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AN EXPERIMENTAL STUDY OF FIBER REINFORCED GEO-POLYMER CONCRETE SLAB FOR CONTINOUSLY INCRESING HEIGHT OF IMPACT LOAD

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Abstract

Geo-polymers are a kind of materials that are formed by the polymerization of aluminium (Al_2O_3), silicon (SiO_2) and oxygen species to form a 3-D framework structure. Concrete made by such a binder system possess many advantages as compared to conventional ordinary Portland cement concretes (OPCCs). Many research works has been Reported on the behaviour of reinforced concrete structural elements under impact load whereas similar studies have not been reported on GPCs. This project work describes the experimental study on the behaviour of reinforced GPC slabs under repeated impact loading of low velocity. The aim of this project work is to study the impact behaviour of reinforced GPC slabs with and without steel fibers then compare the result with OPCC slabs. The overall dimensions of the GPC slab are 100cmx100cm, with 6cm thickness. Further there are wide scopes of geo-polymer need to develop in many engineering applications. Also it is use as a substitute of cement in the construction field with many limitations because it is sensitive to its production as well as in its use.

Keywords— local available fly-ash, GGBS, Alkaline activated solution etc.

1 INTRODUCTION

Impact load is an instantaneous application of load on the structure. Impact load may occur in reinforced concrete slabs and walls in certain types of structures, under low speed accidentally. Any structure which is strong under large static load may get failure due to sudden application of loads of relatively small magnitudes due to the effect of impact. There are many studies have been carried out on cementitious materials under impact load effect. A conventional ordinary Portland cement concrete have large CO_2 emission and high energy consumption, so it is necessary to develop more eco-friendly concrete. Geopolymer concrete can full fill such a requirement of eco-friendly concrete.

This project work carried out an experimental investigation on the behavior of Reinforced geopolymer concrete slab with and without fibers under repeated impact loading of low velocity. Since In Portland cement 90% of carbon dioxide and 85% of the energy attributed to ready-mixed concrete (Marceau et al. 2007), so the carbon dioxide and potential energy can save by the use of geopolymers. Consequently, there is growing interest of geopolymer concrete application in various structures.

The extensive world-wide research efforts can be made on Eco-friendly geopolymer concrete which can be used in similar condition as for Portland cement. Such a kind of cement should be capable of being mixed with a relatively low-alkali activated solution and must cure in a under ambient conditions.

A geopolymer concrete when steam cured attain high early strength. A geopolymer concrete can be used to develop precast railway sleepers and other pre-stressed concrete structures. The property of geopolymer concrete to attain high early strength can be utilized in the precast industry where steam curing is a common practice.

2 LITERATURE REVIEW

Prof. B.V.Rangan in his study found that heat-cured low-calcium fly ash-based geopolymer concrete also shows excellent resistance to sulfate attack, good acid resistance, undergoes low creep, and suffers very little drying shrinkage.

Prof. M.V.Nataraja in his research article published in international journal of civil and structural engineering found that the load deflection characteristics of the RPCC beams and RPGC beams are almost similar. The cracking moment and service load moment were marginally lower for RGPC beams. The ultimate moment capacity of the RGPC beams investigated in the study was found to be more than that of the RPCC beam because of their higher compressive strength.

Rajagopalan (1995) have studied the stiffness degradation of reinforced concrete beams under low-energy impact loading. Nine concrete beams having nominal sectional dimensions of 100mm x 200mm (breadth x depth) and a span of 2300mm are tested under repeated impact loading. The loading is achieved by a freely falling body of a constant mass with a constant height of fall for each test beam.

Muthumani (1995) have studied the behavior of concrete beam under low energy repeated impact loading in his PhD thesis. He found that concrete beam has more toughness under impact load as compared to repeated impact load of low energy. Banthia (1987), Banthia, (1989) et al., Mindness and Banthia (1986) and Ross (1997) have reported the impact resistance of high strength concrete.

CRC is an ultra-high-performance concrete with compressive strength around 200 MPa and highly energy-absorbing material with its toughness almost three times that of conventional FRC with steel or polymeric fibers. Under impact, CRC is capable of dissipating much higher energy compared to conventional FRC with polymeric or steel fiber. In this project behavior of reinforced geo-polymer concrete slabs under repeated impact loading is studied.

3 MATERIAL USED

1. **FLY ASH** – In the production of geopolymer concrete the low calcium fly ash is used which is obtained from coal-burning power stations. Most of the globally available low calcium fly ash formed as a by-product of burning of bituminous coal.

2. ALKALINE SOLUTION- An alkaline solution is prepared by mixing together sodium silicate solution and sodium hydroxide (NaOH). It is recommended that alkaline solution should be used within 24 hour after making this solution.

This alkaline solution used as binder in geopolymer concrete. The chemical composition of such a solution is shown in the table below.

In general the sodium silicate solution is available in different grades.

compound	**% by mass**
Na_2O	14.7
SiO_2	29.4
H_2O	55.9

Material	**Mix 1 (kg/m^3)**	**Mix 2 (kg/m^3)**
20mm aggregate	280	280
7mm aggregate	638	638
Sand	549	549
Fly ash	399	399
NaOH solution	39	39
Sodium silicate solution	98	98
plasticizer	5	5
Extra water added	nil	19.8

Fig.1: Freshly prepared geo-polymer concrete

4. Experimental Programme

Preparation of test specimen

To prepare geo-polymer concrete mix fly ash, ground granulated blast furnace slag, fine aggregate and coarse aggregates were used. For binding property in geo-polymer concrete an alkaline solution was used which consist of NaOH and sodium silicate solution.

The GPC mix was produced using pan tilting drum mixture.

Slab test specimen of dimensions of 90x90 and thickness of 50 cm were developing using geo-polymer concrete mix. This geo-polymer concrete should have good workability i.e. the slump value should be a minimum of 90 mm and easily compactable.

The specimen was demould after 24 hours of casting and cured at laboratory conditions.

Description of test program

- Piezo-electric accelerometer was fixing from the bottom side of the slab in the middle portion and at 1/4th point and connects with T.E.A.C tape recorder by pre-amplifier.
- Electric resistant strain gauge fixes to the surface of slab and connects with tape recorder for impact test.
- An impact hammer mount to load cell is connect with tape recorder by a strain gauge.
- Repeated drop of an impact hammer with continuously increasing height to the centre of the slab is done by a pulley with rope and the corresponding impact load is measure.
- T.E.A.C. Tape recording setup record the impact, strain and acceleration signal for every drop.

5 RESULTS AND DISCUSSIONS

The test result show that for a fall of weight of 11cm, the maximum Impact value is 17.42 KN and time period of pulse was 4.22ms and it reaches a max. value of 37.45 KN for reinforced geo-polymer concrete slab. Similarly for fiber reinforced geo-polymer concrete slab it varies from 16.29KN to a max value of 38.74KN. For reinforced ordinary geo-polymer concrete slab max impact value varies from 25.14KN to a max. of 37.92KN and for fiber reinforced ordinary geo-polymer concrete slab, this value increases from 31.24 to 45.31KN.

Name of specimen	**Heights of fall (cm)**	**Accelerations the middle of slab (m/s^2)**	**Impact value (K N)**	**Time period for pulse (ms)**
Reinforced geopolymer concrete slab	11	322	17.42	4.22
	22	356	22.34	4.22
	33	392	28.32	4.92
	44	483	33.41	4.92
	55	492	37.45	4.21
Fiber reinforced geopolymer concrete slab	11	279	16.29	4.22
	22	262	19.46	4.22
	33	284	28.81	4.98
	44	312	34.63	4.22
	55	332	38.74	4.98
Reinforced Ordinary Portland cement concrete slab	11	304	25.14	3.64
	22	331	27.32	3.29
	33	416	29.81	3.29
	44	439	33.45	3.64
	55	418	37.92	2.84
Fiber reinforced geopolymer concrete slab	11	295	31.24	2.8
	22	344	42.36	3.29
	33	356	39.18	3.29
	44	363	42.71	3.29
	55	482	45.31	3.29

Fig.2 : Fiber reinforced geo-polymer concrete slab

Fig.3 : Fiber reinforced ordinary Portland cement concrete slab

CONCLUSION

As height of fall increase, the value of maximum impact load also increase and maximum impact load value for slab with steel fiber is more as compare to plain cement concrete slab.The impact load value for continuously increasing height of fall for fiber reinforced geo-polymer concrete slab is equal or slightly more than ordinary cement concrete slab. But the major thing is that cracks after application of load in geo-polymer concrete slab is less as compare to ordinary cement concrete slab.

As the strength characteristics of cement concrete and geo-polymer concrete are almost same specially the impact strength of load taken from increasing height measured in this project, So it can be utilize as a alternate of cement which is environment friendly such as to reduce the impact of global warming.

Also in the point of view of economy it is more economical than Portland cement because its manufacturing consists of waste products such as fly ash, blast furnance slag etc.

These all values are taken at the middle of all kinds of slab.

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