APPENDIX 1

The concrete mix has been designed for M30 grade as per IS10262 – 2009. The specified concrete grade involves the economical selection of relative proportion of cement, fine aggregate, Coarse aggregate and water. Mix design on recommended guide lines is really a process of making an initial guess at optimum combination of ingredients and final mix proportion is obtained only on the basis of further trail mixes.

**Target Mean Strength of concrete**

\[ f_t = f_{ck} + t \times s \]

Where,

- \( f_t \) = Target average compressive strength at 28 days.
- \( f_{ck} \) = Characteristic of compressive strength at 28 days. \( S = \) Standard deviation.
- \( t \) = A statistic depending upon the accepted proportion of low results
  
  Standard deviation for M30 of good quality control \( (s) = 5.0 \)

\[ f_t = 30 + (1.65 \times 5.0) \]

\[ = 38.25 \text{ N/mm}^2 \]

**Selection of Water Cement Ratio**

From table 4.1 of IS 10262 – 2009, the free water cement ratio required for the above target mean strength of 38.25 N/mm\(^2\) is 0.43
Selection of Water and Sand content

From table 4.1 of IS 10262 -1982

Water content per m$^3$ of concrete (20mm size Ca) = 181kg

Determination of Cement Content

Water cement ratio $= 0.43$

Water $= 181$ kg

Cement $= 420$ kg/m$^3$

Determination of Coarse and Fine Aggregate Content

$$V = \left[ W + \frac{C}{S_c} + \frac{1}{\rho} \frac{f_a}{S_{fa}} \right] X \frac{1}{1000}$$

$$V = \left[ W + \frac{C}{S_c} + \frac{1}{1 - p} \frac{c_a}{S_{ca}} \right] X \frac{1}{1000}$$

Where,

$V$ = Absolute volume of fresh concrete, which is equal to gross volume (m$^3$) minus the volume of entrapped air.

$W$ = Mass of the water (kg) per m$^3$ of concrete.

$C$ = Mass of cement (kg) per m$^3$ of concrete.

$S_c$ = Specific gravity of cement.

$p$ = Ratio of fine aggregate to total aggregate by absolute volume

$f_a, c_a$ = Total masses of fine aggregate and coarse aggregate (kg) per m$^3$ of concrete respectively.

$S_{fa}, S_{ca}$ = Specific gravity of saturated surface dry fine aggregate and coarse aggregate respectively.
For the specified maximum size of aggregate of 12mm, the amount of entrapped air in the wet concrete is 2%. Taking this into account and applying into the above equation.

\[
f_a = 622 \text{ kg/m}^3
\]
\[
c_a = 1109 \text{ kg/m}^3
\]

**Mix ratio**

1:1.48:2.64
APPENDIX 2

MIX DESIGN FOR M60 GRADE CONCRETE

Calculation for weight of coarse aggregate

From ACI 211.4R Table 4.3.3 Fractional volume of oven dry rodded CA for 20 mm size aggregate is 0.53m³

Weight of CA 0.53 * 2100 = 1113 kg/m³

Calculation for quality of water

From ACI 211.4R Table 4.3.4

Assuming slump as 50 to 75 mm and for CA size 20 mm the mixing water = 166ml

Void content of FA for this mixing water = 35 %

Void content of FA (V)

\[ V = \frac{1}{1 + \left( \frac{\text{Dry Rodded unit weight}}{\text{specific gravity of FA} \times 1000} \right) \times 100} \]

\[ = \frac{1}{1 - \left( \frac{1726}{2.6 \times 1000} \right)} \times 100 \]

\[ = \frac{1}{1 - 0.6769} \times 100 \]

\[ = 34.62 \% \]

Adjustment in mixing water  \( = (V-35) \times 4.55 \)

\[ = (34.62 - 35) \times 4.55 \]

\[ = -1.725 \text{ ml} \]

Total water required \( = 166 + (-1.725) = 164.3 \text{ ml} \)
Calculation for weight of cement

From ACI211.4R Table 4.3.5(b)

Take w/c = 0.35

Weight of cement = 166/0.35 = 474 kg/m$^3$

Calculation for weight of fine aggregate

From Table 11.9 ACI, the first estimate of fresh concrete for 20 mm, maximum size of aggregate for non-air entrained concrete = 2355 kg/m$^3$

Weight of fine aggregate = 2389 – (166 + 474+ 1113) = 636 kg/m$^3$

Super plasticiser

For 1 % = (1/100) * 474 = 4.74 m$^3$

Correction for water:

Weight of water (For 1 %) = 166-4.74 = 161 kg/m$^3$

Requirements of materials per cubic meter

<table>
<thead>
<tr>
<th>Material</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement</td>
<td>474 kg/m$^3$</td>
</tr>
<tr>
<td>Fine aggregate</td>
<td>636 kg/m$^3$</td>
</tr>
<tr>
<td>Coarse aggregate</td>
<td>1113 kg/m$^3$</td>
</tr>
<tr>
<td>Water</td>
<td>166 kg/m$^3$</td>
</tr>
<tr>
<td>Super plasticiser</td>
<td>4.74 m$^3$</td>
</tr>
</tbody>
</table>

Mix ratio

1:1.34:2.348
APPENDIX 3

MIX DESIGN FOR M30 GRADE GP25 CONCRETE

The concrete mix has been designed for M30 grade as per IS10262 – 2009. The specified concrete grade involves the economical selection of relative proportion of cement, fine aggregate, Coarse aggregate and water. Mix design on recommended guide lines is really a process of making an initial guess at optimum combination of ingredients and final mix proportion is obtained only on the basis of further trail mixes.

**Target Mean Strength of concrete**

\[ f_t = f_{ck} + t \times s \]

Where,

- \( f_t \) = Target average compressive strength at 28 days.
- \( f_{ck} \) = Characteristic of compressive strength at 28 days.
- \( s \) = Standard deviation.
- \( t \) = A statistic depending upon the accepted proportion of low results
  Standard deviation for M30 of good quality control (s) = 5.0

\[ f_t = 30 + (1.65 \times 5.0) \]

\[ = 38.25 \text{ N/mm}^2 \]

**Selection of Water Cement Ratio**

From table 4.1 of IS 10262 – 2009, the free water cement ratio required for the above target mean strength of 38.25 N/mm\(^2\) is 0.43
Selection of Water and Sand content

From table 4.1 of IS 10262 -1982

Water content per m³ of concrete (20mm size Ca) = 181kg

Determination of Cement and Admixtures Content

Water cement ratio = 0.43
Water = 181 kg
Cement = 300.3 kg/m³
Fly ash = 42 kg/m³
Silica fume = 31.5 kg/m³
Slag (GGBFS) = 42 kg/m³
Super plasticiser = 4.2 kg/m³
Total (Cement and Admixtures) = 420 kg/m³

Determination of Coarse and Fine Aggregate Content

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

Where,

\[ V = \text{Absolute volume of fresh concrete, which is equal to gross volume (m}^3\text{) minus the volume of entrapped air.} \]

\[ W = \text{Mass of the water (kg) per m}^3\text{ of concrete.} \]

\[ C = \text{Mass of cement (kg) per m}^3\text{ of concrete.} \]

\[ Sc = \text{Specific gravity of cement.} \]

\[ p = \text{Ratio of fine aggregate to total aggregate by absolute volume} \]
\( f_a, c_a = \) Total masses of fine aggregate and coarse aggregate (kg) per m\(^3\) of concrete respectively.

\( S_{fa}, S_{ca} = \) Specific gravity of saturated surface dry fine aggregate and coarse aggregate respectively.

For the specified maximum size of aggregate of 12mm, the amount of entrapped air in the wet concrete is 2%. Taking this into account and applying into the above equation.

Fine Aggregate:

River Sand \( = \) 466.5 kg/m\(^3\)
Granite powder \( = \) 155.5 kg/m\(^3\)
(total) \( = \) 622 kg/m\(^3\)
\( c_a \) \( = \) 1109 kg/m\(^3\)

Mix ratio

1:1.48:2.64