APPENDIX A

DESIGN MIX CALCULATION FOR M20 GRADE OF CONCRETE

STEP 1- Design Specifications

The data required for mix proportioning is as follows.

- Grade designation : M20
- Type of cement : Portland Pozolana Cement
- Maximum nominal size of aggregates : 20 mm
- Minimum cement content: 280 kg/ m³
- Maximum water-cement ratio: 0.55
- Workability : 0.9 compaction factor
- Exposure conditions : Severe
- Maximum temperature of concrete at the time of placing : 30 °C
- Method of transporting & placing : Lifting and pouring
- Type of aggregate : Angular
- Specific gravity of cement: 3.15
  - Specific gravity of Coarse aggregate: 2.72
  - Specific gravity of Fine aggregate :2.65
  - Water absorption of Coarse aggregate : 0.25

Step 2 - Target Strength for Mix Proportioning:

- The concrete mix is to be proportioned for higher target mean Compressive strength $f'_{ck}$.
  
  $f'_{ck} = 20 + (1.65 \times 4) = 26.6 \text{ MPa}$
  
  Where, $f'_{ck}$ = Target average compressive strength at 28days
\( f'_{ck} \) = Characteristic compressive strength at 28 days

\( S \) = Standard deviation.

**Step 3 - Selection of Water-Cement ratio:**

- Water cement ratio as given in Table 5 of IS 456-2000 for mild environmental exposure condition is 0.55.

**Step 4 - Selection of water content:**

The quantity of maximum mixing water per unit volume of concrete determined from table 2 of IS 10262-2009 is 186 lt.

After many trials the water content adopted is 165 lts.

**Step 5- Calculation of Cement Content:**

\[
\frac{W}{C} = 0.55
\]

\( W = 165 \) lts.

Therefore, Cement Content \( \frac{165}{0.55} = 300 \) kg/ m\(^3\)

From Table 5 of IS 456, minimum cement content for 'severe' exposure condition = 347 kg/m\(^3\) is adopted
Step 6- Proportion of Volume of Coarse aggregate:

From Table 3, volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate (Zone II) for water-cement ratio of 0.50 =0.62.

In the present case water-cement ratio is 0.55. Therefore, volume of coarse aggregate is required to be decreased to increase the fine aggregate content. As the water-cement ratio is increased by 0.05, the proportion of volume of coarse aggregate is decreased by 0.01 (at the rate of -/+ 0.01 for every ± 0.05 change in water-cement ratio).

Therefore, corrected proportion of volume of coarse aggregate for the water-cement ratio of 0.55 = 0.62 – 0.01 = 0.61

Step 7 Mix Calculations

<table>
<thead>
<tr>
<th>Volume of concrete</th>
<th>1 m3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume of cement</td>
<td>(\frac{347}{3.15} \times \frac{1}{1000} = 0.1101 \text{ m}^3)</td>
</tr>
<tr>
<td>Volume of water</td>
<td>(\frac{165}{1} \times \frac{1}{1000} = 0.165 \text{ m}^3)</td>
</tr>
<tr>
<td>Vol. of Total (C.A+F.A)</td>
<td>(1 - (0.1101 - 0.165) = 0.725 \text{ m}^3)</td>
</tr>
<tr>
<td>Mass of coarse aggregate</td>
<td>0.725 \times 0.61 \times 2.72 \times 1000 = 1202 \text{ kg/ m}^3</td>
</tr>
<tr>
<td>Mass of fine aggregate</td>
<td>0.725 \times 0.39 \times 2.65 \times 1000 = 749 \text{ kg/ m}^3</td>
</tr>
</tbody>
</table>
### Step 8 Mix Proportions after trials

<table>
<thead>
<tr>
<th>Grade of concrete</th>
<th>Cement (kg/m³)</th>
<th>Fine aggregate (kg/m³)</th>
<th>Coarse Aggregate (kg/m³)</th>
<th>Water (Lt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M15</td>
<td>320</td>
<td>576</td>
<td>1360</td>
<td>176</td>
</tr>
<tr>
<td>M20</td>
<td>350</td>
<td>437.5</td>
<td>980</td>
<td>182</td>
</tr>
</tbody>
</table>