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Flexural behavior of Reinforced Fly Ash Concrete in Comparison to Reinforced Normal Concrete beams in Terms of Moment-Curvature Relation

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Abstract— ***The plastic behavior of any structural member is limited by the amount of deformation that occurs at a critical section when it is subjected to applied loads. Curvatures are obtained by dividing the sum of extreme fiber strains by the corresponding effective depth. Study of curvature assists in evolving the rotation capacities of the beam and also helps in assessing the capacity of the structure to redistribute the moment after yielding. In this paper moment curvature variation of RFAC beams considered are compared with RNC beams for each grade of concrete. Comparison of RFAC beams (with 20%, 35% and 50% replacement of cement by Fly ash) with RNC beams designed as balanced section cured for 28 days. From the study of the moment curvature relations of all three grades of concrete, it is observed that the trend of moment curvature relation of RFAC beams is similar to that of RNC beams at any load level, the curvature of the RFAC beams are lesser than RNC beam. It is also observed that as the CRLs by Fly ash increases, the curvature in RFAC beams decrease in M30 and M40 concretes and are all almost same in M50 concrete***

Index Terms— ***Fly ash, cement replacement material, concrete beams, flexural behaviour of reinforced Fly ash concrete, movement curvature relation.***

I. MOMENT-CURVATURE RELATION:M30 CONCRETE

Variation of curvature at mid span of beams for different applied moments is shown in Figure 1. It is seen that there is no considerable difference in ultimate moment carrying capacities between RFAC beams with varying percentages of Fly ash and RNC beams as all beams belong to grade M30 and contain same magnitude of reinforcement required from balanced section consideration. The curvature of the RFAC beams is found to be lesser than RNC beam at any load level. It can be observed that at ultimate moment value of 28.7 kN-m a minimum curvature value of 32.11 x 10-6 radians was observed for RFAC beam with 50% CRL and a maximum value of 44.05 x 10-6 radians was recorded for RNC beam at ultimate moment of 28.63 kN-m.

II. MOMENT-CURVATURE RELATION:M40 CONCRETE

Variation of curvature at mid span of beams for different applied moments is shown in Figure. 2. It can be observed from Figure 2 that there is no considerable difference in ultimate moment carrying capacities between the beams with varying percentages of Fly ash.

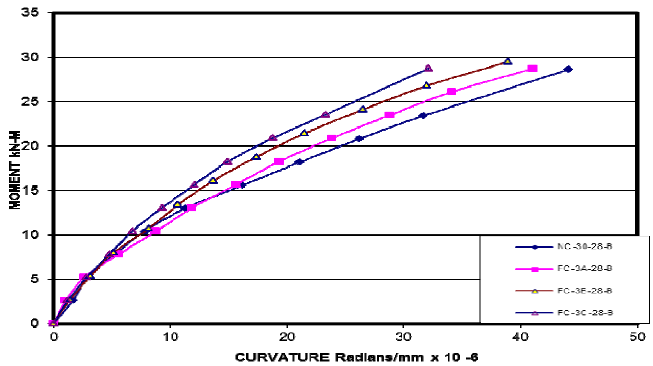

Figure 1 Comparison of moment vs curvature between RFAC and RNC beams M30 (all balanced section; 28 days curing period and different CRLs)

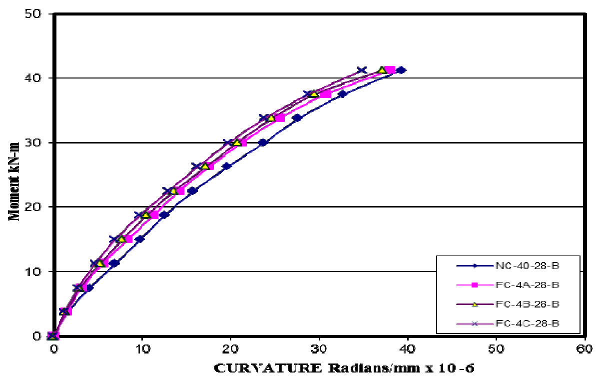

Figure 2: Comparison of moment vs curvature between RFAC and RNC beams M40 (all balanced section; 28 days curing period and different CRLs)

The curvature of the reinforced Fly ash concrete beams is found to be lesser than RNC beam but no considerable difference between different CRLs of RFAC beams. It can be observed that at ultimate moment value of 41.25 kN-m a minimum curvature value of 34.93 x 10-6 radians was observed for reinforced Fly ash concrete beam with 50% CRL and a higher value of 39.32 x 10-6 radians was recorded for RNC beam.

III. MOMENT-CURVATURE:M50 CONCRETE

Variation of curvature at mid span of beams for different applied moments is shown in Figure 3.

It is seen from Figure 3 that there is no considerable difference in ultimate moment carrying capacities between the

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beams with varying percentages of Fly ash. The curvature of the RFAC beams is found to be slightly less as compared to RNC beam. It can be observed that at ultimate moment value of 45 kN-m a minimum curvature value of 29.4 x 10-6 radians was observed for RFAC beam of 50% CRL and a higher value of 40.42 x 10-6 radians was recorded for RNC beam at ultimate moment of 52.5 kN-m.

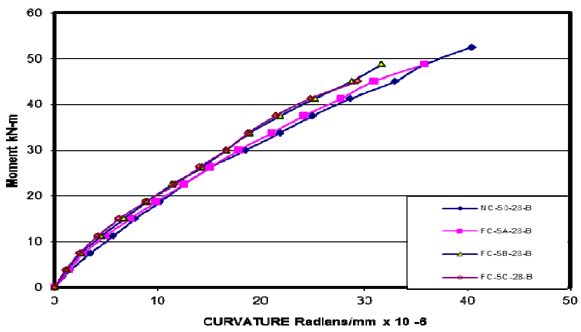

Figure 3 Comparison of moment vs curvature between RFAC and RNC beams M50 (all balanced section; 28 days curing period and different CRLs)

Experimental evaluation:

From the study of the moment curvature relations of all three grades of concrete, it is observed that the trend of moment curvature relation of RFAC beams is similar to that of RNC beams at any load level, the curvature of the RFAC beams are lesser than RNC beam. It is also observed that as the CRLs by Fly ash increases, the curvature in RFAC beams decrease in M30 and M40 concretes and are all almost same in M50 concrete.

Referring to Figures 3 to 6, wherein comparison of moment vs curvature behaviour of RFAC beams of M30, M40 and M50 beams with different CRLs is represented separately, it is seen that the curvature of RFAC beams M30 with 20%, 35% and 50% CRLs is 0.93, 0.88 and 0.73 times the value of curvature of RNC beam. The largest difference in curvature, which was about 27%, occurred when substituting 50% of Portland cement with Fly ash in M30 concrete.

The curvature of RFAC beams M40 with 20%, 35% and 50% CRLs is 0.97, 0.94 and 0.89 times the value of curvature of RNC beams. The largest difference in curvature, which was about 11%, occurred when substituting 50% of Portland cement with Fly ash in M40 concrete.

The curvature of RFAC beams M50 with 20%, 35% and 50% CRLs is 0.89, 0.78 and 0.73 times the value of curvature of RNC beams at 28 days. The largest difference in curvature, which was about 27%, occurred when substituting 50% of Portland cement with Fly ash in M50 concrete.

The curvature of RFAC beams for M30, M40 and M50 with 20%, 35% and 50% CRLs and RNC beams decreases with the increase in grade of concrete. For RFAC beams with 20% CRL, curvature of M30 beams is 1.12 times the curvature of M40 beams and 1.09 times that of M50 beams. For RFAC beam with 35% CRL, curvature of M30 beams is 1.12 times the curvature of M40 beams and 1.09 times that of M50 beams. For RFAC beam with 50% CRL, curvature of M30 beams is 1.12 times the curvature of M40 beams and 1.09 times that of M50 beams. For RNC beams, curvature of M30 beams is 1.12 times the curvature of M40 beams and 1.09 times that of M50 beams. LVA Sheshasayi and Subbarao have observed that the moment-curvature relation of Fly ash concrete beams are similar to that of ordinary Portland cement concrete beams, which is also so in the present experimental investigation.

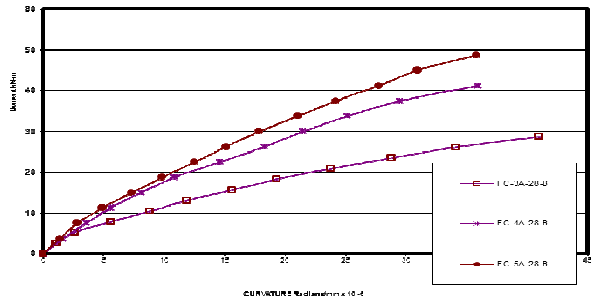

Figure 4: Comparison of moment vs curvature between RFAC beams for all three grades of concrete (all balanced section; 28 days curing period and 20% CRL)

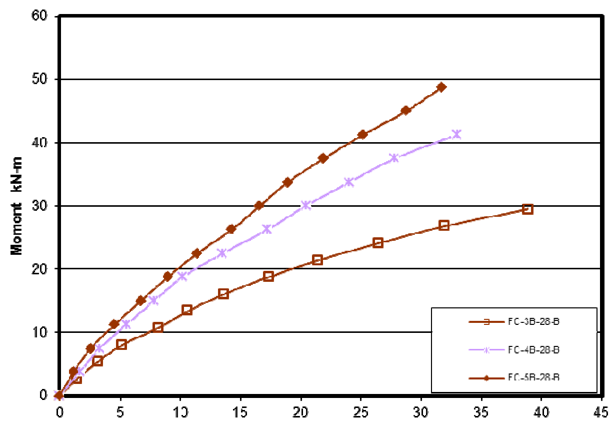

Figure 5: Comparison of moment vs curvature between RFAC beams for all three grades of concrete (all balanced section; 28 days curing period and 35% CRL)

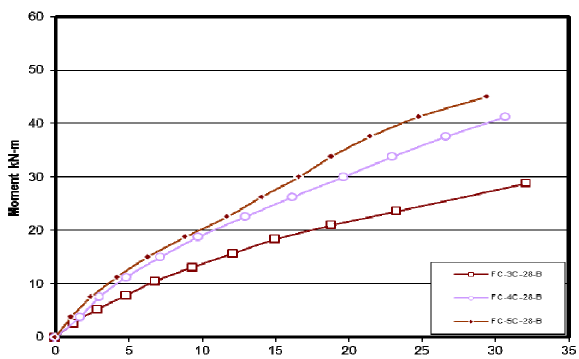

Figure 6: Comparison of moment vs curvature between RFAC beams for all three grades of concrete (all balanced section; 28 days curing period and 50% CRL)

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Dr.B.K.Narendra has obtained Bachelor's, Master's and Doctoral degrees from Bangalore University. His field of is concrete with special interest on fly ash. Since 26 years, he is in the teaching profession by serving in different levels in reputed Engineering College. Presently, he is working as Principal, BGS Institute of Technology, BG Nagar, Mandya, Karnataka, India. There are good numbers of technical papers in national and international journals to his credit.

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