environmentally sustainable. Self Compacting Geopolymer Concrete is a blended version of Self Compacting Concreting and Geopolymer Concrete. Self Compacting Concrete is a concreting technique prepared to make concreting practice economical by reducing requirement of compacting equipments while Geopolymer Concrete is a concreting technique prepared to make concreting environmentally sustainable by replacing Ordinary Portland Cement (OPC) with other cementitious material. In the present investigation we have prepared a mix of SCGC using Waste Foundry Sand, Geopolymer Concrete and Self Compacting Cement Concrete(SCC) for M40 grade and compared the cost of each for one cubic meter volume of concreting. It is found that though the cost of alkaline solution is higher comparative to other admixtures but use of cementitious wastes and Industrial By-products reduces the overall cost and makes SCGC a low cost concreting technique.

Keywords: self-compacting geopolymer concrete, Fly Ash, ground granulated blast furnace slag, waste foundry sand and molarity of NaOH solution.

I. INTRODUCTION

Concrete is the primary material in construction industry. It consists of cement, coarse aggregate, fine aggregate, water and other admixtures. Generally Ordinary Portland cement is used in concreting but the production of OPC causes a huge amount of carbon emission and also it uses a huge amount of non-renewable natural resources. The concrete construction practice in use is considered as unsustainable because it consumes a huge quantity of sand, stone and water and 2.5 billion tones of OPC per year. So to resolve the problem of emission of greenhouse gases Davidovits developed a innovative concreting technique. Davidovits proposed that an alkaline liquid could be used to react with the silicon (Si) and Aluminum (Al) in a source material of geological origin or in by-products materials such as Fly Ash (FA) and Rice Husk (RHA) to produce binders. The two main constituents of geopolymer, namely the source materials and the alkaline liquids. This could be natural mineral such as kaolinite, clays etc. Alternatively, by-products such as fly ash, silica fume, slag, rice husk, GGBS, red mud etc. The material used as geo-polymer binders should be rich in silicon (Si) and Aluminium (Al). Both Fly Ash and GGBS in certain proportion were found to be geopolymer source materials to obtain sufficient strengths of geopolymer concrete. Alkaline liquids are from soluble alkali metals that are usually sodium or potassium based. The most common alkaline liquid used in geopolymerisation is a combination of sodium hydroxide (NaOH) or Potassium Hydroxide (KOH) and Sodium Silicate or potassium silicate. Many of the GPC mixes earlier tested required the use of high temperature curing. Heat curing substantially assists the chemical reaction that occurs in the geo-polymer paste. Both curing time and curing temperature influence the compressive strength of geopolymer concrete. However recent studies revealed that GPC mixes can be developed for ambient room temperature. It was noticed that fresh GPC was highly viscous with low workability and hence, super plasticizer (SP) was found to be used to attain adequate workability. One of the major problem faced in construction industry is the lack of skillful labors for concreting but to resolve this problem Japanese scientists Okamura et al and Ozawa et al proposed a new concreting technique named " self compacting concrete" in which the concrete compacts due to its self weight and can pass through congested reinforcement easily. Self compacting concrete has the follow properties: higher slump flow, high viscosity, passing ability and resistance to segregation. Use of self compacting geopolymer concrete in construction industry can solve the problem of greenhouse gas emission as well as it reduces the problems faced due to lacking of skilful labour and using waste foundry sand as replacement of river sand can solve the problems of river mining, solves problems of disposal of waste foundry sand and reduces the cost of concreting. Studies reveals that the compressive strength of SCGC increases when thermal cured at 60-70 0C, but it decreases when temperature exceeds 70 ^{0}C. It is found that on increasing molarity of NaOH the fresh properties of concrete decreases. It is observed that the alkaline solution, super plasticizer and extra water should be premixed before adding to the dry mix of concrete to get improved workability of SCGC. In metal industries for various processes in metal casting foundry sand is used. After the casting of metal the burnt fine grained foundry sand can be re-used for various purposes in construction industry. It will reduce the cost of construction. But split tensile strength decreases on increasing the percentage of waste foundry sand. In the present research we examined how self compacting geopolymer concrete using waste foundry sand is economical compared to other concreting techniques. Economy in concreting is to be achieved without sacrificing the strength and durability of concrete and in the previous experiments we have examined that SCGC using Waste Foundry Sand achieves quite good strength and durability.

II. EXPERIMENTAL STUDIES

- **Materials Used :**

The materials used in this study were

1) Cement:

Cement is a main constituent of concrete which is used in powdered form main constituents of cement are Lime, Silica, Iron Oxide etc. which helps to achieve strength when it is mixed with water due to chemical reactions. We have used 53 grade OPC Ambuja Cement.

2) Class F fly ash:

Nowadays fly ash is the material which is most extensively used in construction industry as a partial replacement of cement. The burning of harder, older anthracite and bituminous coal typically produces Class F fly ash. This fly ash is pozzolanic in nature, and contains less than 7% lime (CaO). Possessing pozzolanic properties, the glassy silica and alumina of Class F fly ash requires a cementing agent, such as Portland cement, quicklime, or hydrated lime mixed with water to react and produce cementitious compounds. Alternatively, adding a chemical activator such as sodium silicate (water glass) to a Class F ash can form a geopolymer .We are using class F fly ash obtained from "Wanakbori Thermal Power Station, Gujarat, India".

3) Ground Granulated Blast Furnace Slag:

It is obtained as a by-product of iron and steel-making from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder. It is used as a partial replacement of cement, when it is used in certain proportion with fly ash it significantly helps in increasing the compressive strength. The main components of blast furnace slag are CaO (30-50%), SiO_2 (28-38%), Al_2O_3 (8-24%), and MgO (1-18%). In general increasing the CaO content of the slag results in raised slag plasticity and an increase in compressive strength.

4) River Sand:

Aggregate contains almost 75-80% of the concrete volume. While in SCGC for self compaction the fine aggregate content should be 40% of the mortar volume. Ordinary sand which pass through 4.75mm IS sieve and having no more than 5% coarser material are included in fine aggregate. River sand is obtained by river mining which is a non-renewable source .fine aggregate fills the voids and increases the workability of concrete.

5) Waste Foundry Sand:

Mostly metal industries prefer sand casting system. In this system mould made of uniform size and uniform sand with high silica content is used. After the casting of metal foundries reuse and recycle the sand but after several time of using it the sand is discarded and it is called waste foundry sand. Their uses in construction industry is economical and also solve the problems of its disposal.

6) Coarse Aggregate:

The aggregate having size more than 4.75mm is termed as coarse aggregate. In order to achieve self compactibility and pass ability of concrete through congested reinforcement coarse aggregate of two different sizes are used in SCGC. In SCGC the coarse aggregate content is 50% of the solid volume and coarse aggregate in two different sizes at 60:40 ratio can be used.

7) Super Plasticizer:

Self compacting concrete can be prepared by compounding admixture with high efficiency water reducing agent. According to requirement of performance of SCGC , climate conditions and the construction technology , combined with concrete raw materials performance, adaptability to cement and mix proportion and other factors, the species and dosage of admixture can be determined through the test.

8) Alkaline Solution:

Generally sodium hydroxide or potassium hydroxide and sodium or potassium silicate is used as alkaline activators for formation of C-S-H gel. Studies reveal that only using sodium hydroxide or sodium silicate is not much effective. So combination of sodium hydroxide and sodium silicate is used generally. Sodium hydroxide pellets is 97-8% purity is generally used and sodium silicate with Na_2O = 13.7%, SiO_2 = 29.4% and water = 55.9% is generally used. With the increase in concentration of solution in terms of molarity (M) the concrete becomes brittle with increased compressive strength. Cost of sodium hydroxide solids is high and preparation is very caustic. Generally sodium silicate-to-sodium hydroxide ratio of 2 to 2.5 is maintained in concrete casting which will help in gaining the strength after 24h of casting.

9) Water:

Water plays an important role in concrete while in self compacting geopolymer concrete water does not play any important role in gaining strength rather it helps in improving the workability. As studies reveals that geopolymer mix is less workable so to attain self compact ability extra water is needed to add in the mix.

III.COST ANALYSIS

Table.1. Cost analysis for self-compacting cement concrete for 1cu.m. For m40 grade

MATERIALS REQUIRED	RATE	UNIT	QUAN-TITY	AMOUNT
Cement	INR. 330	Bag (50 Kg.)	6.3	INR. 2079
Fly Ash	INR. 400	MT	0.135	INR.54
Coarse Aggregate	INR. 650	MT	0.712	INR. 462.8
Fine Aggregate	INR. 800	MT	0.984	INR. 787.2
Super plasticizer	INR. 75	Liter	13.5	INR. 1012.5
Miscellaneous Charges	INR. 400			
Total				INR. 4512

Table.2. Cost analysis for geopolymer concrete (10m) for 1 cu.m. For m40 grade

MATERIALS REQUIRED	RATE	UNIT	QUAN-TITY	AMOUNT
Fly Ash	INR.400	MT	0.315	INR. 126
GGBFS	INR.1500	MT	0.135	INR.202.5
Coarse Aggregate	INR.650	MT	0.712	INR. 462.8
Fine Aggregate	INR.800	MT	0.984	INR. 787.2
Na_2SiO_3 Solution	INR.8	kg	145	INR.1160
NaOH pellets	INR.25	kg	21.11	INR.527.75
Super plasticizer	INR.75	kg	4.5	INR. 337.5
Miscellaneous Charges	INR.1000			
Total				INR. 4603.75

Table.3.cost analysis for self- compacting geopolymer concrete (10m) using waste foundry sand for 1cu.m. For m40 grade

MATERIALS REQUIRED	RATE	UNIT	QUAN-TITY	AMOUNT
Fly Ash	INR. 400	MT	0.315	INR. 126
GGBFS	INR. 1500	MT	0.135	INR. 202.5
Coarse Aggregate	INR. 650	MT	0.712	INR.462.8
Fine Aggregate	INR. 800	MT	0.689	INR.551.2
Waste Foundry Sand	INR. 70	MT	0.295	INR.20.65
Super plasticizer	INR.75	Liter	13.5	INR.1012.5
Na_2SiO_3 Solution	INR.8	Kg	145	INR.1160
NaOH pellets	INR.25	kg	21.12	INR.527.75
Miscellaneous Charges	INR.400			
Total				INR. 4463.4

Table.4. Cost comparision of scc & scgc (with 30% wfs replacement) for m40 grade

SR. NO.	MIX DESIGNATION	COST OF SELF COMPACTING CEMENT CONCRETE	COST OF SELF-COMPACTING GEOPOLYMER CONCRETE USING WFS	EXCESS (%)	LESS (%)
1.	M 40	INR. 4512	INR.4463.4	-	1.08

Table.5. Cost comparision of gpc & scgc (with 30% wfs replacement) for m40

SR NO.	MIX DESIGNATION	COST OF GEOPOLYMER CONCRETE	COST OF SELF-COMPACTING GEOPOLYMER CONCRETE USING WFS	EXCESS (%)	LESS (%)
1.	M 40	INR. 4603	INR. 4463.4	-	3.03

IV. CONCLUSIONS

a) In the previous experiments we found that SCGC prepared by replacing river sand with waste foundry sand (up to 30%) satisfies the required fresh properties for self compactibility.

b) On replacing sand by 60% or more the concrete fails in achieving the required fresh and hard property.

c) From the above tables we can say that Self Compacting Geopolymer Concrete using Waste Foundry Sand is cheaper compared to GPC and SCC.

d) Use of Waste Foundry Sand as partial replacement for river sand in SCGC reduces the cost of concreting without affecting the properties of concrete.

e) The concrete formed is cheap and environmentally sustainable.

f) The cost of vibrators and extra labours are eliminated.

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