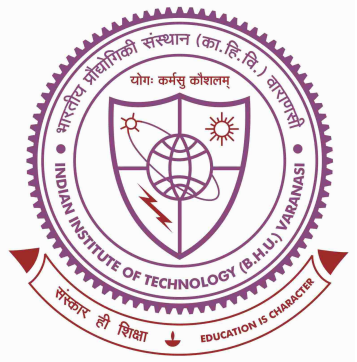
Effective utilization of recycled concrete aggregate (RCA) in the structural applications



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Chapter 7

CONCLUSIONS AND FUTURE SCOPE

7.1 Summary and Conclusion

Most of the past studies observed the effects of only C-RCA on the properties of concrete, while F-RCA was ignored due to the complexities associated with its usage. It compelled the authors to assess the effects of different ratios of F-RCA on properties of concrete containing either 100% treated C-RCA or C-NA. Following salient points can be concluded from the current investigation:
Conclusion on the study of the different treatment methods on C-RCA and effect of old concrete strength on properties of produced C-RCA; also analysis of concrete produced with 100% C-RCA (with different treatment methods)

- Untreated RCA has lower physical and mechanical properties as compared to NA. Smaller size RCA shows even more depreciated properties than the larger size.

- For reducing adhered mortar, the quenching and abrasion (QA) method removed the highest amount of adhered mortar, followed by the heating and abrasion (HA)and simple dry abrasion (SDA) method. The physical and mechanical properties of coarse-RCA were considerably improved after the application of treatment methods. HA treated C-RCA showed better performance than SDA treated C-RCA. Compared to NA-concrete, the compressive strength of RCA-concrete samples was lower at an early age, equivalent at 28-days, and higher after 90-days.

- RCAM1-concrete prepared with QA treated RCA obtained from a mix of old concrete containing different mineral admixture showed highest compressive strength (greater than 4% than NA-concrete).
- Aggregates treated with the DA method showed lower values than the aggregates treated with the QA method; although mechanical properties of concrete with DA treated RCA is equivalent to that of NA-concrete.
- A new combined approach that includes the recycling process, primary and secondary crushing, treatment, and remodified two-stage mixing approach (R-TSMA), concrete with 100% RCA, shows similar properties equivalent to natural aggregate (NA) concrete.
- The mechanical and physical properties of C-RCA are significantly strengthened by abrasion (against each other) but are still lower than that of C-NA. The water absorption of C-RCA is 6.4 to 7.7 times (without abrasion) and 3.6 to 4.6 times (after abrasion) higher than that of C-NA. Similarly, F-RCA has 5.2 times higher water absorption than F-NA. C-RCA can be used in the non-wearing course before abrasion and in the wearing course after abrasion

Conclusion on the study of percentage replacement of F-RCA as well as C-RCA on the properties of new concrete are as follows:

- Both workability and fresh density of FxRC and C100FxRC reduce with an increase in F-RCA content. Nevertheless, all concrete mixes can be categorised into 'ordinary concrete' (except mix C100F100RC and F100RC, which can be categorised into 'semi-lightweight concrete') as per the past studies' classification of concrete based on fresh density.
- FxRC and C100FxRC have lower strength than CC, irrespective of curing age (except compressive strength of F30RC and C100F0RC at 90 days). Amongst these strengths, flexural strength is least affected due to the addition of recycled aggregates. As the curing time increases, the adverse effects of F-RCA on concrete strength begin to diminish.
- 100% C-NA replacement by treated C-RCA or 30% FNA replacement by F-RCA or simultaneous utilisation of both are optimal and feasible alternatives for producing

concrete of M30 grade. In case of F-RCA content of more than 30%, M30 grade concrete's target compressive strength can be achieved, but for that purpose, the curing time of FxRC and C100FxRC should be increased beyond 28 days.

- The water permeability of FxRC and C100FxRC increases with an increase in the replacement ratio of F-RCA. Also, their carbonated compressive strength is higher than their water-cured compressive strength. Moreover, few concrete samples (F30RC, C100F0RC, C100F30RC and C100F60RC) have higher carbonated compressive strength than CC.

- Mostly, F-RCA is more compatible with C-NA at 30% replacement level and treated C-RCA at 60% and 100% replacement level.

- By graphical analysis, it was observed that the density of F-RCA and treated C-RCA (compared to their water absorption) has a more significant impact on concrete properties. Also, the water permeability of FxRC and C100FxRC (followed by their carbonation and compressive strength) is most affected by aggregates' density and water absorption.

- As per SEM analysis, micro-cracks and macro-pores are more common in C100FxRC and FxRC, respectively. FxRC has a tenuous microstructure, while C100FxRC has a compact microstructure at 60% and 100% F-RCA content and vice-versa at 30% F-RCA content.

7.2 Limitations and Scope for Future Work

7.2.1 Limitations

In the present study, an attempt has been made to study the effect of C-RCA and F-RCA on the properties of produced concrete. The application of the re-modified two-stage mixing approach (R-TSMA) in the production of RCA-concrete has very high significance. A new combined approach that includes the recycling process, primary and secondary crushing, treatment, and R-TSMA, concrete with 100% C-RCA, shows similar properties equivalent to NA-concrete. Despite these, when both C-RCA and F-RCA are used together, the properties of new concrete does not meet the requirements for structural

application. F-RCA used in the new concrete mix was not passed through any treatment application as in C-RCA.

7.2.2 Scope for Future Work

The scope of the present study for future work is summarized as follows:

- Studies are required to enhance the properties of F-RCA.
- New mixing approach should be researched for using the F-RCA in the new concrete mix without reducing the fresh and hardened concrete properties.
- Mix design needs further refinement for using F-RCA together with C-RCA for the production of new concrete.
- More study is required for establishing the use of RCA in new concrete according to the strength need for different structural application.