What is Concrete Mix Design.?

Concrete mix design is the process of finding the proportions in which the concrete materials (cement, water, fine aggregates and course aggregates) should be combined in order to provide the required strength, workability, durability and other specified properties.

The various factors which affect mix design are., Compressive strength, Durability, Workability, Maximum Nominal Size of Aggregate and Grading & Types of Aggregate.

Steps

- **Step-1: Determining the Water/ Cement Ratio**
- **Step-2: Calculation of the target mean strength, f_m**
- **Step-3: Determination of the Free-Water Content**
- **Step-4: Determination of Cement Content**
- **Step 5: Determining the Total Aggregate Content**
- **Step 6: Determining of The Fine and Coarse Aggregate Contents**
  - **Final output**
  - **Cement: Sand: Aggregate**
  - **Water Content**

Specified Mix Variables;

1.Charactersistic Compressive Strength $30N/mm^2$ after 28 days

2.Portland Cement Class $42.5N$

3.Maximum Aggregate Size $20mm$ (Crushed)

4.Maximum Water Cement Ratio 0.65 (BS 5328)

5.Minimum Cement Content $275Kg/m^3$ (BS 5328)

6.Exposure Condition: $Mild$

7. Nominal Slump: $Medium$ $(75mm)$ (BS 5328)

8. Fine aggregate: 60% passing 600 µm sieve (uncrushed) (Laboratory Tested)

9.Relative Density Course Aggregate: 2.637~ 2.6 (Laboratory Tested)

Stage 1: Selection of target water/cement ratio

$$M = k\,x\,s \text{.....I}$$

Where: M = *the margin*

k = *a value appropriate to the 'percentage defectives' permitted below the Characteristic strength*

s = *the standard deviation.*

$$Fm = Fc + M \text{.....II}$$

Where: Fm = *the target mean strength*

Fc = *the specified characteristic strength*

M = *the margin*

tage 1: Selection of target water/cement ratio Cont..

$= k\,x\,s$.....I

r the 5% defective level specified in BS 5328, k = 1.64

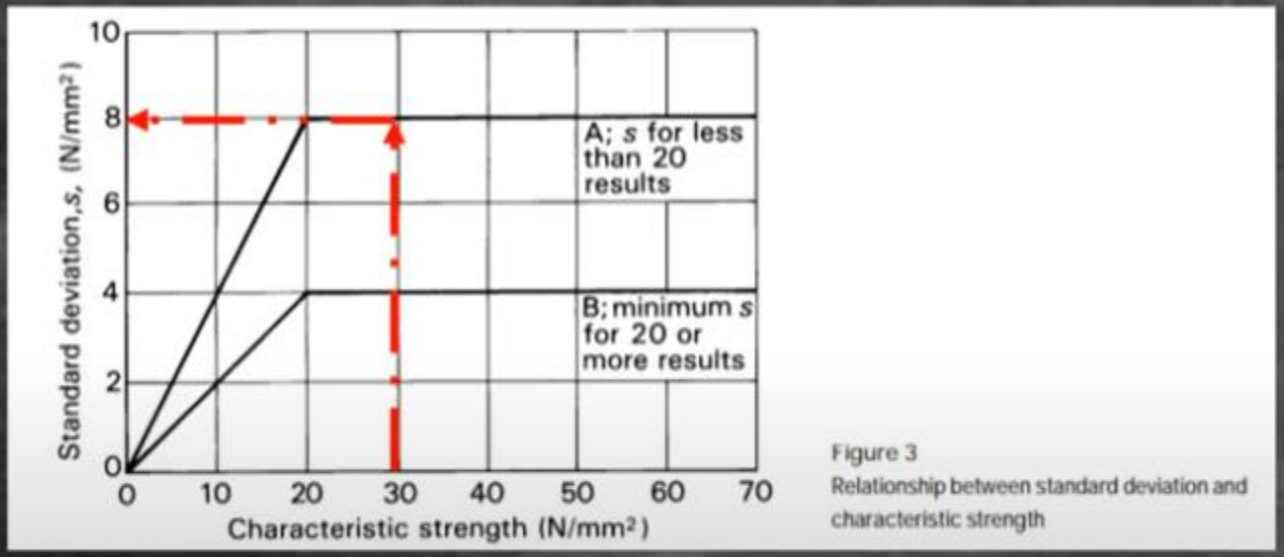


Figure 3
Relationship between standard deviation and characteristic strength

ndard Deviation $8\frac{N}{mm^2}$ since number of cube sample taken for test is less than 2

$$M = 1.64\,x\,8 = 13.12\,N/mm$$

Stage 1: Selection of target water/cement ratio Cont..

$Fm = Fc + M$.....II

$Fm = 30 + 13.12 = 43.12N/mm^2$

$\therefore Target\ Mean\ Strength\ is\ 43.12N/mm^2$

Next, a value is obtained from Table 2 for the strength of a mix made with a free-water/cement ratio of 0.5 according to the specified age (28 Days) , the strength class of the cement (42.5N) and the aggregate to be used (20mm Condition Crushed)

Stage 1: Selection of target water/cement ratio Cont..

Table 2 Approximate compressive strengths (N/mm^2) of concrete mixes made with a free-water/cement ratio of 0.5

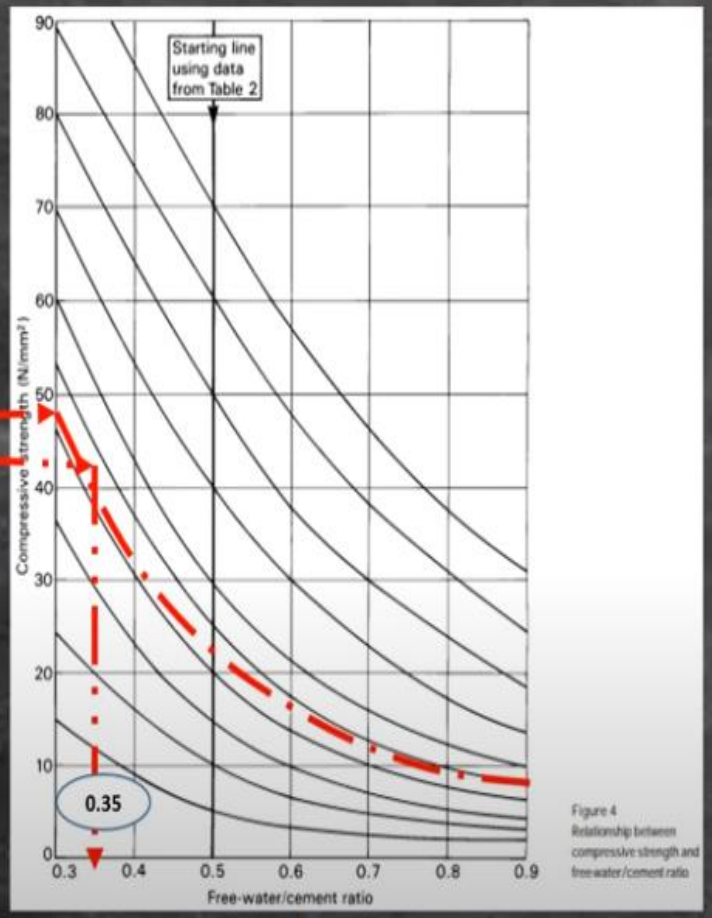
Cement strength class	Type of coarse aggregate	Compressive strengths (N/mm^2) Age (days) 3	7	28	91
42.5	Uncrushed	22	30	42	49
	Crushed	27	36	49	56
52.5	Uncrushed	29	37	48	54
	Crushed	34	43	55	61

Throughout this publication concrete strength is expressed in the units N/mm^2.
$1\ N/mm^2 = 1\ MN/m^2 = 1\ MPa$. (N = newton; Pa = pascal.)

∴ Strength value is $49N/mm^2$

This value is then plotted on Figure 4 and a curve is drawn from this point and parallel to the printed curves until it intercepts a horizontal line passing through the ordinate representing the target mean strength

Stage 1: Selection of target water/cement ratio Cont..



49

43.12

The corresponding value for the free-water/cement ratio was read from the abscissa. This value is compared with specified maximum free-water/cement ratio which is 0.65 and the lower of these two values used.

After comparison

∴ Free-water/cement ratio to be used is 0.35

∴ The corresponding free-water/cement ratio is 0.35

Stage 2: Selection of free water-content

From Table 3 depending upon the type and maximum size of the aggregate (Crushed Coarse Aggregate 20mm) to give a concrete of the specified slump (75mm)

Table 3 Approximate free-water contents (kg/m³) required to give various levels of workability

Slump (mm)		0–10	10–30	30–60	60–180
Vebe time (s)		>12	6–12	3–6	0–3
Maximum size of aggregate (mm)	Type of aggregate				
10	Uncrushed	150	180	205	225
	Crushed	180	205	230	250
20	Uncrushed	135	160	180	195
	Crushed	170	190	210	225
40	Uncrushed	115	140	160	175
	Crushed	155	175	190	205

∴ The free-water content is 225 Kg/m^3

Stage 3: Determination of Cement Content

$$Cement\ Content = \frac{Free\ -Water\ Content}{Free\ Water/Cement\ Ratio}$$

Where:

$Free\ Water/Cement\ Ratio = 0.35\ (Stage\ 1)$

$Free\ -Water\ Content = 225Kg/m^3 (stage\ 2)$

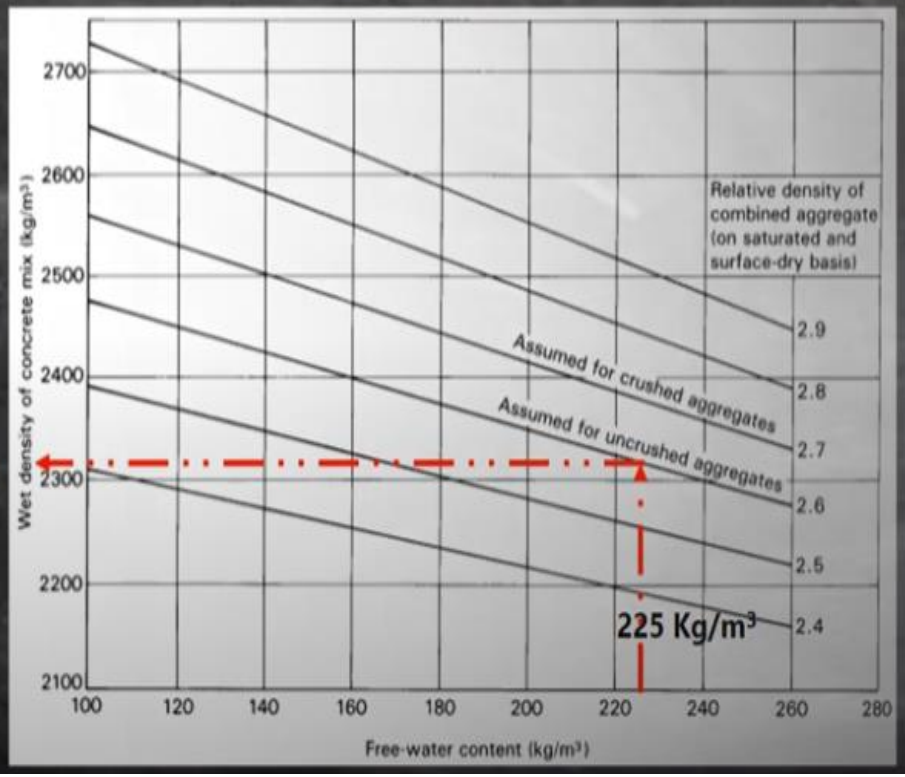
$$Cement\ Content = \frac{225}{0.35} = 642.85Kg/m^3$$

The resulting value should be checked against any maximum or minimum value that may be specified.

∴ The cement content is 642.85 Kg/m^3

Stage 4: Determination of Total Aggregate Content

Density of the fully compacted concrete which is obtained from Figure 5 depending upon the free-water content (225 Kg/m³) and the relative density of the combined aggregate in the saturated surface-dry condition (SSD) (2.6 Laboratory Tested).



2310 Kg/m³

∴ Density of the wet concrete mix is 2310 Kg/m³

Stage 4: Determination of Total Aggregate Content Cont...

From this estimated Density of the wet concrete mix (2310 Kg/m^3) the total aggregate content is determined

$$Total\ Aggregate\ Content = Wet\ Density\ of\ Concrete - Cement\ Content - Free\ Water\ Content$$

Where:

$$Free\ -Water\ Content = 225 Kg/m^3 (stage\ 2)$$

$$Cement\ Content = 642.85\ Kg/m^3 (Stage\ 3)$$

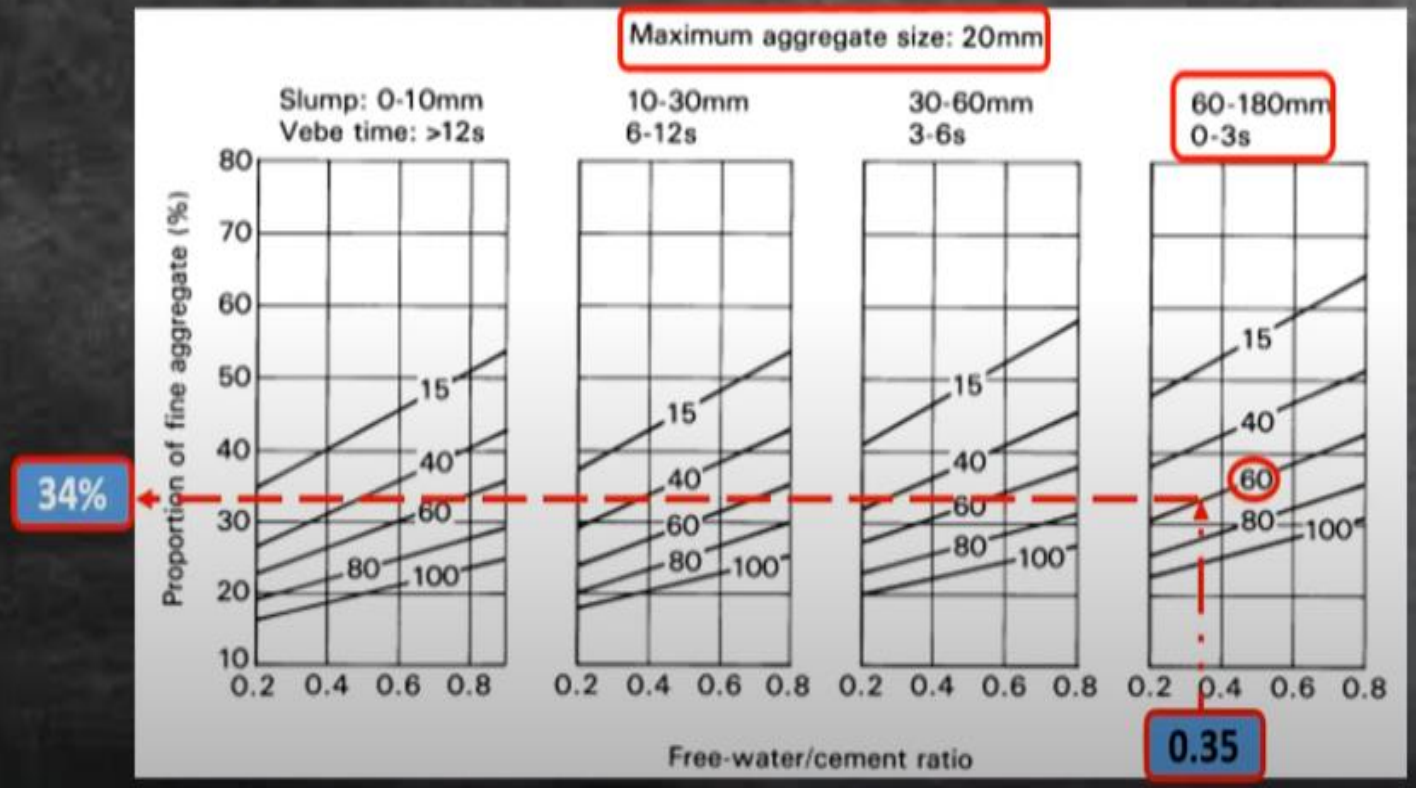
$$Wet\ Density\ of\ Concrete = 2310\ Kg/m^3 (Stage\ 4)$$

$$Total\ Aggregate\ Content = 2310 - 642.85 - 225$$

$$Total\ Aggregate\ Content\ is\ 1442.15\ Kg/m^3$$

Stage 5: Selection of Fine and Coarse Aggregate Content

Figure 6 shows recommended values for the proportion of fine aggregate (34%) depending on the maximum size of aggregate (20mm), the workability level (slump 75mm (60-180mm)), the grading of the fine aggregate (defined by its percentage passing a 600 μm sieve~ 60%) and the free-water/cement ratio (0.35).



Stage 5: Selection of Fine and Coarse Aggregate Content

Cont...

$$Fine\ aggregate\ content = Total\ aggregate\ content \times proportion\ of\ fines$$

$$Fine\ aggregate\ content = 1442.5 \times 34\%$$

$$Fine\ Aggregate\ Content\ is\ 490.85\ Kg/m^3$$

$$Coarse\ aggregate\ content = Total\ aggregate\ content - Fine\ Aggregate\ Content$$

$$Coarse\ aggregate\ content = 1442.5 - 490.85$$

$$Coarse\ Aggregate\ Content\ is\ 951.65\ Kg/m^3$$

Finally

Thus the quantities of the constituent materials per M^3 are:

i. Cement 642.85 Kg

ii. Water 225 Kg

iii. Fine aggregate 490.85 Kg (saturated surface-dry)

iv. Coarse aggregate 951.65 Kg (saturated surface-dry)

$642.85 : 490.85 : 951.65$ (*Divide by* 642.85 *throughout*)

∴ Cement : Sand : Aggregate (1 : 0.8 : 1.5)