Repair of cracks by using a Geopolymer with ambient curing

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ABSTRACT

This paper presents the crack repairing process with Geopolymers mortar with experimental method. This method is used to repair the structural and non-structural cracks on concrete, RCC structures, brick wall by using injection of Geopolymers based grouts. We attempt on structural members to recover the original strength of severely cracked elements repaired by Geopolymers based grout injections. It is decided to study in Masonry wall, PCC floors with grouting injection. The Geopolymers mortar mixture is prepared by fly ash-based Geopolymers mortar suitable for ambient curing condition. Generally, fly ash and slag blend has improved the early-age mechanical properties of Geopolymers concrete cured at ambient condition. This mix is injected into the cracks and the strength of the masonry is studied by using Non Destructive testing methods before and after grouting.

Keywords: *Geopolymers, Ambient curing, Repairing, Structural and Non Structural cracks.*

Introduction

There are mainly two types of cracks that affect the concrete structure one is structural and nonstructural cracks, Structural cracks consist of many types according to the type of construction, quality of material, loading conditions, environmental conditions etc., Nonstructural cracks are given a minor impact to the structure, the main problem in the nonstructural cracks is aesthetic and it leads to bring several environmental problems to the structures and pavements the cracks in concrete wall is shown in figure 1 , and the pavement is shown in figure 2. In this paper we concentrate more about nonstructural cracks like shrinkage cracks on concrete surface. Repairing of cracks by using cement mortar is not the permanent solution in this types of cracks because the shrinkage cracks are developed due to improper curing or insufficient amount of water present in the concrete. We repair the concrete by using the mortar again curing is the problem after repairing the concrete surface when curing is not properly done by the people again the concrete leads to the shrinkage cracks in the same surface. So as to improve the quality of the surface after repairing we prefer geoploymer as the solution for the problem mentioned above as it reduces the greenhouse effect.

The increasing environmental pollution has been the driving force to develop the Geopolymers in construction, as it is an economical and eco-friendly building material. The environmental impact is very high when using the cement product in construction, Cement creates greenhouse effect and gas emitting product. Geopolymers have good binding property with low CO2 emission compared to that of cement. Geopolymers also exhibit similar and superior properties compared to any other binder especially cement. Ground blast furnace slag is added in to the mix to enhance the early age properties of concrete setting times of Geopolymers pastes. Class-F fly ash is used as the base material which when reacted on by sodium hydroxide and sodium silicate solutions workability as fresh concrete and compressive strength after ambient curing is investigated. Geopolymer is an inorganic alumino-silicate polymer synthases from alkaline activation of various aluminosilicate materials of geological origin or by-product materials like fly ash, metakaolin, blast furnace slag etc. The polymerization process takes place with aluminosilicate minerals under alkaline conditions that creates three dimensional polymeric chain.

Figure 1. Shrinkage cracks in wall

Figure 2. Shrinkage cracks in Pavement

Three basic concepts lead to chemical reaction dissolution of atoms from source

Material, orientation of precursor ions into the monomers, setting of monomers into the structures the final products of geopolymerisation are influced by many factors regarding chemical composition of source of the materials and activators.

The polymerization process is generally accelerated in the high temperature than the atmospheric temperature, fly ash based geopolymer being produced in ambient curing. The amount of calcium oxide (CaO) improves the strength of geopolymer in ambient curing. The GGBS is used to attain the strength with ambient curing. Recently, the suitability of fly ash based geopolymers mixed with silica fume, metakaolin and blast furnace slag has been studied by several investigators.

Geopolymer mortar produced without using elevated heat for curing will widen its application. Hence this study is aimed to produce geopolymer concrete suitable for ambient curing condition. Ground blast furnace slag is mixed with low calcium fly ash to study the setting time, workability and the strength properties of geopolymer mortar.

Geopolymer Mortar

Fly Ash

F class fly ash used in this process of geopolymer paste, F fly ash sourced from the coal of power station it contains high silicon and aluminum content and loss of ignition.

GGBS

Ground-granulated blast-furnace slag (GGBS) is the iron slag from steel manufacturing company the product is collecting from blast furnace. It contains high cementitious and high silicate and it is used to enhance the bonding property of geoplymer. It also helps to reduce the heat of hydration so far it is used to curing the geopolymer in ambient temperature. The chemical composition of GGBS and fly ash as shown in the Table1.

Sample	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	SO_3	P_2O_5	TiO_2	LOI_a
Fly ash (%)	50.0	28.25	13.5	1.79	0.89	0.32	0.46	0.38	0.98	1.54	0.64
GGBS (%)	32.4	14.3	0.61	43.1	3.94	0.24	0.33	4.58	0.02	0.55	0.09

Alkaline solutions

Alkaline solutions is used to react with fly ash to produce an effective binder, sodium silicate solution type A53 is used for concrete production. Sodium hydroxide solution is prepared by dissolving sodium hydroxide pellets in water. The pellets are commercially graded with purity of 97%.

Fine aggregate

Fine sand is used for the mortar paste. The sand has fineness modulus of 1.98, and the clay content is 3% is used for the mix.

Mix proportion

The mix proportion is chosen according to the trial and error method with the alkaline liquid to volume of fly ash by mass of 0.35 and fine aggregate. The mixture is done by pan mixture. Aggregate prepared in saturated surface dry condition, and the binders (fly ash and GGBS) are dry mixed thoroughly in the mixer. Premixed alkaline activator solution is then added gradually in the mixer. Mixing is continued for 4-6 minutes further depending on the consistency of the mixture. The mixture is ready for injection. Figure 3 shows the mixture.

Figure 3. Geopolymer mix

Geopolymer injection

The surface is cleaned with water so that the dust are removed from the surface crack with 2mm thickness and thickness is cleaned properly. The geopolymers are filled in the injection and with pressure the cracked surface is grouted by the geopolymer injection.

Tension test on specimen

Testing is carried out with concrete cube of size 150 mm x 150 mm x 150 mm with cracked surface then that cube crack was injected by the geopolymer injection and tension test is carried out the failure load could be noted. When the pressure is increased the cracks are completely filled with geopolymer based injection after completion of the grouting finishing the surface with geopolymer based mortar. With ambient curing the test were made on 24 hours after injecting the geopolymer mortar.

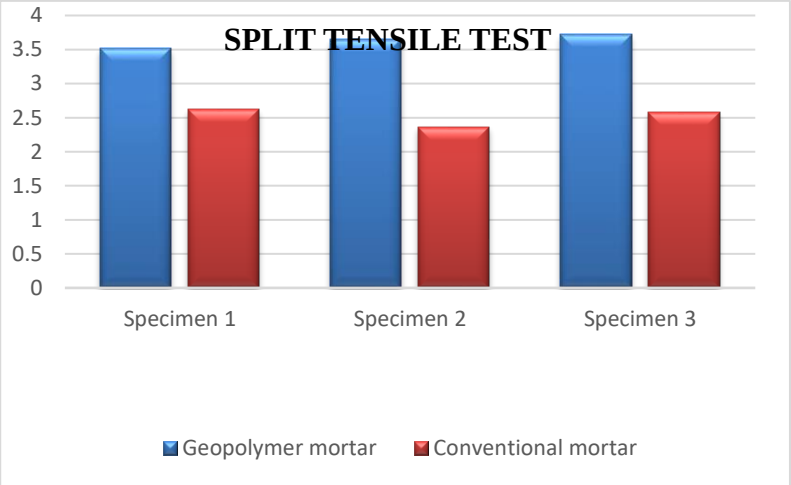

Figure 4 Split tensile test

Conclusion

Repairing by using injection is the best method, Repair by injection of grouts made of Geopolymer is effective for recovering the strength of the cracked concrete surface. Good quality of injection process is crucial to achieving effective repair as Cement or lime do not produce good results.

Six specimens are tested under split tensile test from that three of them are geopolymer injecting with ambient curing has given the best results, as a result 44% of strength attained in by using geopolymer with ambient curing, when compared to conventional mortar.

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