Nature Environment and Pollution Technology
An International Quarterly Scientific Journal

ISSN: 0972-6268	Vol. 14	No. 2	pp. 451-454	2015

Original Research Paper

Reduction of Green House Gases Emission in Self Compacting Geopolymer Concrete Using Sustainable Construction Materials

T. G. Ushaa, R. Anuradha* and G. S. Venkatasubramani**
Karpagam University, Coimbatore, Tamilnadu, India
*Department of Civil Engineering, SNS College of Technology, Coimbatore, Tamilnadu, India
**Paavai Engineering College, Rasipuram, Tamilnadu, India

Nat. Env. & Poll. Tech.
Website: www.neptjournal.com
Received: 7-10-2014
Accepted: 23-11-2014

Key Words:
Fly Ash
Self compacting geopolymer concrete (SCGC)
Compressive strength
Green house gases

ABSTRACT

The global warming is caused by emission of green house gases such as carbon dioxide and carbon monoxide into the atmosphere. The cement industry is held responsible for some of the carbon dioxide emissions, because the production of one tonne of Portland cement emits one tonne of carbon dioxide into the atmosphere. In terms of global warming the geopolymer technology could significantly reduce the carbon dioxide emission into the atmosphere caused by cement industries. This research is aimed to give awareness about the green house gas emissions from the cement manufacturing industries and the methods of reducing this by the use of fly ash and GGBFS. Two kinds of systems have been considered in this study, 100% replacement of cement by fly ash and 100% replacement of river sand by manufactured sand. The workability of Self Compacting Geopolymer Concrete (SCGC) for various molarities was investigated and fixed to 12M. The work focused on the concrete mixes with a fixed water-to-geopolymer solid (W/Gs) ratio of 0.33 by mass and a constant total binder content of 450 kg/m^3. The workability related fresh properties for molarity of 12M of SCGC were assessed through slump flow, T_{50cm} slump flow, V-funnel, L-box and U-Box test methods. The mix proportions are arrived according to EFNARC (European Federation of National Associations Representing for Concrete) guidelines. Based on the results from workability and strength study, the results have been discussed for SCGC.

INTRODUCTION

Geopolymeric materials have become the focus of interest and received a considerable attention because of the environmental benefits, such as the reduction in consumption of natural resources and the decrease in production of CO_2. Unlike ordinary Portland cement, the production of raw material for geopolymers does not require a high level of energy consumption because the high temperature calcining is not required. It is demonstrated that the geopolymeric cement generates 5-6 times less CO_2 than Portland cement. Therefore, the use of geopolymer concrete technology not only significantly reduces CO_2 emissions but also utilizes the industrial waste and/or by-product, converting a potentially hazardous material to a valuable construction material. To save our rivers from sand mining and to sustain our environment, M-sand is used. The manufactured sand was used as a fine aggregate since the demand and cost of river sand is high. Self-compacting concrete, also referred to as self-consolidating concrete, can flow and consolidate under its own self weight and de-aerate almost completely while flowing in the formwork. It is cohesive enough to fill the spaces of almost any size and shape without segregation or bleeding. This makes self-compacting concrete particularly useful wherever placed such as in heavily reinforced concrete members or in complicated formworks. Self-compacting concrete can save labour, eliminate consolidation noise and lead to innovative construction methods.

SCGC (Self Compacting Geopolymer Concrete) is relatively a new concept and can be regarded as a revolutionary development in the field of concrete technology.

It is an innovative type of concrete that can achieve the combined advantages of both geopolymer concrete and SCC. Literature review indicated that, up to date, no research has been conducted on SCGC. This research study was therefore intended to explore the feasibility and potential of SCGC made with locally available constituent materials by examining their basic physical and mechanical properties. The present work investigated the workability related fresh properties of SCGC through slump flow, T_{50cm} slump flow, V-funnel, L-box and U-Box test methods. Jhumarwala et al. (2013) studied that, maximum compressive strength of self compacting geopolymer concrete is achieved at elevated temperature cured concrete, and as molarity increases the strength goes on decreasing but after 14M the strength again increases at 16M and at 8M maximum strength is observed. Memon et al. (2011) have reported that the addition of extra water improved the workability characteristics of concrete mixtures, however, the inclusion of water beyond a certain limit resulted in bleeding and segregation of fresh concrete and decreased the compressive strength of the concrete. The compressive strength of SCGC was significantly decreased as the amount of extra water exceeded 12% by mass of FA.

EXPERIMENTAL WORK

The materials used for making SCGC specimens are low calcium fly ash as the source material, manufactured sand, coarse aggregate as the filler, alkaline such as sodium hydroxide solution, sodium silicate solution as binder and water and super plasticizer as workability measure. In this investigation, class F type of fly ash was obtained from Metur power plant with fineness modulus and specific gravity as 7.86 and 2.21 respectively. The sodium hydroxides (NaOH) is available in solid state in the form of pellets. The cost of the sodium hydroxide mainly varies according to the purity of the substance. In this investigation 94% to 96% purity NaOH was used. Sodium silicate, also known as water glass or liquid glass, is available in a liquid (gel) form. In present investigation the ratio between sodium hydroxide and sodium silicate was taken as 1:2.5.

Glenium B233 is an admixture of a new generation based on modified polycarboxylic ether. The product has been primarily developed for applications in high performance concrete where the highest durability and performance is required. It is free of chloride and low in alkali. It is compatible with all types of cements. In this investigation, the hyper plasticizer used was Glenium B233, high range water reducing, super plasticizer based on polycarboxylic ether formulation. The product shall have specific gravity of 1.09 and solid contents not less than 30% by weight. Optimum dosage of Glenium B233 should be determined with trial mixes. As a guide, a dosage range of 500 mL to 1500mL per 100kg of cementitious material is normally recommended.

Table 1: Mass of NaOH per litre.

NaOH	% of solids	Solids(g)	% of water
8M	26.23	262	73.77
10M	31.37	314	68.63
12M	36.09	361	63.91
14M	40.43	404	59.57

PREPARATION OF SELF COMPACTING GEOPOLYMER CONCRETE

Sodium hydroxide: Sodium hydroxide pellets were dissolved in water. Sodium hydroxide should be prepared 24 hours prior to use and also if it exceeds 36 hours, it terminates to semi-solid liquid state. So the prepared solution should be used within this time. To find the best molarity various calculations were done. The mass of NaOH solids in solution varied depending on the concentration of the solution expressed in terms of molarity (M) as given in Table 1.

Molarity calculation: The solids must be dissolved in water to make a solution with the required concentration. The mass of NaOH solids in a solution varies depending on the concentration of the solution.

For instance, NaOH solution with a concentration of 12 molar consist of $12 \times 40 = 480$g of NaOH solids per litre of water, where 40 is the molecular weight of NaOH. This amount of NaOH solids in one litre of water will be large of its volume so it reduces to 361g for 12 molar concentration.

Alkaline liquid: Generally, alkaline liquids are prepared by mixing of sodium hydroxide solution and sodium silicate at the room temperature. When the solutions are mixed together, both solutions start to react with each other and the polymerization process takes place. It liberates large amounts of heat so it is recommended to leave it for about 20 minutes, thus the alkaline liquid is ready as a binding agent.

Preparation of fresh SCGC: For the preparation of fresh SCGC, fine powdered materials (i.e., fly ash, and fine aggregate) were firstly placed in a pan mixer and blended manu-

Table 2: Typical range of SCC constituents suggested by EFNARC.

Constituent	Typical range by mass(kg/m^3)	Typical range by volume (liters/m^3)
Powder	380 - 600	
Paste		300 - 380
Water	150 - 210	150 - 210
Coarse aggregate	750 - 1000	270 - 360
Fine aggregate (sand)	Content balances the volume of the other constituents, typically 48-55% of total aggregate weight.	
Water/Powder ratio by volume		0.85 - 1.10

Table 3: Mix proportions based on replacement of R-Sand and M-Sand.

Mix No.	Cement	Fly Ash	GGBFS	M-Sand	R-Sand	CA	NaoH	Na_2SiO_3	Molarity	SP	W/G's	H_2O
M1	-	315	135	-	900	1000	57	143	12	6%	0.33	12%
M2	-	315	135	675	225	1000	57	143	12	6%	0.33	12%
M3	-	315	135	450	450	1000	57	143	12	6%	0.33	12%
M4	-	315	135	225	675	1000	57	143	12	6%	0.33	12%
M5	-	315	135	900	-	1000	57	143	12	6%	0.33	12%

ally. Afterwards, the coarse aggregate in saturated surface dry condition was added to the mixer and mixed mechanically for about 2.5 min. At the end of this dry mixing, a well-shaken pre-mixed liquid mixture, containing alkaline solution, super plasticizer and extra water, was added in the mixer. This duration was not less than 3 min. The freshly prepared concrete mix was then assessed for the essential workability tests required for characterizing SCC. Slump flow, V-funnel, and L-box tests were performed for this purpose.

Mix design of SCGC: The mix design in the case of SCGC is inverse to that of conventional concrete. The design is made with the help of EFNARC guidelines as given in Table 2. For this study, mix proportions using EFNARC guidelines for SCGC are given in Table 3. The water to geopolymer solids (W/G's) ratio by mass for all the mixes was maintained at 0.33 and the total powder content was fixed at 450 kg/m^3. To obtain the requested workability characteristics of SCGC, a water content of 12% and super plasticizer dosage of 6% by mass for the binder were used.

COMPRESSION TEST

Compression test is the most common test conducted on hardened concrete, because it is an easy test to perform and most desirable characteristic properties of concrete are

Fig. 1: Compressive strength for various mixes.

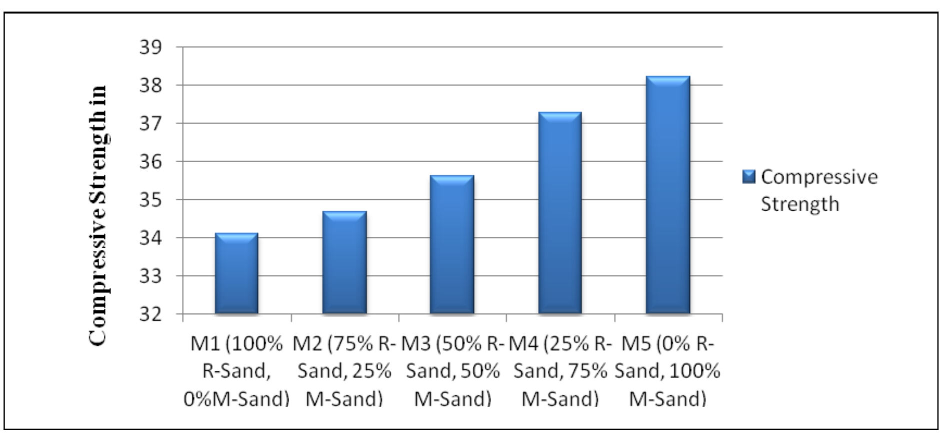

Fig. 2: Compressive tests on self compacting geopolymer concrete cube.

qualitatively related to its compressive strength. The compression test is carried out on the specimen in a cubical or in cylindrical shape. The test was carried out in 150×150×150mm size cubes. Fig. 1 shows the compressive strength test using compression testing machine. The test results are shown in Fig. 2.

DISCUSSION

This paper deals with the strength of SCGC with various replacements of M-Sand and R-Sand. From Fig. 2, it is clearly seen that the Mix M5 with 100% M-Sand and 0% R-Sand gives the best results in case of compressive strength. As the percentage of R-Sand increases, the workability characters of SCGC gradually decrease.

REFERENCES

EFNARC 2005. European Guidelines for Self-Compacting Concrete, Specification, Production and Use.

Ilangovana R. 2008. Strength and durability properties of concrete containing quarry dust as fine aggregate. ARPN Journal of Engineering and Applied Science, 3(5): 20-26.

IS 3812: 1981. Specification for fly ash for use as pozzolana and admixture. Bureau of Indian Standards, New Delhi, India.

IS 383: 1970. Specification for coarse and fine aggregates from natural sources for concrete. Bureau of Indian Standards, New Delhi, India.

Jhumarwala, A. Rashida, Rao, P. S. and Patel, T.N. 2013. Experimental investigation on self compacting geopolymer concrete (SCGC). Research Paper, S.V.I.T, Vasad.

Memon, Fareed Ahmed, Muhd Fadhil Nuruddin, Samuel Demie and Nasir Shafiq 2011. Effect of curing conditions on strength of fly ash-based self-compacting geopolymer concrete. International Journal of Civil and Environmental Engineering, 80: 183-186.