## CONTENTS

### CHAPTER-7: CONCLUSIONS AND RECOMMENDATIONS

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CHAPTER-7

CONCLUSIONS AND RECOMMENDATIONS

7.1 General

The need and motivation for the present investigation has been presented in Chapter-1. Now a day’s time framed constructions, usage of high strength and durable concretes have got more prominence in the civil engineering construction field. So we have come to know the necessity for the study of Metakaolin based NRLMFRFHPc which gives the high strength and durability. The need to conduct a systematic study to evaluate the effect of steel fibres and Natural rubber latex on the properties of NRLMFRHPC such as workability, compressive strength, Split Tensile strength, Flexural Strength and durability has been identified. The aims and specific objectives are decided accordingly for the present investigation.

After knowing the aim and objectives for the particular research work, experimentation is carried out in the laboratory with the Metakaolin based NRLMFRHPC mixes. The workability of the fresh NRLMFRHPC is determined with compaction factor test and Vee-bee time test. Cubes, cylinders and beams were cast as explained in chapter 4. Similarly the specimens were cast to determine the durability of NRLMFRHPC mixes by using the Rapid chloride ion permeability test apparatus.

The effect of steel fibres and Natural rubber latex on workability, compressive Strength, split tensile strength and Flexural strength are evaluated for various water binder ratios ranging from 0.325, 0.350, 0.375, 0.40 and 0.425. Similarly, the effects of steel fibres and Natural rubber latex on durability characteristics are also determined. The mineral admixture Metakaolin and polymer Natural Rubber latex
which are used in the present investigation are obtained from Vadodara in Gujarat and from Calicut in North Kerala- respectively. The investigation work carried out in this research on NRLMFRHPC will pave the way for greater applications in future and it will be helpful for further investigations also.

7.2 Conclusions:

From the results of laboratory tests and the analysis carried out, the following conclusions are drawn.

- The test data of compaction factor and Vee bee tests indicates that the workability of NRLMFRHPC decreases with increasing dosage of NRL. However, up to 0.5% dosage of NRL, the decrease is marginal.

- The literature survey carried out led to the identification of the need for conducting the feasibility study of producing NRLMFRHPC with locally available raw materials, naturally available rubber latex and indigenously produced mineral admixture, Metakaolin.

- The workability of NRLMFRHPC mixes decreases with increase in the percentage of Natural Rubber Latex. NRLMFRHPC mixes possessed lesser workability when compared to corresponding mix with 0% rubber latex.

- It is observed that, at 0.5 % of rubber latex and 1.0 % of steel fibres the decrease in the compaction factor is very much marginal, i.e. about 10.71%. Also, it is observed that these mixes are quite cohesive even at lower water-binder ratio of 0.325 because of the polymer (Natural Rubber Latex) used in the mix. Hence, it can be concluded that NRLMFRHPC mixes with 0.5 % of Rubber latex and 1.0 % of steel fibre can be produced to have sufficient workability.
• The 28-day compressive strength of NRLMFRHPC mixes increases with increase in percentage of Rubber latex up to 0.5% and increase in percentage of steel fibres up to 1.0%. It can be observed that the maximum compressive strength of 103.67 MPa is obtained at 0.5% of rubber latex and 1.0% of steel fibre and having W/B as 0.325. It is also noticed that by increasing Rubber Latex to 0.75%, the compressive strength decreases to 99.24 MPa.

• The 90-day compressive strength of NRLMFRHPC mixes also increases with increase in percentage of Rubber latex up to 0.5% and increase in percentage of steel fibre up to 1.0%. It can further be observed that the maximum 90 day compressive strength of 108.62 MPa is obtained at 0.5% of rubber latex, 1.0% of steel fibre and W/B is 0.325. It is also noticed that by increasing Rubber Latex to 0.75%, the compressive strength decreases to 106.16 MPa.

• The 28-day tensile strength of NRLMFRHPC mixes increases with increase in percentage of Rubber latex up to 0.5% and increase in percentage of steel fibres up to 1.0%. It can be observed that the maximum Tensile strength of 7.57 MPa is obtained for mix with 0.5% of rubber latex, 1.0% of steel fibre and W/B as 0.325. It is also noticed that by increasing Rubber Latex to 0.75%, the tensile strength decreases to 7.48 MPa.

• The 90-day tensile strength of NRLMFRHPC mixes also increases with increase in percentage of Rubber latex up to 0.5% and increase in percentage of steel fibre up to 1.0%. It can further be observed that the maximum 90 day Tensile strength of 8.06 MPa is obtained for the mix with 0.5% of rubber latex, 1.0% of steel fibre and W/B as 0.325. It is also noticed that by increasing Rubber Latex to 0.75%, the tensile strength decreases to 7.95 MPa.
As the percentage of fibres increases, the split tensile strength of NRLMFRHPC also increases. The increase of fibre percentage beyond 1.0% is difficult for mixing of fibres and causes the formation of fibre lumps.

The 28-day Flexural strength of NRLMFRHPC mixes increases with increase in percentage of Rubber latex up to 0.5% and increase in percentage of steel fibres up to 1.0%. It can be observed that the maximum flexural strength of 7.94 MPa is obtained for mix with 0.5% of rubber latex, 1.0% of steel fibre and W/B as 0.325. It is also noticed that by increasing Rubber Latex to 0.75%, the flexural strength decreases to 7.61 MPa.

The 90-day flexural strength of NRLMFRHPC mixes also increases with increase in percentage of Rubber latex up to 0.5% and increase in percentage of steel fibre up to 1.0%. It can further be observed that the maximum 90 day flexural strength of 8.42 MPa is obtained for the mix with 0.5% of rubber latex, 1.0 % of steel fibre and W/B as 0.325. It is also noticed that by increasing Rubber Latex to 0.75%, the flexural strength decreases to 8.30 MPa.

The maximum compressive strength, tensile strength and flexural Strengths are obtained at 0.5% dosage of Natural Rubber Latex. Hence, The addition of 0.5% of Natural rubber latex is considered as optimum from strength considerations for Natural Rubber Latex modified fibre reinforced high – performance- concrete (NRLMFRHPC).

As the volume percentage of steel fibres increases, the compressive, tensile and flexural Strengths of NRLMFRHPC increased up to 1%. The percentage
of fibre content is restricted to 1.0%, as the increase in fibre content leads to balling of fibres.

- In this investigation it is observed that for all of NRLMFRHPC mixes, the chloride Ion permeability increases with increase of W/B ratio. It is also observed that chloride ion permeability decreases with the increase in natural rubber latex up to 0.5% and then it starts increasing. Hence optimum dosage of rubber latex is taken as 0.5% from permeability criteria.

- The chloride ion permeability decreases with the increase in volume of steel fibres up to 1%. The volume of steel fibre is restricted to 1.0% to avoid lumping of fibres.

- The mix design methods available for conventional concrete cannot be used for NRLMFRHPC as they are oriented towards compressive strength alone while other performance parameters are also to be considered in proportioning NRLMFRHPC mixes.

- The unified mix design methodology developed from the results of the present investigation allows proportioning of mixes for compressive, tensile and flexural strengths. It considers the durability in terms of permeability in proportioning NRLMFRHPC mixes.

- The proposed unified mix design method uniquely combines the features of strength, workability and durability so that NRLMFRHPC mixes can be proportioned to any chosen performance parameter.

- Regression models have been developed to define water-binder ratio laws for NRLMFRHPC.
Regression models have been developed for various inter relationships and their performance is satisfactory.

From this investigation it is recommended to use a dosage of 0.5% of Natural rubber latex and 1.0% of steel fibres both from workability, strength and durability aspects of NRLMFRHPC.

7.3 Contributions of the present work

- A systematic study has been carried out to evaluate the influence of Natural Rubber Latex and volume percentage of steel fibre on workability, compressive, tensile, and flexural strengths of NRLMFRHPC.

- Optimum dosage of NRL for use in the production of steel fibre reinforced HPC has been established.

- The influence of type and quantity of Polymer and Steel fibre content on the Rapid Chloride Ion permeability of NRLMFRHPC has been established.

- Regression models and mix design procedure for NRLMFRHPC have been developed.

7.4 Suggestions for future work

- In the present investigation, NRLMFRHPC is produced with the incorporation of Natural Rubber Latex. Future investigations may be carried out to produce other types of fibre reinforced HPC with the addition of different types of polymers and fibres instead of natural rubber latex and steel fibres.

- In the present work, percentage of Metakaolin and Aggregate Binder ratio is kept constant. These parameters may be varied for future investigations so that more generalized mix design charts can be prepared.
Now a days the availability of natural coarse and fine aggregates have become problem. Hence a feasibility study may be carried out to produce NRLMFRHPC with re-cycled aggregates and manufactured sand.

In the present work metakaolin is the only admixture used in producing NRLMFRHPC. In future works, a combination of mineral admixtures like fly ash silica fume may also be tried in producing NRLMFRHPC.

In the present work, the durability of NRLMFRHPC has been studied with respect to Rapid Chloride Ion Permeability Test only. The other durability studies such as acid immersion freeze and thaw, abrasion resistance etc. may also be studied so that they can be included in the mix design.

The results of the present investigation may be synthesized for developing macro-mechanical models for NRLMFRHPC using neural networks.