CHAPTER 7

CONCLUSION AND SCOPE FOR FUTURE WORK

7.1 GENERAL

The present study investigated the effectiveness of GFRP sheets as strengthening element for geopolymer concrete short and long columns. In addition to this initial tests were also carried out to ascertain the geopolymer concrete properties used in this research work.

Since geopolymer concrete was considered as an alternative to OPC concrete. The durability characteristics, when exposed to harsh environment were also investigated and studied.

7.2 CONCLUSION

Based on the investigation the following conclusions were drawn.

- The utilization of geopolymer as cementious material provides additional environmental as well as technical benefits. The geopolymer technology reduces the cost of making concrete and increases its strength and durability characteristics.
- The initial setting time of flyash based geopolymer binding material is higher upto 75% when compared with OPC, however the final setting time is almost similar.
- The setting time is achieved only through elevated atmospheric temperature of around 65°C, hence it was concluded that heat curing is the possible way of curing geopolymer concrete.
- The strength of mortar cubes increases the maximum of 75.86% on third day when compared to OPC specimens. The increase in strength reduces as the age increases, hence it is concluded that the
maximum strength of geopolymer mortar cube was achieved in its early ages.

- The workability of geopolymer concrete is less than OPC concrete. The workability decreases with increase in concentration of NaOH but false within the allowable limit.

- The slump cone value for geopolymer concrete lies between 80 to 100mm. The slump value of M30 and M50 is maximum and G30-12M and G50-12M is minimum. All mix shows the true slump behavior during testing.

- The flow table value reduces upto 24% in G40-12M mix when compared to M30 and 34.57% in G50-12M when compared to M50, hence it was concluded that higher NaOH concentration and higher grade of geopolymer concrete affects the flow properties.

- The results of compressive and split tensile strength have indicated that the strength have indicated that the strength of geopolymer concrete increases with respect to NaOH concentration. Further G30-8M and G50-8M has higher strength when compared to M30 and M50 respectively.

- The results of compressive and split tensile strength of G30 and G50 specimens were maximum during early ages. Due to faster hydration, the strength normalizes on later ages. The maximum value of compression and splitting strength is observed in G30-12M and G50-12M on all ages.

- There were about 37.8% increases in flexural strength for G30-12M geopolymer concrete when compared to M30 and 28.7% increase in flexural strength for G50-12M when compared with M50. The reason for increases in flexural strength was lesser internal voids and lesser capillary channel in geopolymer column.
• The results of ultrasonic pulse velocity have indicated that all geopolymer specimens have excellent quality. The G30-12M and G50-12M have higher pulse wave velocity when compared with normal OPC specimen.

• The increase in pulse wave velocity was 3.24% for G30-12M specimen and 1.35% for G50-12M specimen.

• Water absorption of geopolymer concrete was lower when compared with OPC specimen. The lowest value of water absorption is observed at G50-12M and G30-12M respectively.

• The G50-12M specimen has 27% lesser water absorption when compared to M50 and G30-12M has 40% lesser absorption when compared to M30. The lower water absorption is due to denser micro structural bond in geopolymer concrete.

• The geopolymere specimen exposed to 5% of chloride solution for 4 weeks and 8 weeks losses its mass. The maximum loss is observed in OPC specimen when compared with geopolymer specimen.

• The G30 specimens had lost its mass by 1.87% after 4 weeks and 3.6% after 8 weeks. Similarly the G50 specimen showed a loss of 1.2% after 4 weeks and 2.5% after 8 weeks.

• Geopolymer concrete cubes exposed to 5% of sodium sulphate solution showed no visible sign of surface erosion, cracking or spalling of specimen upto 4 weeks and little erosion is noticed after 4 weeks.

• The increase in mass of specimen soaked in sodium sulphate solutions was approximately 1.2% after 4 weeks and 1.72% after 8 weeks of exposure.
• OPC specimen soaked in sodium sulphate solution shown an increase in mass which was about 4.63% after 8 weeks of exposure which is higher than geopolymer mix.

• Exposure of heat cured flyash based geopolymer concrete specimens to sodium sulphate solutions had strength loss of about 6.26% for G30 and 4.99% for G50. But in OPC concrete the changes is compressive strength was about 13.89% for M30 grade and 8.76% for M50 grade after 8 weeks of exposure.

• Geopolymer concrete cubes exposed to concentrated sulphuric acid exhibited marginal weight loss of 1.70% Initial and weight loss of 20.43% was noticed after 8 weeks of observation. On the contrary OPC specimen had weight loss of 50% after 8 weeks of exposure.

• All geopolymer concrete specimens exposed to concentrated sulphuric acid have lesser surface erosion. When compared to OPC specimen, hence geopolymer concrete is more resistive towards adverse condition

• It was also noted that the thick white paste formed on the surface was due to the high content of calcium in concrete. The erosion of surface was not observed in geopolymer concrete with higher molarity which is due to excess amount of silicate and hydroxide elements.

• In rapid chloride penetration test the presence of sodium hydroxide in the geopolymer specimen produced more heat which started melting and collapsing the test setup. This has proved that RCPT could not be done on geopolymer concrete specimen due to its high alkalinity and low conductivity of current.

• The load carrying capacity of G30 short columns increases with respect to OPC specimen.
• The load carrying capacity gets increased when number of layers of GFRP sheets wrapped around the columns increases.
• The G30-8M (double wrap) increase its ultimate load by 108.9% in comparison with M30 specimen.
• The G30-12M (double wrap) increase its ultimate load by 58.61% with respect to G30-12M.
• The GFRP sheets provide more restraintment for geopolymer columns when compared with OPC column.
• The G50 geopolymer short column has higher load carrying capacity when compared with OPC.
• The G50-12M (double wrap) has around 84.35% increase in load carrying capacity when compared with M50 and 64.98% when compared with G50-12M.
• The G30 and G50 specimens fail suddenly. The failure of GFRP wrapped columns was observed to be sudden due to the restraintment provided by GFRP and also due to the rupture of GFRP layers.
• The local buckling of longitudinal reinforcement was observed in unwrapped column. The buckling is very less in wrapped columns when compared to unwrapped columns.
• The failure of GFRP wrapped columns was observed near the heads due to the stress concentration.
• The use of GFRP materials around the short geopolymer columns (G30 & G50 series) increases the overall behavior when the layers are maintained as two.
• The geopolymer long column G30 and G50 posses more strength when compared to M30 and M50 specimens. But the failure of geopolymer specimen where sudden when compared to OPC
specimen and this is due to the higher restraintment achieved in geopolymer specimen.

- The G30-8M (double wrap) long column has 45.69% increase in load carrying capacity when compared with M30 specimen and G30-12M (double wrap) has increase in ultimate load of 49.95% when compared with M30.
- The G50-12M (double wrap) long column has 35.27% increase in load carrying capacity when compared with M50 specimen.
- The deflection of long column shows that the axial displacement was more in geopolymer columns.
- The geopolymer columns increase its displacement at failure and the column had similar behavior before reaching its failure load.
- In long columns single layer of GFRP wraps does not provide much enhancement to the behavior of geopolymer column where in the maximum increase in the load carrying capacity is only 14.71% for G50-12M (single wrap).
- Therefore GFRP double wrap is more efficient when compared to single wrap in enhancing the overall behavior of the geopolymer columns.
- From all the above discussions it can be concluded that the geopolymer concrete is more durable than OPC specimens. The geopolymer concrete properties increase with increase in NaOH concentration.
- The increase in strength of geopolymer concrete column than the OPC column was mainly due to the homogeneity of the concrete. The intra axial bond between the geopolymer elements was higher when compare to the OPC concrete.
- The geopolymer short column and long column increases its strength and overall behavior with increase in number of GFRP
wraps around the column. Hence the strength and behavior can increase by increasing the number of wraps around the columns.

7.3 RECOMMENDATIONS FOR FUTURE WORKS

From the available literatures on Geopolymer concrete and based on the findings in this research, following works are recommended for further research.

- Investigations on the effect of varying percentage of reinforcement and study on buckling and load carrying capacity of slender column.
- Strengthening the top and bottom ends reinforced Geopolymer concrete columns with wrapping, avoiding heads.
- The effect of GFRP wrapping on flexural members
- Effect of CFRP wrapping on Columns and Beams.