Microstructure of Geopolymer Concrete Based on Fly Ash Using M-Sand

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Geopolymers prepared from a class F-fly ash and a mixed alkali activator of sodium hydroxide and sodium silicate solution were investigated. A high compressive strength was obtained when the modulus of the activator viz., molar ratio of $\text{SiO}_2/\text{Na}_2\text{O}$ was 2.5. Any presence of the temporary phase with different composition was not found between geopolymer and aggregate as it is at the concretes from Portland cement. Geopolymer composition is almost the same in the close nearness even in the geopolymer matrix. Elastic modulus evaluated for the mixed geopolymeric concrete was found to be $E = 4389 (f_{ck})^{0.535}$ Mpa. Such result is comparable (a little bit lower) to ordinary Portland cement pastes.

Key Words: Geopolymer concrete, M-Sand, Fly ash.

INTRODUCTION

When strongly alkali surrounding is effective to aluminosilicate substances like cement, marl, slag, fly ash or heat activated kaolin substances, new materials-geopolymers arise. Their base is two or three dimensioned structure Si-O-Al. Great attention is devoted to these new materials¹⁻⁷. In these works there are mentioned the study synthesis results of geopolymers, microstructures (mainly SEM) but also resulting possibilities how to apply them, mainly when using the waste inorganic materials. Geopolymers give the potential possibilities to prepare inorganic bonds and building materials from the by product of thermal power plant like fly ash. When geopolymers are prepared, the burning process at high temperatures is not needed as it is during production of cement or lime. Building material production from geopolymers does not effect encumbrance the environment by CO_2 emissions and that is why these materials present the potential possibility of building material production without CO_2 emissions¹⁻⁷. Out of the up-to-date knowledge of geopolymer qualities, some materials are obvious to have the same or even better qualities than those based on Portland cement. The materials based on geopolymers are evidently the parts of the ancient constructions aged several thousand years as the detailed search of these ancient constructions in Egypt and other countries shows^{8,9}. The attention is mainly devoted to geopolymer's polymer character (NMR in solid phase), mechanical characters, influence of aggressive environment, ability of leaching and others. This study is based on characteristics of geopolymer concrete.

EXPERIMENTAL

Twenty five 150 mm × 150 mm × 150 mm cubes specimens were casted incorporating M-sand. Optimized mix ratios are taken. For this study, the concrete ingredients were mixed in a pan mixture for about 5 min. Then alkaline liquids were added and mixing was continued for another 5 min. On completion of the mixing, the flow value of fresh geopolymer concrete was determined using the slump test described in IS 516:1959. The fresh concrete could be handled for about 120 min without setting. After the flow test, the fresh concrete was placed in moulds as described in the IS 516:1959. The fresh concrete was cast and compacted by the usual methods as in conventional concrete. The specimens were left for 1 h and then cured at 60 °C for about 24 h. After cooling, the specimens were tested for compressive strength in accordance with IS 516:1959. The strength data reported here is average of three results (Table-1).

TABLE-1

Content/M-sand Grade	MS 20	MS 25	MS 30	MS 35
Fly ash	410	470	550	620
M-Sand	756.3	667.5	575.2	492
Coarse aggregate	1035	953.2	858.43	767.5
NaOH solution	66.8	81.9	95.85	109.83
Na_2SiO_3	167	204.8	239.64	274.6
Water	16.4	14.1	16.5	12.4
Compressive strength (Mpa)	27	30	36	38

4) In the presence of Ca contained ingredients (slag) as a result of geopolymer coexistence and C-S-H phase and maximal geopolymer strength was reached.

5) Any presence of the temporary phase with different composition was not found between geopolymer and aggregate as it is at the concretes from portland cement. Geopolymer composition is almost the same in the close nearness even in the geopolymer mass.

6) Elastic modulus evaluated for the geopolymeric phase by means of nanoindentation was found to be $E = 4389$ (f_{ck}) 0.535. Such result is comparable (a little bit lower) to ordinary portland cement pastes.

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