CONCLUSIONS AND
FUTURE SCOPE
CHAPTER 6

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6.1 GENERAL
Present study was undertaken to develop self-compacting concrete using blend of flyash and Rice husk ash. Various fresh and hardened properties of Self compacting concrete were investigated within the available resources and conclusions drawn from the present study have been presented in the chapter. All the experiments were repeated thrice and the error of results obtained was in the range of 1% to 2%.

The high strength Self Compacting Concrete mixes which were developed from the present experimental investigation and recommended are hereunder:

- Highest compressive strength of all the SCC mixes developed using flyash has been obtained for the mix AC85F100. The mix AC85F100 achieved compressive strength of 54.19 MPa at 28 days, 67.74 at 60 days and 79.7 at 180 days.

- Highest compressive strengths of all the SCC mixes using blend of flyash and RHA has been obtained for the mix AC85F95R5. The compressive strength results obtained for AC85F95R3 were 53.11 MPa at 28 days and 65.85 MPa at 60 days and 76.16 MPa at 180 days.

Self-compacting mixes from AC40F100 to AC85F100 were developed with 60 to 15% replacement of cement by flyash. Further SCC mixes were developed replacing 5 to 30% of pozzolanic cementitious material by Rice husk ash. Range of Self compacting concrete mixes have been developed using varying proportion using flyash, blend of flyash and Rice husk ash have been developed from the present investigations. The mixes can be used for various projects both big and small projects. The broad conclusions drawn from the investigation and suggestions for further research work are also presented hereunder.

6.2 CONCLUSION
From the present experimental investigation following broad conclusions can be drawn:

1. The Water-powder ratio obtained for flow test on mortar of cement and flyash corresponding to zero slump flow is 0.81 by volume and 0.32 by
weight. Mortar test was repeated on blend of Cement, flyash and Rice husk ash to study the effect of Rice husk ash on rheology of mortar. The Water/Powder ratio obtained is 0.9 by volume and 0.36 by weight. Thus, the mortar flow test result shows the minimum dose of superplastizer as 1.5 % and water/powder ratio as 0.81 to 0.90 for flowability.

2. It is observed that increase in flyash content improves filling and passing ability of SCC mixes. Increase in the Rice husk ash content increased viscosity of concrete. It can be inferred that addition of flyash in mix improves filling and passing ability of concrete, whereas rice husk ash imparts viscosity of concrete improving segregation resistance of concrete mix. Flyash and RHA blend well improving rheological properties of Self compacting concrete.

3. Segregation resistance of SCC is accomplished using viscosity modifying admixture (VMA). This viscosity modifying admixtures are very expensive and one of the main cause of increase in the cost of SCC. In the present investigation VMA was not required for SCC mixes using flyash and Rice husk ash. Rice husk ash serves the functions of VMA. Use of RHA as VMA reduces the cost of SCC.

4. All other mixes except mixes with 35 % rice husk ash of SCM and mixes AC85F75R25, C85F70R30 do not satisfy acceptance criteria laid by EFNARC for self-compacting characteristics. Hence RHA content upto 30 % is desirable for achieving self compactability.

5. Control mix AC100 obtained 28 days compressive strength of 65 MPa. Compressive strengths at 28 days obtained for AC40F100 to AC85F100 are in the range from 28.52 to 54.19 MPa. Thus there is improvement in compressive strength of SCC mixes from 16.63 to 56.12% for increase in flyash content from 15 to 60 % as compared to control mix. Mix AC85F95R5 to AC85F80R20 exhibit reduction in compressive strength of 2 to 9 %, 2.79 to 11.41 % and 4.4 to 14.53% at 28, 60 and 180 days as compared to compressive strength of mix AC85F100 at 28, 60 and 180 days. Decreasing trend of compressive strength is observed in all mixes with increase in RHA content. The increase in RHA content increases water requirement of mixes which affects water cement ratio reducing strength of mixes.

6. In comparison with normal concrete M50 grade the mix AC85F95R5 obtained reduction in compressive strength of 22.3%, and 14 % at 7 and 28 days
whereas improvement of in compressive of 2.5% of 7.9% has been achieved at 60 and 180 days. Similarly mix AC85F100 obtained reduction of 18.30% and 12.22% at 7 and 28 days and improvement of 5.2% and 13% has been obtained at 60 and 180 days. From the present study as well as study from other researchers show that Self compacting concrete mixes unlike normal concrete it gains low early strength but compressive strength improves beyond 28 days. After rate of gain of strength of cement slows down, the continued pozzolanic activity of flyash and rice husk ash contributing to the increasing strength gain at later age.

7. Flexural strength, Split tensile strength and abrasion resistance improve with decrease in flyash and Rice husk ash content. Flexural strength, Split tensile strength and Impact resistance have good correlation with compressive strength. Correlation coefficient of flexural strength Split tensile strength and Impact resistance were 0.931, 0.95 and 0.902. These properties follow variation pattern of compressive strength. All the results improve with decreasing flyash and Rice husk ash content.

8. Impact resistance of SCC mixes improved with decreasing flyash content from 60% to 15% for AC40F100 to AC85F100. Mixes AC40F100 to AC85F100 achieve higher impact resistance in their respective category (of % cement replacement). It is further improved with decrease in Rice husk ash content from 30% to 5% for all categories of mixes.

9. The reduction in compressive strength of control mix AC100 is 8.8%, 21.95% and 29% due to exposure of concrete cubes to 200°C, 400°C and 600°C respectively. It is observed that residual compressive strength decreases with increase in temperature, increase with flyash and rice husk ash content. More Cracking and spalling was observed at 600°C for SCC mixes with flyash content more than 25%. The explosive spalling occurred for mixes AC40F75R25 and AC40F70R30.

10. The rebound number of the SCC mixes was strongly correlated with the compressive strength. The correlation coefficient (R) for concrete rebound number and compressive strength was 0.931.

11. The Ultrasonic Pulse Velocity values decreased with increasing flyash and RHA replacement of cement in SCC. There is a good correlation with a linear
relationship between USPV and compressive strength. The correlation coefficient obtained is 0.9546.

12. In order to achieve low cost SCC locally available Rice husk ash which is waste product from local industry, flyash from GGSTP thermal power station and locally available sand of zone III was used for development of Self compacting concrete. Self-compacting concrete mix with 10% replacement of cement by blend of flyash and Rice husk ash saves 7.65% cost over control SCC mix. The control mix AC100 has achieved 28 days compressive strength results of 65 MPa, 74.75 MPa and 87.75 at 28, 60 and 180 days respectively whereas mix AC85F95R5 obtained compressive strengths of 53.11 MPa, 65.85 MPa and 76.16 MPa at 28, 60 and 180 days respectively. Mix AC40F70R30 is saving 29.29% cost as compared to control mix and has achieved compressive strength results of 22.30 MPa, 23.19 MPa and 27.65 MPa at 28, 60 and 180 days respectively.

13. The results of compressive strength predicted by the ANFIS model when compared with experimental results found average error of 0.29% only. Predicted compressive strength plotted against actual compressive strength exhibit very good coefficient of correlation 0.91. ANFIS model shows the excellent performance and is capable to predict compressive strength. The above results obtained validate the model.

14. Mix AC85F95R5 obtained compressive strength of 54.19 MPa, 67.74 MPa and 79.70 MPa at 28, 56 and 180 days and which is higher compressive strength of all mixes using flyash and Rice husk ash in the present study. It has flexural strength of 6.35 MPa, split tensile strength of 4.68 MPa and abrasion of 0.83 mm. It has endurance limit for impact resistance of 15 blows. It has rebound number of 48 and Ultrasonic Pulse Velocity of 4.32 km/sec. It has residual strength of 47.8, 41.43 and 35.58 MPa at 200, 400 and 600 °C temperature. It has coefficient of permeability of 4.32 x 10^{-4} m/sec. Overall performance of this mix in respect of fresh and hardened properties is higher as compared to mixes using flyash and Rice husk ash.

Rice husk ash is a waste product from local Chandigarh industries by using husk as fuel to generate steam for the parboiling process which is disposed of as waste material. Flyash is byproduct from Guru Gobind Singh Thermal Power Plant Ropar.
Use of these waste products will solve problem of their disposal and reducing environmental pollution.

Range of SCC mixes with varying proportion of flyash and Rice husk ash have been developed. The final results may be used in various projects both big and small. SCC mix using blend of flyash and locally available rice husk ash will reduce the cost of construction by limiting the use of cement content.

Elimination of discontinuous mechanical vibrations makes concrete more consistent having reliable properties. It will enhance the working environment which will improve health and safety of workers. It will limit the utilisation of cement and will help to conserve natural resources. It shall reduce the problem of CO₂ evolution, thereby contributing in reduction of the global warming. Self compactability increase placing rate thereby increase productivity. It will provide outlet for utilisation of flyash and Rice Husk Ash and eliminate disposal and environmental problem. Concreting in inaccessible areas with congestion of reinforcement will be possible. Thus use of flyash and Rice husk ash in Self compacting concrete is conversion of waste into wealth.

6.3 FUTURE SCOPE FOR RESEARCH

Self-compacting concrete is a new area of research. Testing methods and mix design methods have not yet been included in the BIS codes. Hence there is wide scope for research in this area. Following studies are suggested for further research work.

1. From literature review it has been found that SCC using flyash and RHA can resist chemical attack. Hence further research work can be carried out in this area.

2. Research work also can be carried out on structural performance of SCC mixes. Flexural and Shear parameters can be studied on the beams casted using these SCC mixes.

3. Research work also can be undertaken for properties fibre reinforced Self compacting concrete using different fibers.