APPENDIX

MIX DESIGN

A.1 ORDINARY PORTLAND CEMENT CONCRETE

1. Stipulations for Proportioning

   Grade designation : M30
   Type of cement : OPC 53 grade
   Exposure condition : Severe
   Type of aggregate : Crushed angular aggregate
   Type of chemical admixture : Superplasticizer

2. Test Data for Materials

   Specific gravity of cement : 3.15
   Specific gravity of fine aggregate : 2.54
   Specific gravity of coarse aggregate (20mm) : 2.79
   Specific gravity of coarse aggregate (12mm) : 2.92
3. Target Strength for Mix Proportioning

\[ f'_c = f_c + 1.65 \sigma \]
\[ = 30 + 1.65 \times 5 \]
\[(\sigma = 5 \text{ N/mm}^2, \text{Table 1, IS 10262: 2009}) \]
\[ f'_c = 38.25 \text{ N/mm}^2 \]

4. Selection of Water–Cement Ratio

From Page 20, Table 5 of IS 456:2000, maximum water cement ratio = 0.45.

5. Selection of Water Content

From Table 2 of IS 10262:2009, maximum water content for 20mm aggregate = 186 kg (for 25 – 50 mm slump).

From Page 2 of IS 10262:2009, estimated water content for 150mm slump = 186 + (12\times186/100) = 208.32 kg.

A.1.1 Mix Calculation with GLENIUM B233 Superplasticizer

Based on trials with super plasticizer, water content reduction of 20% has been achieved. Hence, the arrived water content = 208.32\times0.8
\[ = 166.656 \text{ liters} \]

1. Calculation of Cement Content

Water-Cement ratio = 0.45

Cementitious material content = \[ \frac{166.656}{0.45} \]
\[ = 370.346 \text{ kg/m}^3 \]
From Table 5 of IS 456:2000, minimum cement content for ‘severe’ exposure conditions is 320 kg/m\(^3\).

\[
370.346 \text{ kg/m}^3 > 320 \text{ kg/m}^3, \text{ hence it is accepted.}
\]

2. **Proportion of Volume of Coarse and Fine Aggregate Content**

From table 3, volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate (Zone III) for water-cement ratio of 0.50 = 0.66

Volume of coarse aggregate \(= 0.62\)

Volume of fine aggregate \(= 0.38\)

Volume of concrete \(= 1 \text{ m}^3\)

Volume of cement \(= \frac{\text{mass of cement}}{\text{specific gravity of cement}} \times (\frac{1}{1000})\)

\[= \frac{370.346}{3.08} \times \frac{1}{1000} = 0.120 \text{ m}^3\]

Volume of water \(= \frac{\text{Mass of water}}{\text{specific gravity of water}} \times (\frac{1}{1000})\)

\[= \frac{177.44}{1} \times \frac{1}{1000} = 0.177 \text{ m}^3\]

Volume of superplasticizer (at 0.7% by weight of cementitious material)

\[= \frac{\text{Mass of admixture}}{\text{specific gravity of admixture}} \times (\frac{1}{1000})\]

\[= \frac{394.31 \times 0.007}{1.09} \times \frac{1}{1000} = 0.0026 \text{ m}^3\]

Volume of all in aggregate \(= (1-(0.120+0.177+0.002)) = 0.70 \text{ m}^3\)

Mass of coarse aggregate \(= 0.70 \times 0.62 \times 2.75 \times 1000 = 1193.5 \text{ kg/m}^3\)
Mass of fine aggregate \(= 0.70 \times 0.38 \times 2.71 \times 1000 = 720.86 \text{ kg/m}^3\)

Mass of super plasticizer \(= 2.99 \text{ kg/m}^3\)

Concrete mix was made for 30\%, 40\%, 50\%, 60\% and 70\%. An example for concrete with 50\% GGBS replacement is given below.

A.2 CONCRETE WITH 50\% GGBS REPLACEMENT

A.2.1 Mix Calculation with GLENIUM B233 Superplasticizer

Cement content \(= 185.17 \text{ kg/m}^3 \) (50\% of 370.346 kg/m\(^3\))

GGBS content \(= 185.17 \text{ kg/m}^3 \) (50\% of 370.346 kg/m\(^3\))

Volume of concrete \(= 1 \text{ m}^3\)

Volume of cement \(= \frac{185.17}{3.08} \times \frac{1}{1000} = 0.06 \text{ m}^3\)

Volume of GGBS \(= \frac{185.17}{2.16} \times \frac{1}{1000} = 0.086 \text{ m}^3\)

Volume of water \(= \frac{\text{mass of water} \times \text{sp. gravity of water}}{1000} \)
\(= \frac{177.44}{1} \times \frac{1}{1000} = 0.177 \text{ m}^3\)

Volume of super plasticizer (at 1\% by weight of cementitious material)
\(= \frac{\text{Mass of admixture} \times \text{specific gravity of admixture}}{1000} \)
\(= \frac{370.346 \times 0.01}{1.09} \times \frac{1}{1000} = 0.0034 \text{ m}^3\)

Volume of all in aggregate \(= 1 - (0.063 + 0.086 + 0.177 + 0.003) = 0.671 \text{ m}^3\)

Mass of coarse aggregate \(= 0.671 \times 0.62 \times 2.75 \times 1000 = 1144.06 \text{ kg/m}^3\)

Mass of fine aggregate \(= 0.671 \times 0.38 \times 2.71 \times 1000 = 690.96 \text{ kg/m}^3\)
Table A.1 Concrete Mix Proportions

<table>
<thead>
<tr>
<th>Water-Cement Ratio</th>
<th>% of Glenium B233</th>
<th>Water Reduction (%)</th>
<th>Cement (kg/m³)</th>
<th>GGBS (kg/m³)</th>
<th>Fine Aggregate (kg/m³)</th>
<th>Coarse Aggregate (kg/m³)</th>
<th>Mix Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.45</td>
<td>0.23%</td>
<td>20</td>
<td>370</td>
<td>-</td>
<td>820</td>
<td>439 658</td>
<td>1:2.2:2.9</td>
</tr>
<tr>
<td>0.4</td>
<td>0.72%</td>
<td>10</td>
<td>256</td>
<td>177</td>
<td>689</td>
<td>434 651</td>
<td>1:1.6:2.5</td>
</tr>
<tr>
<td>0.4</td>
<td>1%</td>
<td>15</td>
<td>210</td>
<td>209</td>
<td>702</td>
<td>442 663</td>
<td>1:1.7:2.6</td>
</tr>
</tbody>
</table>