Study of Long Term Durability Characteristics of Steel Fibre Geopolymer Concrete

Vikas V. Gad[1] Rameez K. Sayed[2] Bhushan H. Chavan[3] Siddharth V. Bhambure[4]
[1,2,3,4]Shivaji University Kolhapur

Abstract— The three basic needs of man are food, clothing and shelter. Civil Engineer has relevance with all basic needs of man directly or indirectly. Cement concrete is one of the most important and relatively cheap construction materials, which contain cement, coarse aggregates and fine aggregates. In developing country like India use of concrete is more which results in increasing demand as well as rates of raw material for concrete so there is need of find some alternatives to these material, now researchers has progressed a lot in developing the method of constructing shelter. Now a day's most of the research has focused on use of the waste material in concrete according to their properties. In this study, M 20 grade of concrete was produced by replacing cement with fly ash. For this 12 cube of Geopolymer concrete with varying proportion of steel fibres and this cube were kept 90 days for chloride attack and then compressive strength and tensile strength were evaluated. The results showed that compressive strength of steel fibre Geopolymer concrete is more than conventional concrete.

Key words: Conventional Concrete, Steel Fibre Geopolymer Concrete

I. INTRODUCTION

Concrete is one of the most widely used construction material. The global use of cement concrete is second only to the use of water. It is mainly related to the Portland cement as the main component for making concrete. The demand for concrete as a construction material is increasing day to day. It has been estimated that the production of cement had increased to 2.2 billion tons in 2010 which was about to 1.5 billion tons in 1995.Geopolymer fly ash-based concrete, concrete made up of fly ash, sand, coarse aggregate, and an alkaline solution of sodium hydroxide and sodium silicate, can play a significant role in its environmental control of greenhouse effects. The reduction in the carbon dioxide emission from cement production can contribute significantly to the turning down of the global thermostat.Concrete is strong in compression but weak in tension, so to improve tensile strength Introducing steel fibre is one of the fastest growing segment in concrete industry, as more and more engineers, architectures, owners and concrete contractor's turning to the used of fibre to supply their reinforcing need in their concrete application. Fibre includes steel fibre, glass fibre, synthetic fibre and natural fibre each of which having varying properties to the concrete.

A. FLY Ash

Fly ash is defined as the finely divided residue that results from the combination of ground or powdered coal and that is transported by the flue gases from the combustion zone to the particle removal system. Fly ash is removed from the combustion gases by the dust collection system, either mechanically or by sing electrostatic precipitators, before they are discharged to the atmosphere. Fly ash particles are typically spherical, finer than Portland cement and lime, ranging from less than 1µm to not more than 150µm.

Fly ash plays the role of an artificial pozzolona, where its silicon dioxide content reacts with the calcium hydroxide from the cement hydration process to form the calcium silicate hydrate (C-S-H) gel. The spherical shape of Fly ash often helps to improve the workability of the fresh concrete, hence to produce dense and durable concrete.

Fig. 1: Fly ash powder

B. Steel Fibre

The steel Fibre used in Geopolymer concrete has diameter 0.45mm, length 25mm, aspect ratio 55.55, and no. of fibres in one kg is 30,946. These steel fibers are available from Stewols India Pvt. Ltd., Nagpur.

Fig. 2: Steel fibres

C. Alkaline Solution

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, it is recommended to use it in next 36 hour.

1) Sodium Silicate

The sodium silicate solution is commercially available in different grades. It is also known as water-glass and is in the gel form. The sodium silicate solution with SiO_2-Na_2O ratio by mass of approximately 2.

Fig. 3: Sodium Silicate Solution

2) Sodium Hydroxides Pallets

The cost of the product depends on the purity. The sodium hydroxide pallets were dissolved in water to make the solution with required concentration. The mass of NaOH solids in solution varies depending upon the concentration of the solution. For instance, NaOH solution, with concentration of 8 Molar consists of 8 x 40 = 320 grams of NaOH solids per litre of solution, where 40 is the molecular weight of NaOH. It is recommended that the NaOH solution should be made 24 hours before casting and should be used within 36 hours of mixing the pallets with water as after that it is converted to semi-solid state.

Fig. 4: Sodium hydroxide pallets

D. Preparation of Liquids

The sodium hydroxide pallets were dissolved in distilled water to make the solution. The mass of NaOH pallets in a solution is varied according to the molarities required. NaOH solution with a concentration of 8M consists of 320 grams of NaOH pallets per litre of the solution. It was noted that mass of the NaOH solids was only a fraction of the mass of the NaOH solution, and water was the major component. When sodium hydroxide is mixed with water, solution kept for 24 hours as it produces large amount of heat. Sodium silicate is already in liquid state and hence no requirement any special procedure.

The mixing of sodium silicate solution and sodium hydroxide solution had two aspects. In first method sodium silicate and sodium hydroxide solutions were mixed together at least one day prior to use it as alkaline liquid for preparing Geopolymer concrete. On the day of casting of the specimens, the alkaline liquid was mixed together with the plasticizer or extra water if needed.

In second method the solutions of sodium hydroxide and sodium silicate were mixed together for preparation of alkaline liquid just before using it for preparing concrete.

II. Results and Discussions

A. Durability

The durability of concrete can be defined and interpreted to mean its resistance to deteriorating influences which may reside inside the concrete itself, or to the aggressive environments. Durability test carried out by chlorides attack. Durability conducted for determining strength of material after chemical attack. Durability tests are conducted by using Compressive testing machine.

1) Chloride Attack

Chlorides are generally present in sea water in the form of sodium chloride. Chloride attack is one of the most important aspects for consideration when we deal with the durability of concrete. Chloride attack is particularly important because it primarily causes corrosion of reinforcement. Statistics have indicated that over 40% of failure of structure is due to corrosion of reinforcement.

Fig. 5: Cubes kept for chloride attack

B. Compression Test

Compressive strength is defined as resistance of concrete to axial loading. Cubes were placed in CTM and load was applied. The readings on dial gauge were recorded and compressive strength was calculated.

The graph showed that compressive strength of all the concrete blocks after 90 days of curing. The strength of concrete increased with curing age.

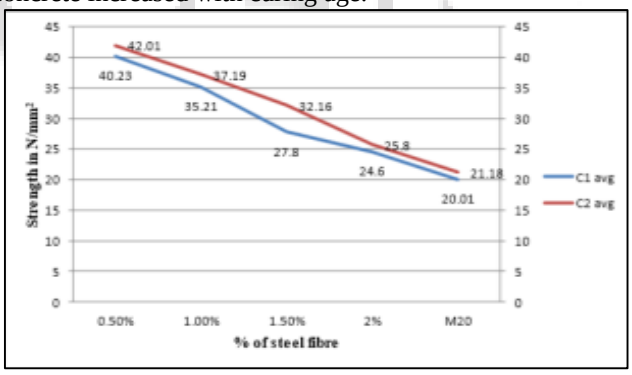

Fig. 6: Steel fibres variation in concrete

C. Chloride Content

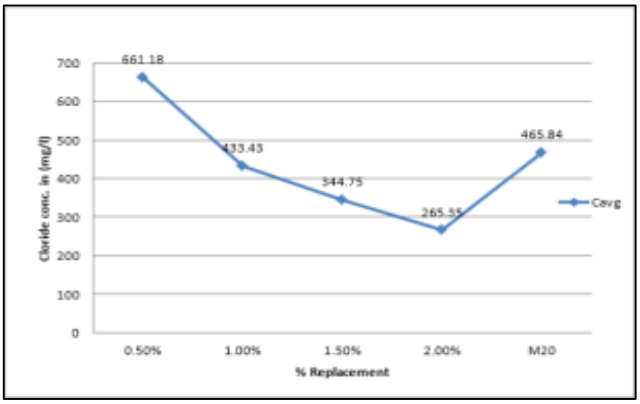

Fig. 7: Variation of chloride concentration

III. CONCLUSION

The following conclusions drawn from the experimentation done for carry out the work:

The compressive strength of steel fibre Geopolymer concrete is more than conventional concrete.

If increasing the oven curing period the strength of cube is increase.

By adding steel fibre in concrete from 0.5% to 1.5% gives very good strength but adding 2% of steel fiber give approximate 20N/mm2 strength.

By adding steel fibre in Geopolymer increase workability is achieved but increasing the percentage of steel fibre strength will goes on decreasing.

By increment in steel fibre GPC shows excellent increment in penetration against chloride attack.

REFERENCES

[1] Bakharev, T. (2005), "Resistance of geopolymer materials to acid attack. Cement and Concrete Research", 35(4), 658-670.
[2] Choi Y, Yuan RL (2005), "Experimental relationship between splitting tensile strength and compressive strength of GFRC and PFRC", Cement and Concrete Research, 35(2005) 1587 91.
[3] Davidovits, J. (1994). Properties of Geopolymer Cements. In Kiev (Ed.), "First International Conference on Alkaline Cements and Concretes" (pp. 131-149). Kiev, Ukraine: Kiev State Technical University.
[4] Hardjito, D., Wallah, S. E., & Rangan, B. V. (2002b). "Study on Engineering Properties of Fly Ash-Based Geopolymer Concrete". Journal of the Australasian Ceramic Society, 38(1), 44-47.
[5] Malhotra VM. (2002) "High-performance high-volume fly ash concrete. ACI Concrete International", No. 7, 24 1-5.
[6] Mzaheripour H(2011), Ghanbarpour S, Mirmoradi SH, Hosseinpour I. "The effect of polypropylene fibers on the properties of fresh and hardened lightweight self-compacting concrete, Construction and Building Materials", 25 351 8.
[7] Okan Karahan, Cengiz Duran Atis The. "Durability properties of polypropylene fiber reinforced fly ash concrete, Materials and Design", 32(2011) 1044 9.
[8] Roy DM. "Alkali-activated cements, opportunities and challenges. Cement and Concrete Research", No. 2, 29(1999) 249-54.
[9] Song, X. J., Marosszeky, Brungs, M. M., & Munn, R. (2005a, 17-20 April). "Durability of fly ash-based Geopolymer concrete against sulphuric acid attack". Paper presented at the 10DBMC International Conference on Durability of Building Materials and Components, Lyon, France.
[10] Torii, K., Taniguchi, K., & Kawamura, M. (1995) "Sulphate Resistance of High Fly Ash Content Concrete. Cement and Concrete Research", 25(4), 759-768.
[11] Van Jaarsveld, J. G. S., van Deventer, J. S. J., & Lukey, G. C. (2003). "The characterisation of source materials in fly ash-based geopolymers. Materials Letters", 57(7), 1272-1280.

