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UTILISATION OF GRANULATED MARBLE IN GEOPOLYMER CONCRETE

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Abstract - *This project present study on geopolymer concrete by replacing fine aggregate with granulated marble. Geopolymer concrete utilizes waste materials such as fly ash (FA) together with alkaline solution (NaOH & $NaSiO_2$), which results in a great binder to replace cement and using granulated marble as the fine aggregate. This research study focuses as on complete elimination of Portland cement for production of concrete that can achieve 28 days cube strength in the range of 40-50Mpa with the emphasis on the curing techniques applicable for in-situ construction. Heat-cured low-calcium fly ash-based geo polymer concrete has excellent compressive strength, suffers very little drying shrinkage and low creep, excellent resistance of sulphate attack, and good acid resistance. It can be used many infrastructure application. As it shows good resistance to sulphate and acid attack it can be used for marine structures. Super plasticizers such as naphthalene for workability and, polystyrene and polypropolyne are used for strengthening purposes.*

Key words: *Alkaline solution; Fly ash based geopolymer concrete; Heat-cured*

1. INTRODUCTION

During the last decade, considerable research efforts have been directed towards the development of inorganic Geopolymers, due to the wide range of potential applications for these materials. Several reports can be found in the literature on the synthesis, properties and applications of geopolymers. The development of geopolymer cement is an important step towards the production of environmentally friendly cements. Geopolymer is a type of amorphous alumino-silicate cementitious material. Geopolymer can be synthesized by polycondensation reaction of geopolymeric precursor and alkali polysilicates known as geopolymerization process. Geopolymerization is an innovative technology that can transform several aluminosilicate materials into useful products called geopolymers or inorganic polymers. Geopolymerization involves a heterogeneous chemical reaction between solid aluminosilicate oxides and alkali metal silicate solutions at highly alkaline conditions and mild temperatures yielding amorphous to semicrystalline polymeric structures, which consist of Si–O–Al and Si–O–Si bonds. Geopolymerization is a geosynthesis (reaction that chemically integrates minerals) that depend on the ability of the aluminium ion (6-fold or 4-fold coordination) to induce crystallographic and chemical changes in a silica backbone. The geopolymer cement is produced by totally replacing the Ordinary Portland Cement (OPC). Therefore, the use of geopolymer technology not only substantially reduces the CO2 emissions by the cement industries, but also utilises the waste materials such as fly ash. It is to be noted that fly ash, one of the possible sources for making geopolymer binders, is available abundantly worldwide, and yet its usage to date is very limited . Consumption of fly ash in the manufacture of geopolymers is an important strategy in making concrete more environmentally friendly. For this reason, fly ash has been chosen as a base material for this project in order to better utilise this industrial waste.

2. METHODS

- Collection of materials.
- Testing of materials.
- Mix design (as per IS:10262-2009).
- Cube casting and curing.
- Test on concrete (fresh and hardened).
- Result and discussion.

2.1. Collection of materials

- Flyash (from Ennore Thermal Power station)
- Marble powder
- Chemicals
  - Sodium silicate Gel
  - Sodium hydroxide Flakes

The cement taken in the project work was OPC 53 Grade cement. The various test such as fineness test, specific gravity test and consistency test are conducted on the sample taken. Class F Fly ash been collected from the Ennore Power station for the project work. The various test such as fineness test and specific gravity test are conducted on the sample taken. There are two type of fine aggregates used in this project, first the conventional fine aggregate (Sand) and secondly Marble Powder is used as a replacement of fine

aggregate in geopolymer concrete. The specific gravity test is conducted on the sample taken. A well grade coarse aggregate of size 10 to 20 mm are taken. The specific gravity test is conducted on the sample taken.

Pre-preparation of chemicals

Sodium hydroxide

Generally the sodium hydroxides are available in solid state by means of pellets and flakes. The cost of the sodium hydroxide is mainly varied according to the purity of the substance. Since our geopolymer concrete is homogenous material and its main process to activate the sodium silicate, so it is recommended to use the lowest cost i.e. up to 94% to 96% purity. In this investigation the sodium hydroxide pellets were used

Sodium silicate

Sodium silicate is also known as water glass or liquid glass, available in liquid (gel) form. In present investigation sodium silicate 2.0 (ratio between Na2O to SiO2) is used. As per the manufacture, silicates were supplied to the detergent company and textile industry as bonding agent. Same sodium silicate is used for the making of geopolymer concrete

Alkaline liquid

Generally alkaline liquids are prepared by mixing of the sodium hydroxide solution and sodium silicate at the room temperature. When the solution mixed together the both solution start to react i.e. (polymerisation takes place) it liberate large amount of heat so it is recommended to leave it for about 24 hours thus the alkaline liquid is get ready as a binding agent.

Preparation of alkaline liquids

Sodium hydroxide pellets are taken and dissolved in the water at the rate of 16 molar concentrations. It is strongly recommended that the sodium hydroxide solution must be prepared 24 hours prior to use and also if it exceeds 36 hours it terminate to semi solid liquid state. So the prepared solution should be used within this time.

2.2. Testing of Materials

Cement used : OPC 53 grade confirming to IS 8112
Specific Gravity of Fly ash : 2.6
Specific Gravity of Cement : 3.1
Specific Gravity of Sand : 2.6
Specific Gravity of Granulated Marble : 1.785
Specific Gravity of Coarse Aggregate : 2.8

2.3. Mix Design

Design of M30 concrete mix as per IS:10262-2009, Concrete mix proportioning-guidelines

Design stipulations for proportioning

Grade designation : M30
Type of cement confirming to IS 8112 : OPC 43 grade
Maximum nominal size of aggregates : 20 mm
Minimum cement content : 350 kg/m3
Maximum water cement ratio : 0.45
Workability : 25 - 50 mm (slump)
Exposure condition : Moderate
Degree of supervision : Good
Type of aggregate :Crushed angular aggregate
Maximum cement content : 450 kg/m3

CEMENT	FINE AGGREGATE	COARSE AGGREGATE	WATER
413 kg/m^3	706 kg/m^3	1117 kg/m^3	186 kg/m^3
1	1.71	2.7	0.45

Table 1: Mix Proportions

Experimental programme

Nine cubes of 150 * 150 mm were cast out of which three cubes of each were used to determine the compressive strength at 7,14,28 days for different grades of Geopolymer Concrete. A total of 108 specimens were tested in this study to find out the optimized grades of Geopolymer Concrete incorporating granulated marble. It is recommended to have necessary precaution on workers because of acidic nature of the concrete. The aggregates were prepared in saturated-surface-dry (SSD) condition. Geopolymer concrete can be manufactured by adopting the conventional techniques used in the manufacture of Portland cement concrete. Then the components of concrete ingredients are collected and mixed with the pan mixture for about 5 min. Then Alkaline liquid were then added to the mixture and the mixing was done for another 5 min. After the mixing, the flow value of fresh geopolymer concrete was determined in accordance with slump test IS 516-1959.

2.4 Cube casting and curing

The specimens were left standing for 1 hour and then cured at 60ºC in the curing chamber for about 24 hours. Demoulding was done at 24 hours at the time of curing age. After the curing period the specimens left at the room temperature for about an hour and ready for testing. Thus

the compressive strengths and tensile strength of concrete were tested at the same day in accordance with IS 516-1959. The reported strengths were the average of the three specimens.

3. RESULTS AND DISCUSSION

3.1. Results on Material Testing

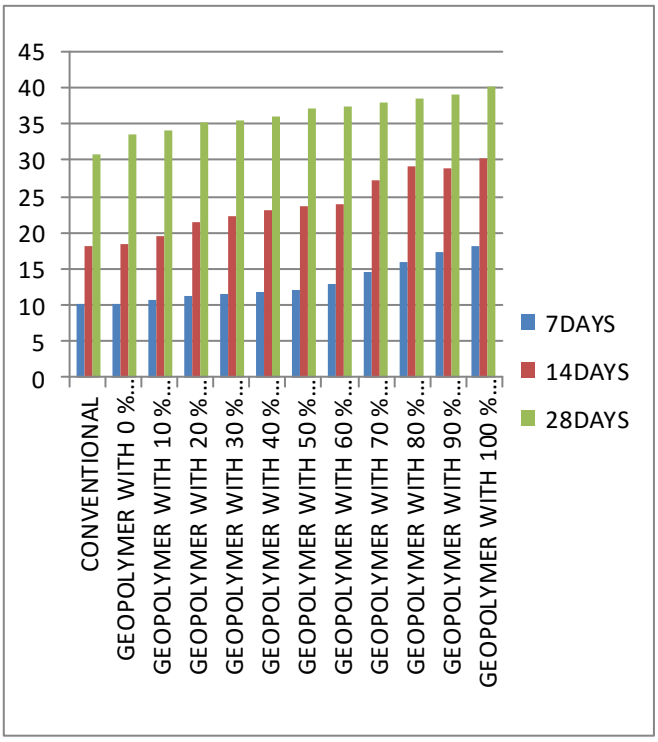
Cement used	: OPC 53 grade confirming to IS 8112
Specific Gravity of Fly ash	: 2.6
Specific Gravity of Cement	: 3.1
Specific Gravity of Sand	: 2.6
Specific Gravity of Granulated Marble	: 1.785
Specific Gravity of Coarse Aggregate	: 2.8

3.2 Compressive Strength Results

Nine cubes of each proportions were casted and each 3 cubes are tested at 7, 14, 28 days respectively and the average of the results of three cubes are reported as the mean compressive strength of the proposed mix. The Testing were done in the UTM machine

S. No	Type of Test Specimen	Compressive Strength N/mm²		
		7th Day	14th Day	28th Day
1	Conventional	10.07	18.22	30.81
2	Geo polymer	10.14	18.34	33.48
3	10% Replacement	10.57	19.4	34.15
4	20% Replacement	11.1	21.47	35.11
5	30% Replacement	11.4	22.36	35.56
6	40% Replacement	11.7	22.96	36.15
7	50% Replacement	12.07	23.55	37.04
8	60% Replacement	12.83	23.85	37.33
9	70% Replacement	14.43	27.11	37.93
10	80% Replacement	15.85	29.1	38.37
11	90% Replacement	17.17	28.73	38.96
12	100% Replacement	17.97	30.21	40.15

Table 2: Compression Test Results



4. CONCLUSION

The project work is done with almost care observing all the guidelines in design aspects as per IS codes. Completion of this project gave sufficient knowledge in the following aspects.

- By using flyash as the partial replacement of cement, we can achieve good and economical concrete.
- By using marble powder as the fine aggregate the compressive strength of the concrete is being increased.
- With the increase in percentage of marble powder the cube tends to set quickly than other geopolymer and conventional cubes.
- By using flyash it significantly reduce the green house gas emission.
- We have made a revolution on concrete by this geopolymer concrete in construction field.
- The compressive strength is increased by 30% comparing to the conventional concrete.

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