Numerical Investigation on Reinforced Geopolymer Concrete Beam with Partial Replacement of Fly Ash Using Waste Granite Powder

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Abstract **- This research work aims to study further sustainability to the cement - less geopolymer concrete by partially replacing fly ash by waste Granite powder. Geopolymer RC beam of grade M35 with 15% granite powder as a replacement to flyash was studied for its flexural behaviour and compared with conventional reinforced cement concrete beam . The analysis was also carried out using ANSYS software. The study derived that in all stages, the performance of the geopolymer beam with granite powder was marginally better than the conventional beam with fly ash. From this numerical investigation, it is concluded that deflection of the beam with 15% granite powder geopolymer concrete beam was lower than the 0% granite powder geopolymer beam. This investigation work encourages the use of Granite powder in concrete with its inherent structural advantage, easy availability and low cost, if not free.**

Index Terms **- Alkaline liquids, Fly ash, GGBS, GPC, Granite Powder.**

I.INTRODUCTION

Geopolymer concrete is one of the building materials that has become more popular in recent years due to the fact that it is significantly eco-friendly than the standard concrete. It deals with the problem of depletion on natural resources such as limestone, which is the primary ingredient to produce cement, and in turn the concrete in India. The primary binder to produce the concrete is Ordinary Portland cement (OPC). Day by day the demand of concrete is increasing for the need of development of infrastructure facilities. Also, it consumes significant amount of natural resources and energy and releases substantial quantity of carbon dioxide to the atmosphere. Newer materials are used in the concrete, so that deficient properties of concrete can be enhanced to our convenience of making concrete a versatile material and eco-friendly. Some of such materials are fibre, slag, fly ash etc. In addition, as the industries grow, their production of waste also increased many times. One of such industrial waste products is Waste granite powder that are greatly accumulated from the industries and therefore usage of those wastes in efficient manner is also taken to account. The utilisation of GGBS, Fly ash and Granite powder thus find its importance in the Geopolymer concrete. The main objective of this paper is to present the numerical investigation of geopolymer concrete with partial replacement of fly ash by waste granite powder.

II. RESEARCH SIGNFICANCE

No research data on the flexural behaviour of fly ash based geopolymer with partial replacement of fly ash by waste granite powder is cited at present. Geopolymer concrete with waste granite powder at optimum replacement was found be effective. This Research work provided satisfactory test results regarding the numerical investigation on reinforced geopolymer concrete.

III. METHODOLOGY

1. To carry out a literature survey on geopolymer concrete and Granite powder properties that can be feasible to use in concrete.
2. To compare the result of the ANSYS model with 0% granite powder model with 15% granite powder model.

IV. MATERIAL COLLECTION

A. FLY ASH

Low calcium fly ash (Class F) is the major deposits produced in the burning of coal. In this work, Class F fly ash is to be used which was collected from Mettur Thermal Power Station, Salem. Generally , Class F fly ash provides good pozzolanic activity and it contains less than 10% of lime (CaO). Fly ash within the concrete mix efficiently replaces Portland cement that successively can aid in making big savings in concrete material prices. The pozzolanic reaction between lime and fly ash will significantly generate less heat thereby preventing thermal cracking. It chemically and effectively binds salts and free lime, which can create efflorescence. The fly ash concrete usually have lower permeability that can reduce the consequences of efflorescence effectively.

B.GROUND GRANULATED BLAST FURNACE SLAG(GGBS)

GGBS (Ground Granulated Blast-furnace Slag) is a cementitious material and it is obtained as a by-product from the blast-furnaces used to make iron.Blast-furnaces operate at temperatures range of 1,500°C and iron ore, coke and limestone are fed with a carefully controlled amount. The iron ore is reduced to iron and subsequently remaining materials form a slag. The so formed slag is tapped off as a molten liquid periodically and for the purpose of utilizing the slag in the manufacture of GGBS it has to be rapidly quenched in large volumes of water. The quenching process enhances the cementitious properties and produces granules almost like a coarse sand. This 'granulated' slag is subjected to drying and ground to a fine powder.

C.GRANITE POWDER

Granite powder, one of the byproducts in granite stone crushing process. It is simply used for filling-up low-lying areas and it is now identified as a replacement material for fly ash in geopolymer concrete. Granite belongs to igneous rock family. The granite waste generated by the stone crushing industry has accumulated over the years. Only insignificant quantities have been utilized and the rest has been unscrupulously dumped resulting in environmental problems. Presently, all the processing units are disposing this industrial waste by dumping it in open yards, that nearly occupying 25% of the total area of the industry. The utilization of those granite powder in the concrete could turn this waste material into a valuable resource with the added benefit of preserving environment. Therefore, this study focused on using locally available granite powder .

D.ALKALINE LIQUIDS

Alkaline Activated solution (AAS) is a mixture of sodium silicate (Na2SiO3) and sodium hydroxide (NaOH). Sodium hydroxide in the flakes form are dissolved in distilled water to get solution with required Molarity. The mass of NaOH solids to be used in a solution change according to the concentration of the solution expressed in terms of molar, M. During the mixing of water with NaOH flakes, more amount of heat was generated. Therefore, it is recommended that the NaOH solution are made 24 hours before casting. After 36 hours it is converted into a semi-solid state, therefore it is used within 36 hours of mixing. The next step is to mix the Sodium silicate solution with the NaOH solution prior to batching. Sodium-based solutions are usually cheaper than Potassium-based solutions, hence used widely.

V.MIX PROPORTION

Fly Ash	Fine Aggregate	Coarse Aggregate	Alkaline Solution
445.53	629.603	1216.89	191.58
1	1.43	2.73	0.43

VI.TEST RESULTS AND DISCUSSION

The specimen is fabricated in the size of 1000*150*150 mm and imported on ANSYS software with fixed support.

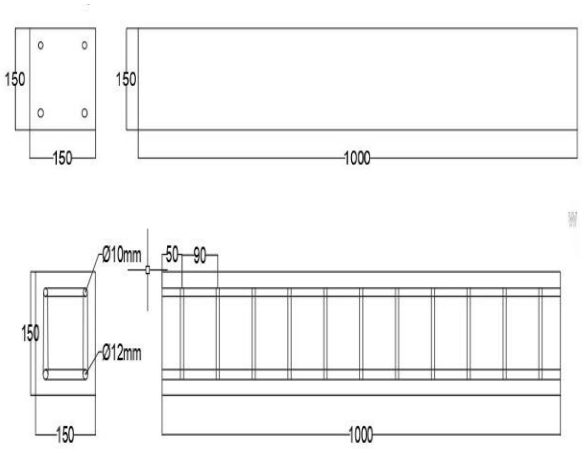

Fig -1: Dimensions of beam

A. REINFORCED GPC BEAM WITH 0% GRANITE POWDER

Table – 1: Properties of steel

S.no	Property	Value
1	Young's modulus	2E+05 MPa
2	Poisson's ratio	0.3
3	Bulk Modulus	1.6667E+11Pa
4	Shear modulus	9.3167E+09Pa

Table – 2: Properties of geopolymer concrete

S.no	Property	Value
1	Youngs modulus	22360MPa
2	Poisson's ratio	0.2
3	Bulk modulus	1.2422E+10Pa
4	Shear modulus	9.3167E+09Pa

Table – 3: Result of reinforced geo polymer concrete beam with 0% granite powder

S. No	Load (KN)	Deformation (mm)	Stress (MPa)	Strain
1	10	0.09286	4.464	0.00025
2	20	0.18426	8.930	0.00049
3	30	0.27652	13.398	0.000675
4	40	0.36887	17.867	0.000900
5	50	0.46130	22.338	0.001126
6	60	0.55382	26.811	0.001351
7	70	0.64643	31.286	0.001577
8	80	0.73913	35.762	0.001803
9	90	0.83191	40.240	0.002029
10	100	0.92479	44.720	0.002256

The beam is design and analysis of specified dimension (1000*150*150mm) with geo polymer. The analysis based on gradually load acting on the beam. Load applied on the beam is 10 to 100 KN and deflection value is 0.09286 to 0.92479 mm respectively. As well as the von misses stress and von misses strain values are increased gradually.

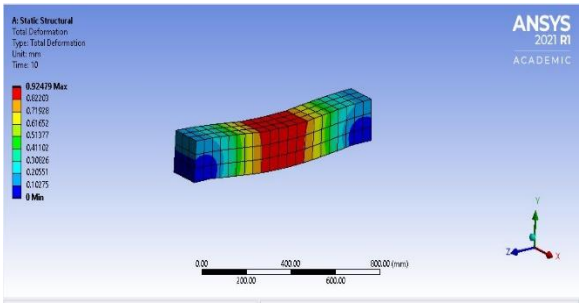

Fig -2: Total deformation of reinforced GPC beam with 0% granite powder

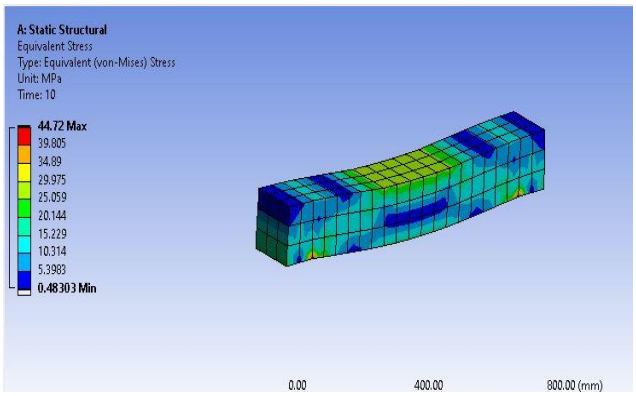

Fig -3: Von mises stress of reinforced GPC beam with 0% granite powder

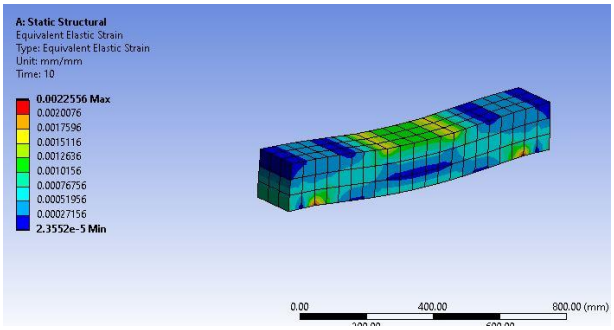

Fig -4: Von mises strain of reinforced GPC beam with 0% granite powder

B. REINFORCED GPC BEAM WITH 15% GRANITE POWDER

Table – 4: Properties of geopolymer concrete

S.no	Property	Value
1	Youngs modulus	30748 MPa
2	Poisson's ratio	0.22
3	Bulk modulus	1.8302E+10Pa
4	Shear modulus	1.2602E+10Pa

Table – 5: Result of reinforced geo polymer concrete beam with 15% granite powder

S. No	Load (kN)	Deformation (mm)	Stress (MPa)	Strain
1	10	0.06876	4.426	0.00016
2	20	0.1338	8.855	0.00032
3	30	0.20076	13.284	0.000484
4	40	0.26778	17.715	0.000646
5	50	0.33484	22.147	0.000807
6	60	0.40194	26.580	0.000969
7	70	0.46909	31.014	0.001313
8	80	0.53629	35.449	0.001293
9	90	0.60353	39.886	0.001455
10	100	0.67082	44.323	0.001617

The beam is designed and analysed with specified dimension (1000*150*150mm) with 15% granite powder. The analysis based on gradually load acting on the beam. Load applied on the beam is 10 to 100KN and deflection value is 0.06876 to 0.67082 mm respectively. Also, the von misses stress and von misses strain values are found to increase gradually.

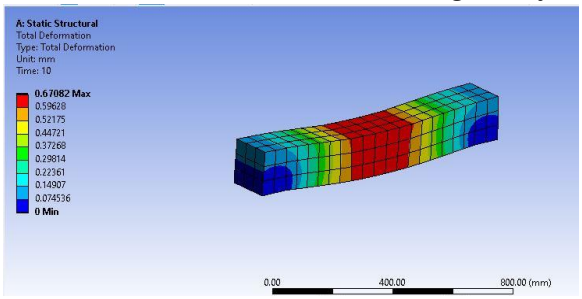

Fig -5: Total deformation of reinforced GPC beam with 15% granite powder

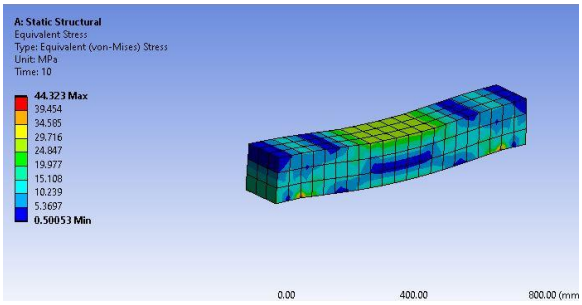

Fig -6: Von mises stress of reinforced GPC beam with 15% granite powder

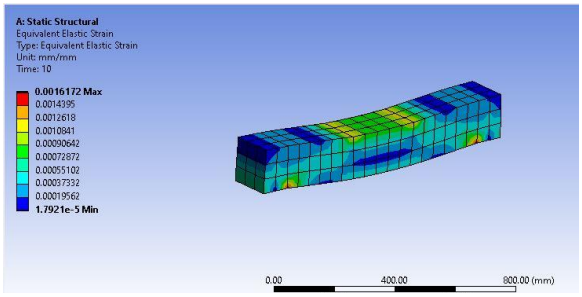

Fig -7: Von mises strain of reinforced GPC beam with 15% granite powder

VII.CONCLUSIONS

1. Geopolymer concrete properties can be enhanced by considering the replacement of fly ash with waste granite powder.
2. The use of GGBS and granite powder as the cementious material with fly ash could be a better alternative for the insitu applications.
3. From this numerical investigation it is concluded that the partial replacement of fly ash by granite powder, the deformation values are found to decrease.
4. This gives the scope that the Geopolymer concrete with fly ash in proportion with Waste Granite Powder be employed in construction for better achievement of strength and durability characteristics

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