MODULUS OF ELASTICITY ON HIGH PERFORMANCE GLASS FIBRE RCC BEAMS WITH PARTIAL REPLACEMENT OF CEMENT BY SILICA FUME

Y. Kamala Raju, M.S. Britto Jeyakumar

Abstract — The present paper contains, Seven blends Mix1 to Mix7 are thrown with 0%, 5%, 7.5% and 10% substitution of bond utilizing SF and another arrangement of examples with 0%, 5%, 7.5% and 10% substitution of concrete utilizing SF alongside 0.2% consistent substitution of Glass fiber to contemplate the mechanical property modulus of versatility. The outcome demonstrates that the ideal substitution of silica smoke is 7.5%. On the off chance that the fiber of 0.2% is included the malleable and flexural quality got expanded.

Absolutely seven RC beams 200 x 200 x 750 mm size were thrown for assessing the flexural test and restored for 28 days. These beams are tested in loading frame of 1000 kN at 28 days, two point burdens are connected over the beam. The Heap from the start split, diversion, and a definitive burden are noted for each blend and similar examination is accomplished for Burden – redirection (P-∆), first break – extreme burden, Moment – Curvature (M-φ) and Moment – rotation with Control and HPC blend examples lastly different malleable natures is plotted.

Keywords: optimum replacement of silica fume, Moment – Curvature, Moment – Rotation, modulus of elasticity, flexural behavior.

I. INTRODUCTION

The modulus of flexibility most ordinarily utilized practically speaking is secant modulus. There is no standard technique for deciding the secant modulus. At some point it is estimated at stresses going from 3 to 14 MPa and at some point the secant is attracted to point speaking to a feeling of anxiety of 15, 25, 33 or 50 percent of extreme quality. Since the estimation of secant modulus diminishes with increment in stress, the worry at which the secant modulus has been discovered must to consistently be expressed.

Table 1 Maximum Stress Strain Values

<table>
<thead>
<tr>
<th>Mix</th>
<th>Stress (MPa)</th>
<th>Strain (Microns)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mix1</td>
<td>60.51</td>
<td>2490</td>
</tr>
<tr>
<td>Mix2</td>
<td>57.32</td>
<td>3050</td>
</tr>
<tr>
<td>Mix3</td>
<td>70.06</td>
<td>2470</td>
</tr>
<tr>
<td>Mix4</td>
<td>63.69</td>
<td>3175</td>
</tr>
<tr>
<td>Mix5</td>
<td>66.24</td>
<td>3300</td>
</tr>
<tr>
<td>Mix6</td>
<td>71.34</td>
<td>3350</td>
</tr>
<tr>
<td>Mix7</td>
<td>62.42</td>
<td>3125</td>
</tr>
</tbody>
</table>

II. REVIEW ON LITERATURE

M Newton Craig (2014) he investigated that the fracture response of RC deep beams and also investigated on the strength and size of beams. RC deep beams and also investigated on the strength and size of beams.

P Kumar Mehta (2004) he studied the RC beams under two point loading conditions.

Zhenhua Wu. (2007) studied that the RC beam for different shear reinforcement patterns

Aruna Munikrishna (2011) mentioned the RC beams under pure torsion. The torsional strength due to the changes in the length of beam and cracks propagation due to various loading conditions were studied and analyzed. He has tested six beams with different length and same reinforcement ratios as per the ACI318-05 code. The author considered multilinear isotropic stress-strain curve for the concrete model.

Table 2 Modulus of Elasticity

<table>
<thead>
<tr>
<th>M</th>
<th>Stress</th>
<th>33% of Ultimate</th>
<th>Strain</th>
<th>Young’s Modulus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mix1</td>
<td>60.5</td>
<td>20.17</td>
<td>0.0004</td>
<td>8</td>
</tr>
<tr>
<td>Mix2</td>
<td>57.3</td>
<td>19.11</td>
<td>0.0004</td>
<td>3</td>
</tr>
<tr>
<td>Mix3</td>
<td>70.0</td>
<td>23.35</td>
<td>0.0004</td>
<td>5</td>
</tr>
<tr>
<td>Mix4</td>
<td>63.6</td>
<td>21.23</td>
<td>0.0004</td>
<td>8</td>
</tr>
<tr>
<td>Mix5</td>
<td>66.2</td>
<td>22.08</td>
<td>0.0005</td>
<td>3</td>
</tr>
<tr>
<td>Mix6</td>
<td>71.3</td>
<td>23.78</td>
<td>0.0005</td>
<td>3</td>
</tr>
<tr>
<td>Mix7</td>
<td>62.4</td>
<td>20.81</td>
<td>0.0005</td>
<td>8</td>
</tr>
</tbody>
</table>

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Y. Kamala Raju, Dept.of Civil Engineering, GRIET, Hyderabad, Telangana, India. (email: kamalaraju@griet.ac.in)

M.S. Britto Jeyakumar, Dept.of Civil Engineering, GRIET, Hyderabad, Telangana, India. (email: m.s.britto@griet.ac.in)

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Stress-Strain Behavior
Tests were led to study pressure strain conduct of HPC on chamber examples of size 100x300mm for all the blends in the pressure testing machine of limit 2000kN. These examples were tried under hub pressure and the estimations of pivotal pressure and hub strain were recorded at standard interims. The pressure versus strain bends are appeared for the blends Mix1 to Mix7 in Figs. The most extreme pressure and greatest strain esteem for different blends are given in Table. It is discovered that Mix3 (with 7.5% silica rage) indicates higher quality and extreme strain contrasted with ordinary cement.

Preparation of Beam Specimen
All the reinforced beam specimens were cast at the structural laboratory. The raw materials for concrete mixes already described in the previous section were mixed by a rotary mixer. The wooden mould were prepared and lubricated with oil before the concrete was poured. The reinforcement bars were cut to the required lengths. The longitudinal bars and stirrups were secured to each other at correct spacing by means of binding wires.

A mixing time of 3 to 5 minutes was given to ensure uniform mixing. Wooden moulds were used to cast the beams. The specimens were demoulded after 24 hours and cured for 28 days using gunny bags. After curing period, the beams were kept for 24 hours in a dry state. After drying they were cleaned with a sand paper to remove all grit and dirt. Then all the specimens were prepared by white washing from all sides. White washing was done to facilitate easy detection of crack propagation.

Experimental Test Setup for Beam Specimens
A total of seven beams were cast. Out of those seven beams cast, one is conventionally reinforced concrete beam. Remaining six beams were separated into two categories and were cast with concrete, one with the 5%, 7.5% & 10% silica fume replacement and the other with above mentioned replacement of silica fume in addition to the glass fibers. All the beams were tested for flexure under a loading frame of capacity 1000kN. These beams were tested on a effective span of 750mm with simply supported conditions under two point loading. Deflections were measured under the loading point and at the mid span using Linear Variable Differential Transducers (LVDTs). The crack patterns were also recorded at every load increment. All the beams were tested up to failure.

Design of Flexure Beams
Grade of Concrete M80
Grade of steel Fe 415
Length of Beam 750mm
Breath of beam 200mm
Depth of Beam 200mm
Loading Method Two Point Load (Equal Distance (L/3))
End Condition Simply Supported Beam

We have to design a Beam failures occurs in the mode of flexure

\[
\frac{x_u}{d} = \frac{\varepsilon_{cu}}{\varepsilon_s}
\]

\[
\varepsilon_{cu} = 0.0035 \quad (\text{IS 456-2000 38.1(b)})
\]

\[
\varepsilon_s = 0.002 + \frac{0.87 f_y}{E_s} \quad (\text{IS 456-2000 38.1})
\]

\[
x_u = \frac{0.0035}{d} \quad (\text{IS 456-2000 Note 38.1})
\]

\[
A_{st} = 0.36 A_{st} f_{ck} / \beta d \quad (\text{IS 456-2000})
\]

Annex G 1.1(c)

\[
A_{st} = \frac{0.5 f_{ck}}{f_{y}} \left[ 1 - \frac{4.6 A_{st} f_{ck}}{f_{ck} f_{y} b d^2} \right] b d
\]

\[
M_u = 0.87 f_{ck} A_{st} \left[ 1 - \frac{1.3 A_{st} f_{ck}}{f_{ck} f_{y} b d^2} \right]
\]

\[
M_u = 13.24 \text{kNm} < M_u\text{limit}
\]

The section is failure mode of flexure.

Increase the shear resistance capacity of the beam.

\[
M_\delta = \frac{w f_y}{3}
\]

\[
w = 3 \times \frac{13.24}{1.5}
\]

\[
w = 26.48 \text{kN}
\]

Design of shear Resistance:

\[
%\text{of steel} = \frac{100 \times 226}{100 \times 174} = 1.30 \%
\]

From Table 19, IS 456-2000,

For fck = 80 N/mm² & pt=1.30

Design shear strength of concrete τc = 0.75 N/mm²

From Table 20,

Maximum shear stress τc,max = 4 N/mm²

\[
\frac{v}{bd} = 1.52 \text{N/mm²}
\]
\[ \tau_v < \tau_{\text{max}} \]

\[ V_u = (\tau_v - \tau_c) \times bd = (1.52 - 0.75) \times 100 \times 174 = 13.40 \text{ kN} \]

IS 456 clause no : 40.4 (a)

\[ S_v = \frac{0.87 f_{c} A_v d}{V_u} \]

\[ A_{sv} = \text{total cross sectional area of stirrup legs} \]

Using 8mm φ (2 legged stirrup)

\[ A_{sv} = \frac{2\pi X 5^2}{4} = 101 \text{ mm}^2 \]

\[ s_v = \frac{0.87 \times 415 \times 101 \times 174}{13.4 \times 10^3} = 473 \text{ mm} \]

Provide maximum spacing of shear resistance

As per IS 456 –2000 26.5.1.5
1. Shall not exceed 0.75d for vertical stirrups (131.25mm)
2. Spacing should not exceed 300mm

We choose 8mm φ 2 legged vertical stirrups at a 125mm c/c distance

Beam with stand up to \( V_u = V_c + V_s \)

\[ V_s = \frac{0.87 \times 415 \times 101 \times 174}{125} \]

\[ V_s = 50.76 \text{ kN} \]

\[ V_c = 0.75 \times 100 \times 174 = 13.05 \text{ kN} \]

\[ V_u = V_c + V_s = 63.81 \text{ kN} > 26.48 \text{ kN} \]

The section is failure mode of flexure.

**Beam Test Results**

Testing of beam was carried out as per the procedure. The test results for beam tested for Flexure are shown in Tables.

<table>
<thead>
<tr>
<th>Beams</th>
<th>Ultimate Displacement ( \Delta_u ) (mm)</th>
<th>First Yield Displacement ( \Delta_y ) (mm)</th>
<th>Displacement Ductility ( \mu = \Delta_u / \Delta_y )</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>12.46</td>
<td>3.88</td>
<td>3.21</td>
</tr>
<tr>
<td>M2</td>
<td>14.65</td>
<td>4.26</td>
<td>3.44</td>
</tr>
<tr>
<td>M3</td>
<td>17.75</td>
<td>5.01</td>
<td>3.54</td>
</tr>
<tr>
<td>M4</td>
<td>16.26</td>
<td>4.69</td>
<td>3.47</td>
</tr>
<tr>
<td>M5</td>
<td>17.89</td>
<td>5.11</td>
<td>3.50</td>
</tr>
<tr>
<td>M6</td>
<td>21.77</td>
<td>5.39</td>
<td>4.04</td>
</tr>
<tr>
<td>M7</td>
<td>19.08</td>
<td>4.85</td>
<td>3.93</td>
</tr>
</tbody>
</table>

**Table 3 Test Results for Flexure Beam**

<table>
<thead>
<tr>
<th>Specimens</th>
<th>% Of SF</th>
<th>Fiber (%)</th>
<th>First Crack Load (kN)</th>
<th>Ultimate Load (kN)</th>
<th>Deflection at Ultimate Load (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>0</td>
<td>0</td>
<td>26</td>
<td>46</td>
<td>12.46</td>
</tr>
<tr>
<td>M2</td>
<td>5</td>
<td>0</td>
<td>28</td>
<td>48</td>
<td>14.65</td>
</tr>
<tr>
<td>M3</td>
<td>7.5</td>
<td>0</td>
<td>32</td>
<td>54</td>
<td>17.75</td>
</tr>
<tr>
<td>M4</td>
<td>10</td>
<td>0</td>
<td>30</td>
<td>52</td>
<td>16.26</td>
</tr>
<tr>
<td>M5</td>
<td>5</td>
<td>0.2</td>
<td>35</td>
<td>52</td>
<td>17.89</td>
</tr>
<tr>
<td>M6</td>
<td>7.5</td>
<td>0.2</td>
<td>38</td>
<td>58</td>
<td>21.77</td>
</tr>
<tr>
<td>M7</td>
<td>10</td>
<td>0.2</td>
<td>37</td>
<td>54</td>
<td>19.08</td>
</tr>
</tbody>
</table>
Table 5 Curvature Ductility

<table>
<thead>
<tr>
<th>Beams</th>
<th>Maximum Curvature $\phi_u$ (rad/mm) x 10^6</th>
<th>Curvature at First Yield $\phi_y$ (rad/mm)x10^6</th>
<th>Ductility $\mu = \phi_u / \phi_y$</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>152.14</td>
<td>53.68</td>
<td>2.83</td>
</tr>
<tr>
<td>M2</td>
<td>155.84</td>
<td>42.68</td>
<td>3.65</td>
</tr>
<tr>
<td>M3</td>
<td>167.35</td>
<td>44.11</td>
<td>3.79</td>
</tr>
<tr>
<td>M4</td>
<td>160.66</td>
<td>43.82</td>
<td>3.67</td>
</tr>
<tr>
<td>M5</td>
<td>167.42</td>
<td>45.34</td>
<td>3.69</td>
</tr>
<tr>
<td>M6</td>
<td>196.25</td>
<td>49.29</td>
<td>3.98</td>
</tr>
<tr>
<td>M7</td>
<td>181.25</td>
<td>46.89</td>
<td>3.87</td>
</tr>
</tbody>
</table>

Table 6 Rotation Ductility

<table>
<thead>
<tr>
<th>Beams</th>
<th>Maximum Rotation $\theta_u$ (rad)</th>
<th>First Yield Rotation $\theta_y$ (rad)</th>
<th>Ductility $\mu = \theta_u / \theta_y$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mix 1</td>
<td>0.0182</td>
<td>0.0055</td>
<td>3.309</td>
</tr>
<tr>
<td>Mix 2</td>
<td>0.0215</td>
<td>0.006</td>
<td>3.583</td>
</tr>
<tr>
<td>Mix 3</td>
<td>0.0257</td>
<td>0.0067</td>
<td>3.836</td>
</tr>
<tr>
<td>Mix 4</td>
<td>0.0237</td>
<td>0.00654</td>
<td>3.624</td>
</tr>
<tr>
<td>Mix 5</td>
<td>0.0263</td>
<td>0.0068</td>
<td>3.868</td>
</tr>
<tr>
<td>Mix 6</td>
<td>0.0321</td>
<td>0.00796</td>
<td>4.033</td>
</tr>
<tr>
<td>Mix 7</td>
<td>0.0282</td>
<td>0.00718</td>
<td>3.928</td>
</tr>
</tbody>
</table>
III. DISCUSSION OF BEAM TEST RESULTS

Test consequences of pillars under flexure show that, the bar with 7.5% of silica seethe (M6) has the most astounding burden conveying limit of 58 kN. This is about 1.26 occasions higher than that of the control bar (CB).

A definitive burden conveying limit acquired tentatively is more prominent than the worth got hypothetically. The principal break showed up at the jack heap of 26kN for M1 shaft where as the primary split burden was 32 kN for M3 bar which is 23.07% higher than that of the control bar. A definitive heap of M3 shaft is 54KN which is 17% higher than that of a definitive heap of the M1.

From the Occasion Ebb and flow relationship, inside the yielding stage the 5% silica smoke shafts show higher solidness than the control and 7.5% silica smoke pillars. In any case, in the plastic stage, the 7.5% bars (M3) show better malleability conduct contrasted with that of customary and 5% silica smoke supplanted shafts.

The arch pliability, turn malleability and ebb and flow flexibility is incredibly expanded in the bars which contains SF of 7.5% substitution.

The incorporation of fiber expands the heap conveying limit with regards to M6 bar about 26.08% contrasted and the Control example M1 and with the ideal SF substance of 7.5 % the addition is 7.41%.

IV. CONCLUSION

The following conclusions were made:

a. The Mix3 blend which is without fiber gives most extreme flexural quality of cement without expansion of fiber (ie) 6.05 MPa which is 11.42% more noteworthy than control blend.

b. The Mix6 blend which is with fiber gives most extreme flexural quality of cement without expansion of fiber (ie) 6.70 MPa which is 23.39% more noteworthy than control blend.

c. The consideration of fiber expands the heap conveying limit with regards to M6 shaft about 26.08% contrasted and the Control example M1 and with the ideal SF substance of 7.5 % the augmentation is 7.41%.

d. The introductory break is deferred when contrasted and the pillars without incorporation of strands.

V. SCOPE FOR FURTHER INVESTIGATION

The following are the some of the aspects recommended for further in depth study.

1. Water Cement Ratio can be varied.
2. Durability studies can be extended.
3. Corrosion resistance test can be studied for long term durations.
4. Shear beams can be cast to study the shear behavior of Silica fume and Fiber.
5. Varying Percentage replacement of admixtures.
6. Different Combination of Fiber and dosage of Superplasticizer can be varied.

Various fibers like steel, Synthetic fibers can be mixed and the properties can be studied.

REFERENCES

AUTHORS PROFILE

Shri. Y. Kamala Raju, Assistant Professor of Civil Engineering, He received his B. E in Civil Engineering from Osmania University in 2007, and M. Tech in Structural Engineering from JNTUK in 2011. Over 10 years of professional experience in Industry, Academic and Research. He guided several graduates. His experience, practical knowledge and innovative teaching practices helped to students in understanding the subject and creativity for Project works. He supervised about 14 Under Graduates under his supervision.

His major research area of interest in the Applications in structural Engineering, Design of structures, Concrete Materials. He has published his research about 9 publications in various International, National Conferences/Journals.

Mr. M. S. Britto Jeyakumar, Assistant Professor of Civil Engineering, completed his Master of Engineering (Structural Engineering) from Sathyabama University, Chennai. He has over 1.5 years of academic experience in Gokaraju Rangaraju Institute of Engineering and Technology (GRIET) and 7.5 years of Rajas Engineering College, Tamilnadu. He had 9.5 years of industrial experience at varies industrial organizations. He had earned Bachelors of Engineering (Civil Engineering) Madurai kamaraj university, Tamilnadu. His research interests include Concrete Technology and Design of Concrete Structures, in which he has 3 publications, in various conferences. He is currently Class coordinator, Department of Civil Engineering at Gokaraju Rangaraju Institute of Engineering and Technology (GRIET). He is also a Life Member of ISTE and IASTER.