ABSTRACT

Due to growing environmental concerns of the cement industry, alternative cement technologies have become an area of increasing interest. It is now believed that new binders are indispensable for enhanced environmental and durability performance. On the other hand, already huge volumes of fly ash are generated around the world, most of the fly ash is not effectively used, and a large part of it is disposed in landfills. As the need for power increases, the volume of fly ash would increase. Both the above issues are to be addressed. An effort in this regard is the development of geopolymer concrete, synthesized from the materials of geological origin or by product materials such as fly ash, which are rich in silicon and aluminum. So far, the main thrust of research involving geopolymer concrete has been aimed at characterizing the mechanical properties of geopolymer concrete. Majority of these studies are limited to geopolymer concrete cured at elevated temperature. Practical applications of geopolymer concrete are affected by this curing method. This method would prevent the geopolymer concrete to be applied in a cast in situ concrete work. Therefore this research is focused on the utilization of ambient temperature to cure the geopolymer concrete.

Also, studies to investigate the effect of addition of fibres on the strength characteristics of geopolymer concrete are limited. Hence, there exists a technical knowledge gap in this area. Hence, an attempt has been made through the present investigation to conduct an experimental programme to study the effect of addition of fibres such as steel, polypropylene and glass on the strength and other engineering properties of geopolymer concrete composites. Despite the engineering characteristics of the geopolymer concrete, the performance of fibre reinforced geopolymer concrete composites under impact loading is not still well known. Hence an
effort has been made in this investigation to study the performance effectiveness of plain and fibre reinforced geopolymer concrete under impact load. In addition to that, the information on the flexural behavior of fibre added geopolymer reinforced concrete beams is also not available in the past literatures. And flexural behaviour study is vital for the use of fibre reinforced geopolymer concrete for structural applications. Therefore, extensive experimental and analytical investigations were carried out, to study the flexural behavior of plain and fibre added geopolymer composite composite RC beams.

In order to accomplish the above objectives, the present investigation has been divided into five major parts: The first part deals with the studies on the strength characteristics of geopolymer concrete prepared by using fly ash obtained from two different sources. The second part provides a solution for utilizing geopolymer concrete for cast-in situ construction by developing geopolymer concrete composites. The third part deals with studies on the effect of addition of fibres such as steel, polypropylene and glass on the fresh and hardened properties such as workability, density, compressive strength, split tensile strength, flexural strength, impact strength, modulus of elasticity, water absorption and sorptivity of geopolymer concrete composites. The fourth part deals with the experimental investigation on the flexural behavior of geopolymer concrete composite RC beams reinforced with various types of fibres namely steel, polypropylene and glass at different volume fractions. The fifth part deals with the nonlinear finite element analysis using "ANSYS 10.0" software to predict the load versus deflection behaviour of geopolymer composite reinforced concrete beams on significant stages of loading.

Based on the investigations conducted for the above parts, the following conclusions are drawn:

- Geopolymer concrete did not harden immediately at room temperature as in conventional concrete. Geopolymer concrete
specimens took a minimum period of 3 days for complete setting without leaving a nail impression on the hardened surface. These two observations are considered as drawbacks of this concrete to be used for practical applications. Limitations of GPC mix was eliminated by replacing 10% of fly ash by OPC which resulted in Geopolymer concrete composite. Unlike GPC, geopolymer concrete composite hardens immediately and starts gaining its strength within a day without any necessity of heat curing.

- Addition of steel fibres in GPCC resulted in improvement of compressive strength, split tensile strength, flexural strength, impact strength, modulus of elasticity, ductility and energy absorption capacity. Geopolymer concrete composite specimens reinforced with steel fibres leads to lower water absorption and sorptivity values compared to control GPCC specimens. The average density of GPCC increases with the increase in the volume fraction of steel fibres.

- Even though the addition of polypropylene fibres in GPCC did not show any significant improvement in the compressive strength, but the split tensile and flexural strengths were improved due to the addition of fibres. Inclusion of polypropylene fibres considerably improved the ability of concrete to absorb kinetic energy and hence the impact resistance of PFRGPCC is significantly very high.

- In case of GFRGPCC, the addition of 0.01% and 0.02% of glass fibres did not improve the compressive strength, split tensile strength, flexural strength and modulus of elasticity while the GFRGPCC specimens with 0.03% of glass fibres improves the
above mentioned properties. The impact resistance of GFRGPCC specimen is comparatively lower than SFRGPCC and PFRGPCC specimens.

- In case of SFRGPCC beams, the first crack load and the ultimate load increased as the volume fraction of steel fibres increases. The gain in ultimate load carrying capacity is more significant in the case of SFRGPCC beams due to the addition of steel fibres. For steel fibre reinforced geopolymer concrete composite beams, as the fibre content increases, the ductility also increases. The maximum value of the ductility factor is obtained for the beam with a fibre volume fraction of 0.5%. Due to the addition of polypropylene fibres, the increase in ultimate load is very marginal as compared to control GPCC beam. Beams reinforced with polypropylene fibres did not show any improvement in ductility when compared with control GPCC beam. In case of GFRGPCC beams, the increase in ultimate load carrying capacity was not that much significant when compared to control GPCC beam. In the case of glass fibre reinforced geopolymer concrete beams, ductility factor increases for all the volume fractions, however the maximum ductility was observed for the beam with a volume fraction of 0.01%.

- The failure mechanism of GPCC beam and fibre reinforced GPCC beams were modeled quite well using finite element software ANSYS and the failure loads predicted were found to be very close to the failure load recorded during experimental testing. The analytical models developed using ANSYS have shown to provide accurate prediction of the load-deflection behaviour of GPCC and fibre reinforced GPCC beams.