APPENDIX 1

CONCRETE MIX DESIGN

For M20 Mix design was done by Indian standard method.

i) Characteristic compressive strength = 20 N/mm$^2$

ii) Maximum size of aggregate = 4.75 mm

iii) Degree of workability = 0.9 (compaction factor)

iv) Degree of quality control = good

v) Type of exposure = mild

vi) Specific gravity of cement = 3.1

vii) Specific gravity of sand = 2.56

viii) Specific gravity of coarse aggregate = 2.74

ix) Sand confirms to zone II

1. Target mean strength of concrete = $20 + 1.65 \times 4$
   
   (IS 456, IS 10262-1982)
   
   = 26.6 N/mm$^2$

2. Water cement ratio for target mean strength = 0.45 (IS10262-1982, Fig-2)

For W/C ratio = 0.45, Workability = 0.9 CF., Sand in Zone II,
Maximum size of aggregate = 4.75mm,

3. Water content per cubic meter of concrete = 200 Kg (IS10262-198, Table 4)

4. Sand as percent of total aggregate by absolute volume = 43%

   Adjustment as per table 6 in IS 10262–1982

   Therefore, required sand as percentage of total by aggregate absolute volume = 34.3%

   Required water content = 186Kg/m³

5. Calculation of cement content

   Water / Cement ratio = 0.45

   Water content = 153 l/m³

   Cement = 340 Kg /m³

6. Calculation of fine aggregate

   Percentage of entrapped air into the concrete for 20 mm size aggregate = 2%

   \[ V = \left( W + \frac{C}{S_c} + \frac{1}{p} \times \frac{F_a}{S_{fa}} \right) \times \frac{1}{1000} \]

   where,

   \( V \) - Absolute volume of fresh concrete

   \( S_c \) - Specific gravity of cement

   \( W \) - Mass of water per cubic meter of concrete

   \( P \) - Ratio of fine aggregate to total aggregate by absolute volume
Fa - Total mass of fine aggregate

$S_{fa}$ - Specific gravity of fine aggregate

Ca - Total mass of coarse aggregate

$S_{ca}$ - Specific gravity of coarse aggregate

To calculate fine aggregate

\[
V = \left[ W + \left( \frac{C}{S_{ca}} \right) + \left( \frac{1}{p} \right) \left( \frac{Fa}{S_{fa}} \right) \right] \times \frac{1}{1000}
\]

\[
0.98 = \left[ 153 + \frac{340}{2.74} + \left( \frac{1}{0.35} \right) \left( \frac{Fa}{2.54} \right) \right] \times \frac{1}{1000}
\]

\[
Fa = 567 \text{ Kg/m}^3
\]

7. To calculate coarse aggregate

\[
Ca = \left[ \frac{(1-p)}{p} \times Fa \times \left( \frac{S_{ca}}{S_{fa}} \right) \right]
\]

\[
= \left[ \frac{(1-0.35)}{0.35} \times 567 \times \left( \frac{2.74}{2.54} \right) \right]
\]

\[
= 1278.5 \text{ Kg/m}^3
\]

8. Mix proportion by weight

<table>
<thead>
<tr>
<th>Water</th>
<th>Cement</th>
<th>Sand</th>
<th>Coarse aggregate</th>
</tr>
</thead>
<tbody>
<tr>
<td>153</td>
<td>340</td>
<td>567</td>
<td>1278.35</td>
</tr>
<tr>
<td>0.45</td>
<td>1</td>
<td>1.67</td>
<td>3.76</td>
</tr>
</tbody>
</table>