CHAPTER 6.

CONCLUSION

Portland cement concrete is one of the most popular materials utilized in every type of structure. The principal difficulty with the use of concrete is its shrinkage during the hardening process. Shrinkage compensating cement or non-shrink cement is a cement which increases in volume after setting and during hardening. And it is used extensively to eliminate or minimize cracking caused by drying shrinkage. Shrinkage compensating cement consists of a mixture of portland cement, an expansive agent in the form of sulphoaluminate cement and a stabilizing element which usually uses fly ash.

6.1 CONCLUSION

In this research, the processes of chemical reaction concerning the source of chemical compounds, the mechanism of ettringite expansion and optimum mix proportion are investigated from a basic chemical theory.

1. The development of an expansive agent from basic chemistry is the burning of aluminium hydroxide ($Al_2(OH)_3$), calcium carbonate ($CaCO_3$) and calcium sulphate ($CaSO_4$) in a stoichiometric ratio at 1,400°C for 4 hours. This sintering temperature makes raw materials clinker and gives an optimum process in cost and chemical reaction.

2. Shrinkage compensating cement consists of mixtures of ordinary portland cement and an expansive agent in the form of calcium sulphoaluminate. Fly ash is used to improve the physical & mechanical properties. Ettringite is the source of expansion in hydrated cement and is produced from the hydration reaction of calcium sulphoaluminate. The growth of ettringite crystals will develop pressure by pushing the cement particles apart and overall volume is thus increased.

3. Shrinkage of the mixture of cement with the expansive agent is reduced due to the effects of ettringite expansion. An increase of 10% of the expansive agent causes approximately 85% shrinkage reduction for cement paste, 80% for cement mortar and 75% for concrete. An optimum proportion of expansive agent in the mixture is 10-15%

because it can form large amounts of ettringite that can compensate for the shrinkage of cement.

4. Shrinkage of a mixture with fly ash replacement is much reduced because cement in mixtures is replaced by non-shrink material. The magnitude of reduction in shrinkage is approximately 25% with an increase of 10% fly ash replacement.

5. From SEM results, needle-like ettringite is formed in the mixture of portland cement with the expansive agent filling the vacant space. But in later ages, ettringite is changed into a prismatic form after 7 days and calcium hydroxide from hydration reaction can be detected. In the paste with fly ash, the round shape of fly ash can be detected until the ages of 7 days. After that, it will be transformed into CSH due to the pozzolanic reaction. A small amount of calcium hydroxide can be detected after 28 days because it is used in the pozzolanic reaction of fly ash.

6. The amount of ettringite in ordinary portland cement paste from the XRD test decreases from early ages until 7 days and then becomes constant because ettringite in ordinary portland cement paste is transformed into monosulfoaluminate due to the lack of sulfate ion (Gypsum). But in the mixture of portland cement with an expansive agent, the amount of ettringite increases up to 7 days and becomes constant, because the hydration reaction of calcium sulphoaluminate in the expansive agent forms ettringite. Increasing the amount of expansive agent will increase the amount of ettringite.

7. Water adsorbed in a mixture of cement slightly increases with an increasing amount of the expansive agent, because ettringite from the hydration reaction of expansive agent can adsorb a large amount of water on its surface. However, in a mixture with fly ash replacement, water adsorbed is reduced, because the product of pozzolanic reaction of fly ash fills pore space and makes the pastes denser. Then water can not penetrate into the pastes resulting in a reduction of water adsorption.

8. Ettringite from the hydration reaction of the expansive agent can contribute to early compressive strength. And an increase in the amount of expansive agent will slightly increase compressive strength. Fly ash in the mixture can contribute to later age strength due to the pozzolanic reaction that occurs after 2 weeks. An increase in the amount of fly ash reduces compressive strength. The magnitude of strength reduction is 10% with an increase of fly ash replacement of 10%.

9. Increasing the amount of expansive agent tends to decrease its workability. This is because the expansive agent can absorb a large amount of water on its surface. However, replacing cement with fly ash will increase its slump and flow because the spherical shape of fly ash can increase concrete's workability. Increasing the amount of fly ash results in increased slump and flow. Increasing the amount of fly ash by 10% in the mixture will effectively increase the slump and flow by 10%.

10. The amount of calcium hydroxide in set portland cement paste with an expansive agent is slightly reduced due to the hydration reaction of calcium sulphoaluminate. And in the paste with fly ash, calcium hydroxide in the mixture is much reduced due to the pozzolanic reaction of fly ash after 7 days. Calcium hydroxide can limit the durability of paste because it can provide deterioration of paste by forming carbonic acid.

6.2 SUGGESTIONS

1. Future studies should focus on natural raw materials to develop the expansive agent.

2. The effects of the fineness of expansive agent in the cement mixture should be studied.

3. The durability and permeability of shrinkage compensating concrete in hot weather should be investigated.

4. Care should be taken regarding the chemical properties of fly ash, this is due to the fact that the chemical properties of fly ash vary despite coming from the same source.