CHAPTER - 9

CONCLUSIONS

The following conclusions can be drawn from the experimental investigations conducted on the behaviour of SCC with GGBS and RHA as Admixtures

1. By using mineral admixtures GGBS, RHA with suitable dosage of superplasticiser and V.M.A, and with proper proportioning SCC of acceptable properties in fresh and hardened state can be produced.

2. Studies indicated that there is a good compatibility between mineral combinations GGBS and RHA along with the chemical admixtures such as SP and VMA when used in SCC.

3. The addition of RHA to GGBS mixes has shown enhanced performance in terms of strength and durability in all grades of SCC. This is due to the presence of reactive silica in GGBS and RHA combination (microstate) which offers good compatibility.

4. The Bolomey’s empirical expression can be used to predict the strength efficiency factors of the GGBS and RHA in SCC at different percentage of replacement levels which are mainly useful to describe the GGBS and RHA combination ability on compressive strength of SCC.

5. The strength efficiency factors are mainly useful to describe the admixtures GGBS and RHA combination’s ability on the compressive strength of SCC and quantify the replacement of
cement by GGBS and RHA combination on a one-to-one basis by weight.

6. The strength efficiency factor ‘k’ of GGBS in SCC mixes at 3 days, 7 days and 28 days was found to be between 0.7 to 1.8. The strength efficiency factor k for normal concrete mixes were reported to be between 0.7 to 1.3 by K.Ganesh Babu and V.Sree Rama Kumar [37], which shows the strength efficiency factors are slightly higher for SCC mixes with GGBS.

7. The optimum dosage of GGBS was found to be 30% in SCC concrete which is similar to that of the findings of K.Ganesh Babu and V.Sree Rama Kumar [37].

8. The strength efficiency factor ‘k’ at 3 days, 7 days and 28 days for SCC mixes with GGBS were improved with the addition of RHA. The ‘k’ values of GGBS and RHA in SCC are found to be 0.74 to 2.20.

9. Based on the stress-strain curves of all the eight SCC mixes with and without steel confinement it is observed that the stress-strain pattern is to be almost similar. The only difference is that compared to that of other mixes, the GGBS-RHA mixes have shown improved stress values. It is observed that for higher grades of concrete with increase in stress there was decrease in strain.

10. Empirical equations for the stress-strain response of SCC mixes have been proposed in the form of $Y = \frac{Ax}{1+Bx^2}$, where x is normalized strain and Y is normalized stress. The same empirical
formula is valid for both ascending and descending portions with different values of constants.

The equations for ascending and descending portions of SCC mixes are mentioned below. These proposed empirical equations can be used as stress block in analyzing the flexural behaviour of sections of SCC structural elements. The proposed equations have shown good correlation with experimental values.

<table>
<thead>
<tr>
<th>Mix</th>
<th>Equations for ascending portion</th>
<th>Equations for descending portion</th>
</tr>
</thead>
<tbody>
<tr>
<td>M20SCC mix</td>
<td>$Y = 1.44x / (1 + 0.53x^2)$</td>
<td>$Y = 1.49x / (1 + 0.71x^2)$</td>
</tr>
<tr>
<td>M20 GGBS mix</td>
<td>$Y = 1.53x / (1 + 0.37x^2)$</td>
<td>$Y = 2.0x / (1 + 1.20x^2)$</td>
</tr>
<tr>
<td>M20 GGBS-RHA mix</td>
<td>$Y = 1.20x / (1 + 0.37x^2)$</td>
<td>$Y = 1.29x / (1 + 1.22x^2)$</td>
</tr>
<tr>
<td>M40 SCC mix</td>
<td>$Y = 1.25x / (1 + 0.58x^2)$</td>
<td>$Y = 2.56x / (1 + 1.77x^2)$</td>
</tr>
<tr>
<td>M40 GGBS mix</td>
<td>$Y = 1.25x / (1 + 0.27x^2)$</td>
<td>$Y = 2.42x / (1 + 1.62x^2)$</td>
</tr>
<tr>
<td>M40 GGBS-RHA mix</td>
<td>$Y = 1.09x / (1 + 0.22x^2)$</td>
<td>$Y = 2.08x / (1 + 1.30x^2)$</td>
</tr>
<tr>
<td>M60 SCC mix</td>
<td>$Y = 1.41x / (1 + 1.0x^2)$</td>
<td>$Y = 2.27x / (1 + 1.47x^2)$</td>
</tr>
<tr>
<td>M60 GGBS-RHA mix</td>
<td>$Y = 1.64x / (1 + 0.33x^2)$</td>
<td>$Y = 2.59x / (1 + 1.80x^2)$</td>
</tr>
</tbody>
</table>

11. It is observed that there is an increase in the peak compressive strength for different SCC mixes made with GGBS and RHA mixes. The increase is due to high reactivity of RHA with GGBS. It is also observed that confinement of small percentage of steel to SCC mixes marginally increases the cylindrical strength.
12. Addition of GGBS and RHA control the initiation of micro cracks, improve the first crack load, the ultimate load and ductility of SCC specimens under flexure. They are also effective in resisting deformation at all stages of loading from first crack to failure.

13. Deflections for under and over reinforced SCC beams at service loads are less than the maximum permissible deflection of 4 mm *i.e.* Span/250 specified by IS 456-2000. Thus, the use of SCC did not violate the serviceability norms of the codes of practice.

14. Load deflection behaviour for all SCC beams is observed to be similar except the increased values of loads at ultimate and at first crack due to addition of GGBS and RHA to SCC mixes.

15. Moment curvature plots for under and over reinforced SCC beams with and without GGBS and RHA are observed to follow similar pattern as that of load deflection plots of SCC beams.

16. Theoretical moment-curvature relationships for SCC and beams followed similar pattern as that of experimental values. The only difference noticed is the values of theoretical moments calculated are lesser than the experimental values. But the variation is very less, thus theoretical values of moments almost coincide with experimental values. This shows a good correlation between them.

17. A decrease in crack width in under-reinforced beams and over-reinforced SCC beams is observed. Also reduction in deflections at service loads in under and over-reinforced beams is also observed.
18. The strength and ductility can be improved by the addition of a GGBS and RHA to SCC mixes retaining self compactability of the mix.

19. An increase in the ultimate load, maximum deflection, load at first crack, ultimate moment in curvature and deflection at service loads is observed in three mixes blended with GGBS and RHA under reinforced and over reinforced beams.

20. The Acid durability factors (ADF) were found to be more in SCC made with GGBS and RHA in all grades.

21. The Acid Attack Factors (AAF) has shown that the GGBS and RHA mixes are more resistant for acid attack.

22. The strength loss and weight loss observed to be less in mixes with GGBS and RHA.

**SCOPE FOR FURTHER STUDIES**

The present work is focused on low, standard and high grade SCC mixes i.e. M20, M40 and M60 grade respectively with GGBS and RHA. It can be extended to study SCC using different mineral admixtures with different percentage replacements and study their stress-strain behaviour at different ages along with mathematical modeling.

These studies can be extended to evaluate the efficiency factors of different admixtures in SCC, study the behaviour of SCC at elevated temperatures and the shrinkage and creep effects in SCC.