Chapter -7

CONCLUSIONS AND SCOPE FOR FUTURE STUDY

7.1 General

A systematic study carried out to understand the possibility of using weathered laterite aggregate for preparing concrete is presented in this thesis. Studies have been made to understand the performance of concrete when weathered laterite fine and all-in aggregates are used in both conventional and self compacting normal strength concrete. The study has been extended to reveal the thermal behaviour of both the types of laterised concretes and to examine its suitability as a fire protection material.

A basic study on laterised concrete with variables like source of laterite aggregate, grades of OPC and types of supplementary cementitious materials has been done to arrive at an amicable combination of various constituents in laterised concrete.

A mix design procedure has been proposed for making normal strength laterised self compacting concrete based on trial mixes and the same has been validated.

The properties of laterised concrete have been examined by considering different parameters like exposure temperature and cooling environments.

The performance of ferrocement flexural elements with laterised self compacting concrete has also been studied by varying the cover to mesh reinforcement, exposure temperature and cooling environments.
7.2 Conclusions

Based on the present study, following major conclusions have been derived.

- The physical properties of weathered laterite aggregates collected from different parts of the state of Kerala are more or less the same.
- In general, concrete with laterised all-in aggregate shows lower slump value, even though marginal, compared to the corresponding conventional concrete.
- The slump value of laterised concrete can be increased by partial replacement of cement with fly ash as well as GGBFS.
- In the present study, compared to the slump value of laterised concrete, when 20% of OPC was replaced by fly ash, the slump value was seen enhanced by 19%.
- In general, the compressive strength of concrete with weathered laterite all-in aggregate is lower compared to a corresponding conventional concrete. In the present study, a 9% lower strength has been observed for laterised concrete when compared to the strength of M25 grade conventional concrete.
- When cement was partially replaced with fly ash or GGBFS, there was no significant reduction in cube compressive strength for both laterised and conventional concrete up to a certain replacement level. Beyond this level, a drastic reduction in cube compressive strength has been observed for both the types of concrete. In the present study, it was noticed that ideally, 20% of OPC can be replaced by fly ash or 25% of OPC by GGBFS in conventional as well as laterised concrete without the compressive strength being affected. Such replacement results in the production of more economical concrete.
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- A mix design method has been proposed for nominal strength (M20 to M40) laterised self compacting concrete (LSCC) with fly ash or GGBFS as addition.
- The proposed mix design method for LSCC has been validated by comparing the experimental results with appropriate standards.
- Unlike conventional SCC, laterised self compacting concrete demands large quantity of additions (fly ash or GGBFS) to achieve required flow properties.
- Even though the strength of laterised concrete is lower at ambient temperature compared with corresponding conventional concrete, at exposure temperature, above 400°C, there is a high rate of reduction in strength for conventional concrete, primarily due to the early development of micro cracks in conventional concrete.
- Addition of mineral admixture (fly ash or GGBFS) reduces the loss of strength of both laterised and conventional concrete at high temperature.
- Unlike the strength of laterised concrete with GGBFS at ambient temperature, the residual compressive strength of laterised concrete as well as laterised self compacting concrete with fly ash is higher at higher temperatures.
- The available equations for the prediction of compressive strength, split tensile strength and modulus of elasticity of normal concrete after exposure to high temperatures yields poor prediction in the case of laterised concrete.
- Lower bound equations to predict the cube compressive strength, split tensile strength and modulus of elasticity of laterised concrete at high temperatures has been proposed based on the present study.
The loss of unit mass of laterised concrete when exposed to a temperature level between 200 °C and 400°C is not significant and is attributed to the physically adsorbed water. However, for exposure temperature above 400°C, considerable reduction in unit mass has been observed and is attributed to the loss of chemically combined water present in hydrated cement products.

While conventional concrete develops distributed cracks at 600°C, laterised concrete did not show any cracks at 600°C, even in water cooled environment.

When mineral admixture (fly ash or GGBFS) was added, the conventional concrete did not crack up to 600°C and laterised concrete did not develop any crack even at 800°C. However laterised self compacting concrete developed distributed hair line cracks at 600°C.

Ferrocement flexural specimen did not show any surface cracking up to 400°C. However, at 600°C, all specimens developed distributed cracks. When specimens were cooled by sprinkling with water, several additional distributed cracks were developed due to the thermal shock induced by water spray.

The loss of chemically combined water in concrete is one of the major factors that control the cracking of concrete specimen when exposed to high temperature.

A lower bound prediction equation for the modulus of rupture of ferrocement flexural elements (made with laterised self compacting concrete having fly ash as addition) with temperature has been proposed based on the present study.

In conclusion, the combined use of weathered laterite aggregate and additions as fly ash or GGBFS in laterised concrete (LC) and laterised self
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Compacting concrete (LSCC) can produce green and economical concrete which has better physical properties compared to conventional concrete when exposed to high temperatures. Hence LC and LSCC are suitable as fire protection materials compared to conventional concrete.

7.3 Scope for Further Studies

Based on the present study and conclusions drawn, following areas have been identified for the further studies.

- The present lower bound equations have been proposed based on M25 grade laterised concrete only. These equations need to be refined by considering different grades of laterised concrete.
- Detailed study on reinforced laterised concrete and laterised self compacting concrete may be carried out for confirming the general purpose application of LC and LSCC.
- Use of laterite aggregate in Geo polymer concrete can be investigated.
- Study of alkali-silica reaction on LC and LSCC exposed to high temperature can be carried out.