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Studies on Compressive strength of Geo polymer concrete using GGBFS (M 15 Grade)

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Abstract

Manufacture of Portland cement produces large of volumes of carbon dioxide (one ton of cement liberates about one ton of carbon dioxide to the atmosphere) and other gases. Releasing these gases causes atmospheric pollution and subsequent environmental degradation. Finding a suitable alternative solution to mitigate the environmental degradation caused by using Portland cement is very important for environmental sustainability. The geopolymer concrete has stepped in the construction industry as an alternate to the cement based concrete. Many of the research about geopolymer concrete states that it has potential to replace the cement based concrete in many countries depending on the locally available resources. The present review deals with the study of mechanical properties of geopolymer concrete. Attempt has been made to collect information about the locally available constituents of geopolymer concrete and the ongoing research, Few mechanical properties with and without fibres in concrete were discussed. The geopolymer concrete chosen is based on 100% ground granulated blast furnace slag (GGBS) cured in laboratory in typical tropical ambient environmental conditions.

KEYWORDS: Geopolymer concrete, fly ash, GGBFS, compressive strength, ultrasonic pulse, velocity, acid environment.

I.INTRODUCTION

This research briefly reviews the constituents of geopolymer concrete and also evaluates the strength and strength efficiency factors of hardened concrete, by replacing Portland cement by 100% of ground granulated blast furnace slag for M20, M30 and M40 grade of concrete.
Laboratory tests are conducted on compressive strength, split tensile strength, ultrasonic pulse, velocity, acid environment and flexural tests for specimens with combination of different molarities. The results obtained are compared analytically.

II.LITERATURE REVIEW

This chapter confers the review of literatures regarding the issue of GGBFS based Geo polymer concrete in past researches and studies. The most preferential result which are relevant to current study are being reviewed.

2.1 SUMMARY OF LITERATURE REVIEW

The information gathered from the literature is discussed in the following section.

2.2 A.Maria Rajesh1, M.Adams Joe2, Roy Mammen3 1Assistant Professor, Dept. of Civil Engineering, ACEW, Nagercoil, Tamilnadu, India. 2Associate Professor, Dept. of Civil Engineering, TREC, Nagercoil, Tamilnadu, India. 3Director of Quality Assurance, Dept. Of Built Environment Engineering, Muscat College, Oman. "Study of the Strength Geopolymer Concrete with Alkaline Solution of Varying

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A.Maria Rajesh, M.Adams Joe and Roy Mammen intended to study the properties of fly ash based geopolymer concrete. GPC can be formed by adopting nominal mix of 1:1.5:3 (fly ash: fine aggregates: coarse aggregates) by varying alkaline liquid to fly ash ratio from 8M to 16M. The compressive strength, tensile strength and flexural strength tests were conducted on geopolymer concrete and parameters that affect it are analyzed and proved experimentally. From the test results, it was concluded that geopolymer concrete possesses the followings

- The compressive strength of GPC specimens with 12M is 1.25 times more than that of GPC with other molarities after 28 days of hot curing
- The split tensile strength of GPC specimens with 12M is 1.18 times more than that of GPC with other molarities after 28 days of hot curing
- The Flexural strength of GPC specimens with 12M is 1.058 times more than that of GPC with other molarities after 28 days of hot curing
- Geopolymer technology does not only contribute to the reduction of greenhouse gas emissions but also reduces disposal costs of industrial waste.
- Geopolymer technology encourages recycling of waste and finally it will be an important step towards sustainable concrete industry.

2.3 Shabarish V. Patil1, Veeresh B. Karikatti1, Manojkumar Chitawadagi2 1Department of Civil Engineering, KLE Institute of Technology, Hubballi,opposite to Airport, Gokul Road,Hubballi – 580 030, Karnataka 2School of Civil and Environmental Engineering, KLE Technological University (BVBCET), Vidyanagar, Hubballi – 580 031, Karnataka"Granulated Blast-Furnace Slag (GGBS) based Geopolymer Concrete – Review" Int. J. Adv. Sci. Eng. Vol.5 No.1 879-885 (2018) 879 E-ISSN: 2349 5359; P-ISSN: 2454-9967

- Shabarish V. Patil1, Veeresh B. Karikatti1, Manojkumar Chitawadagi studied the constituent materials and casting technique of geopolymer concrete and also information available is summarized in his paper.
- Fundamental knowledge on compressive strength of GPC and microstructure of GPC been obtained by his research carried out so far. However, intensive research is required to get optimum mix of geopolymer concrete with and without fibers, durability and microstructure of geopolymer concrete.
- While a larger focus has been investigating mix design and workability of GPC mixes, studies are still required to get a good workable GPC, durability aspects and microstructure of GPC.

1.2 SCOPE

To evaluate the strength properties of geopolymer concrete mixture with different grade of concrete. Making workable, increasing the strength and durable geopolymer concrete containing G.G.B.S (Slag) without usage of ordinary Portland cement.

1.3 OBJECTIVES

- To evaluate the properties of geopolymer concrete in order to use it as alternative for Ordinary Portland Cement.
- To verify the improvement of properties like compressive strength, tensile strength, flexural strength with age by using geopolymer binders instead of OPC.
- To study the plot of compressive strength V/S percentage variation of GGBS.
- To reduce the usage of ordinary Portland cement and to improve the usage of the other by product G.G.B.S (Slag).
- To optimize the mix design for geopolymer concrete.
- To evaluate the performance of geopolymer concrete in Chloride environment compared to normal environment.
- To draw conclusion on whether geopolymer technology can provide an appropriate alternative for Portland cement.

1.4 FIELD APPLICATION

Geopolymer concrete and its technology have just began to capture the imagination of the building industry. Though the geopolymer concrete technology is in the developing stage, but presently it is being used already in some countries in the field application. It has also become commercial in the construction industry.

2.1 Mixing and Casting:

It was found that the fresh geopolymer mix was grey or pale in colour and is cohesive. The amount of water in the mix played an important role on the behavior of fresh mix.

Davidovits (2002) suggested that it is preferable to mix the sodium silicate solution and the sodium hydroxide solution together at least one day before adding the liquid to the solid constituents. The author suggested that the sodium silicate solution obtained from the market usually mixing it together with the sodium hydroxide solution assists the polymerization process. The effects of water content in the mix and the mixing time were identified as test parameters in the detailed study. From the preliminary work; it was decided to observe the following standard process of mixing in all further studies. Mix all dry materials in the pan mixer for about three minutes. Add the liquid component of the mixture at the end of dry mixing, and continue the wet mixing for another four minutes. Compaction of fresh concrete in the cube moulds was achieved by compacting on a vibration table for ten seconds. After casting, the specimens were left undisturbed for 48 hours.

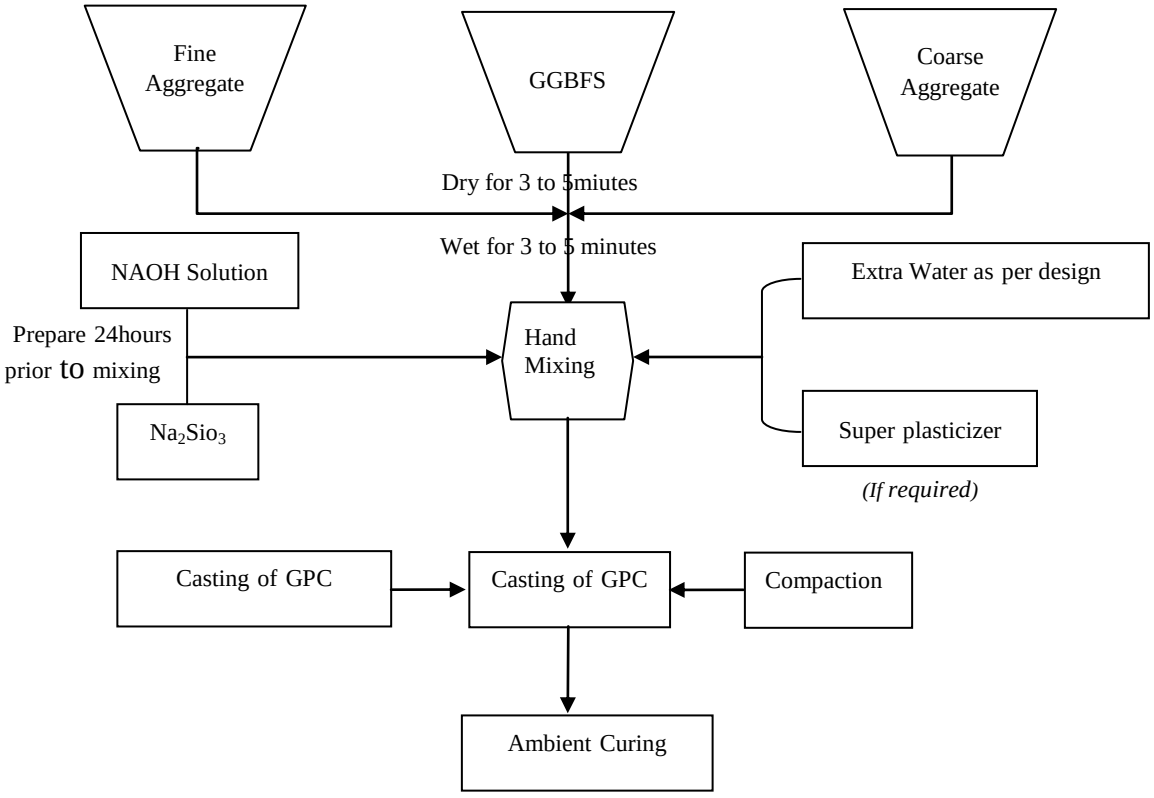

Figure 2 Mixing and casting process of Geo polymer concrete

2.2DESIGN PROCEDURE

Design procedure was formulated for Geopolymer Concrete which was relevant to Indian standard (IS 10262-2009). The illustrative example of mix design for a Geopolymer concrete of M20 grade is given below,

2.2.1 STIPULATIONS FOR PROPORTIONING

Grade Designation	= M-20
Type of cement	= GGBFS
Brand of cement	= JSW
Admixture	= Nil
Fine Aggregate	= Zone-IV
Sp. Gravity	= 2.36
Cement (GGBFS)	= 2.90
Fine Aggregate	= 2.20
Coarse Aggregate (20mm)	= 3.16
Coarse Aggregate (10mm)	= 2.66
Minimum Cement	= 315 kg / m
Maximum water cement ratio	= 0.50

2.2.2 TEST DATA FOR MATERIALS

a) Type of cement = GGBFS
b) Sp. Gravity of GGBFS = 2.9
c) Chemical Admixture = NIL
d) Sp. Gravity of:
   1) Fine Aggregate = 2.20
   2) Coarse Aggregate (20mm) = 3.16
e) Water Absorption:

1) Coarse Aggregate (20mm) = 0.50
2) Fine Aggregate = 1

f) Free (Surface) moisture:
1) Coarse Aggregate (20mm) = 0.50
2) Fine Aggregate = 1

g) Sieve analysis:
1) Coarse Aggregate (20mm) = 0.50
2) Fine Aggregate = 1

Table -2 Materials Requirement for GGBFS Concrete

Material	Weight Per m^3
GGBS	428.57
Fine aggregate	1.85
Coarse aggregate	840
NaOH pellets	57.14
Water	49.2
Na_2SiO_3	114.28

3.1 TARGET STRENGTH FOR MIX PROPORTIONING

Target Mean Strength = $= fck + 1.65\ S = = 20 + 1.65\ X\ 4 = 26.60Mpa$

3.2 SELECTION OF WATER CEMENT RATIO:

From Table 5 of is 456, maximum water cement ratio = 0.55
Adopt water cement ratio 0.5
0.50<0.55,hence ok.

3.3 SELECTION OF WATER CONTENT:

From Table 2 of IS 10262:2009, maximum water cement ratio = 186 kg/m^3 (for 20mm aggregate)
Estimated water cement for 110mm
Slump
(As per Table No. 5, IS: 10262) If super plasticizers are used, the water content can be reduced up to 20% and above.
Based on the trials with super plasticizers water content reduction of 20%has been achieved. Hence, the arrived water content=197X0.80=157.6 litre

$$= 186 + \frac{6}{110} X186$$

$$= 196\ litre$$

3.4 CALCULATION OF CEMENT CONTENT:

Water cement ratio = 0.50
Water content per m of concrete = 140 kg
Cement content = 1567.6/0.50 = 315.20 kg / m^3

From Table 5 of IS 456,
Minimum cement content for exposure condition=300 kg / m^3

Since 315 kg / m^3 > 300 kg / m^3 ,Hence ok.

4.1 MIX PROPORTIONS

GGBFS = 315
Fine Aggregate = 589 kg / m^3
Coarse Aggregate (20mm) = 1530 kg / m^3
Water cement ratio = 0.50

MATERIALS REQUIREMENT FOR GGBFS CONCRETE

Table-1 Mix proportions for various grade

Trial.no	Grade of GPC	Cement (GGBFS)	Fine aggregate	Coarse aggregate
1	M20	1	1.85	2.63

Results:

COMPRESSIVE STRENGTH OF GEO POLYMER FOR ALKALINE LIQUID FROM 2.5 TO 3

Table -3 Compressive Strength of Geo Polymer Alkaline Liquid from 2.5 TO 3

S. No	Grade of Concrete	Dimensions of cube(mm)	Area of bearing face(mm^2)	Date of casting	Age (days)	Ultimate load (N)	Ultimate compressive stress N/mm^2
G1	M20	150x150x150	22500	12.07.2021	7	305000	14
G2	M20	150x150x150	22500	12.07.2021	14	390000	17
G3	M20	150x150x150	22500	12.07.2021	28	420000	19

Conclusion

In this research it found that the compressive strength of geopolymer concrete increased considerably when compared with the nominal concrete and information available is summarized in this paper. Fundamental knowledge on compressive strength and microstructure of GPC has already been obtained by the research carried out so far. However, intensive research is required to get optimum mix of geopolymer concrete.

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