BRE Mix Design Example 4

Calculate the quantities of cement, water, fine aggregate, and coarse aggregate per trial mix of 0.05 m^3 for the following specifications (site condition).

Target mean compressive strength = 45 MPa at 28 days;
Cement strength class 42.5;
Slump required = 10-30 mm;
Max. Aggregate size = 40 mm;
Specific gravity of aggregates = 2.65;
Coarse aggregate CRUSHED (10, 20, 40 mm, use ratio of 1:1.5:3),
Fine aggregate UNCRUSHED (70% pass 600 microns);
Maximum allowable free – water/cement ratio = 0.50;
Minimum allowable cement content = 300 kg/m^3;
Absorption of fine aggregate = 1.0%;
Absorption of coarse aggregate = 1.5%;
Total Moisture content of coarse aggregate = 2.0%;
Total Moisture content of fine aggregate = 2.0%

SOLUTION (moisture correction)-after filling Table 1

Use below relation to know if aggregates are in wet or dry condition:
Total Moisture = (Absorbed Moisture) + (Free Moisture)
Fine aggregate: 2 = 1 + Free Moisture, Free Moisture= +1%. So aggregates are in wet condition. Extra water will be deducted from free-water calculated, same amount will be added to fine aggregates.
Extra moisture from fine Agg. = 439 x (1%) = 4.39 kg
Fine aggregate (net, wet)=439+4.39= 444 kg

Coarse aggregate: 2=1.5% + Free Moisture, Free Moisture = +0.5%. So aggregates are in wet condition. Extra water will be deducted from free-water calculated, same amount will be added to course aggregates.
Extra moisture from Coarse Agg. = 1558 x (0.5%) = 7.79 kg.
Coarse aggregate (net, wet)= 1558 + 7.79 = 1566 kg (10mm: 285 kg, 20 mm: 428 kg; 40 mm: 856 kg)
So, net water content= 151-4.39-7.79= 138 kg

So all field results per m^3 of concrete are:
Cement: 302 kg
Fine aggregate (wet): 444 kg
10 mm wet Coarse aggregate (wet): 285 kg
20 mm wet Coarse aggregate (wet): 428 kg
40 mm wet Coarse aggregate (wet): 856 kg
Net water content: 138 kg

Table 1. Concrete Mix Design Form (BRE method) Job title: EXAMPLE 4

stage	item		Reference or calculation	Values
1	1.1	Characteristic strength	Specified	.....N/mm² at.....**28**.....days Proportion defective .....%
	1.2	Standard deviation	Fig. 3	..... N/mm² or no data ..... N/mm²
	1.3	Margin	C1	(k=.....) .....**x**.....=.....N/mm2
			Specified	..... N/mm²
	1.4	Target mean strength	C2	.....+.....=.....**45** .....N/mm²
	1.5	Cement strength class	Specified	**42.5**/~~52.5~~
	1.6	Aggregate type: coarse		**Crushed**/~~Uncrushed~~
		Aggregate type: fine		~~Crushed~~/**Uncrushed**
	1.7	Free-water/cement ratio	Table 2, Fig. 4	.....**0.53**..... Use the lower value .**0.50**.. .....
	1.8	Max. Free water/cement ratio	Specified	.....**0.50**.....
2	2.1	Slump or VeBe time	Specified	Slump .....**10-30**.....mm or VeBe time.....s
	2.2	Max. Aggregate size	Specified	.....**40**.....mm
	2.3	Free-water content	Table 3	**2x140/3 + 1x175/3 = .151**.....kg/m³
3	3.1	Cement content	C3	...**151**..... / .....**0.50**..... = .**302**..... kg/m³
	3.2	Maximum Cement content	Specified	.....kg/m³
	3.3	Minimum Cement content	Specified	.....**300**.....kg/m³
			Do not use less than 3.3 or more than 3.2	.....**302**..... kg/m³
	3.4	Modified free-water/cement ratio		.....
4	4.1	Relative density of aggregate (SSD)		.....**2.65**.....known/~~assumed~~
	4.2	Concrete density	Fig. 5	.....**2450**..... kg/m³
	4.3	Total aggregate content	C4	.**2450**..... - ..**302**..... - .**151**..... = .**1997**.... kg/m³
5	5.1	Grading of fine aggregate	Percentage passing 600 micron sieve	.....**70**.....%
	5.2	Proportion of fine aggregate	Fig. 6	.....**22**.....%
	5.3	Fine aggregate content	C5	.....**1997**.....**x** .....**0.22**..... = **439**.....kg/m³
	5.4	Coarse aggregate content		..... **1997**..... **-**. .....**439**..... = **1558**.....kg/m³

Quantities	Cement (kg)	water (kg or lt)	Fine aggregate (kg)	Coarse aggregate (kg)		
				10 mm	20 mm	40 mm
Per m³ (to nearest 5 kg)	**302**	**151**	**439**	**283**	**425**	**850**
Per trial mix of .**0.05** m³	**15**	**8**	**22**	**14**	**21**	**42**

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 in 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

1 N/mm^2 = 1 MN/mm^2 = 1 MPa

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

Slump (mm) V-B (s)		0-10 >12	10-30 6-12	30-60 3-6	60-180 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 Wc
	Crushed	170	190	210	225 Wf
40	Uncrushed	115	140Wf	160	175
	Crushed	155	175Wc	190	205

Note: When coarse and fine aggregates of different types are used, the free-water content is estimated by the expression:

$$\frac{2}{3} W_f + \frac{1}{3} W_c$$

where W_f = free-water content appropriate to type of fine aggregate; W_c = free-water content appropriate to type of coarse aggregate.

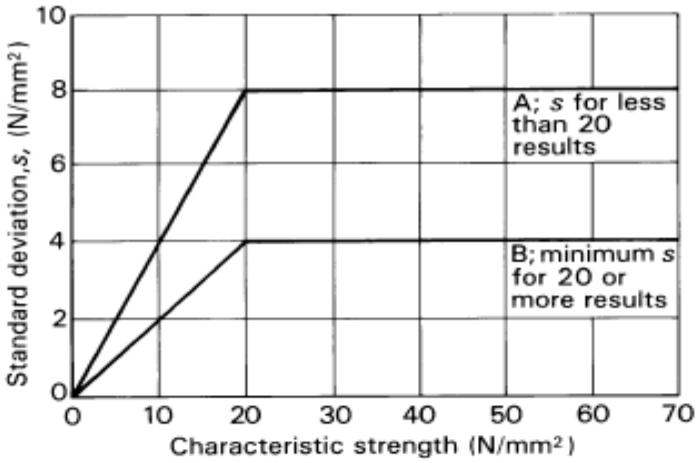

Figure 3
Relationship between standard deviation and characteristic strength

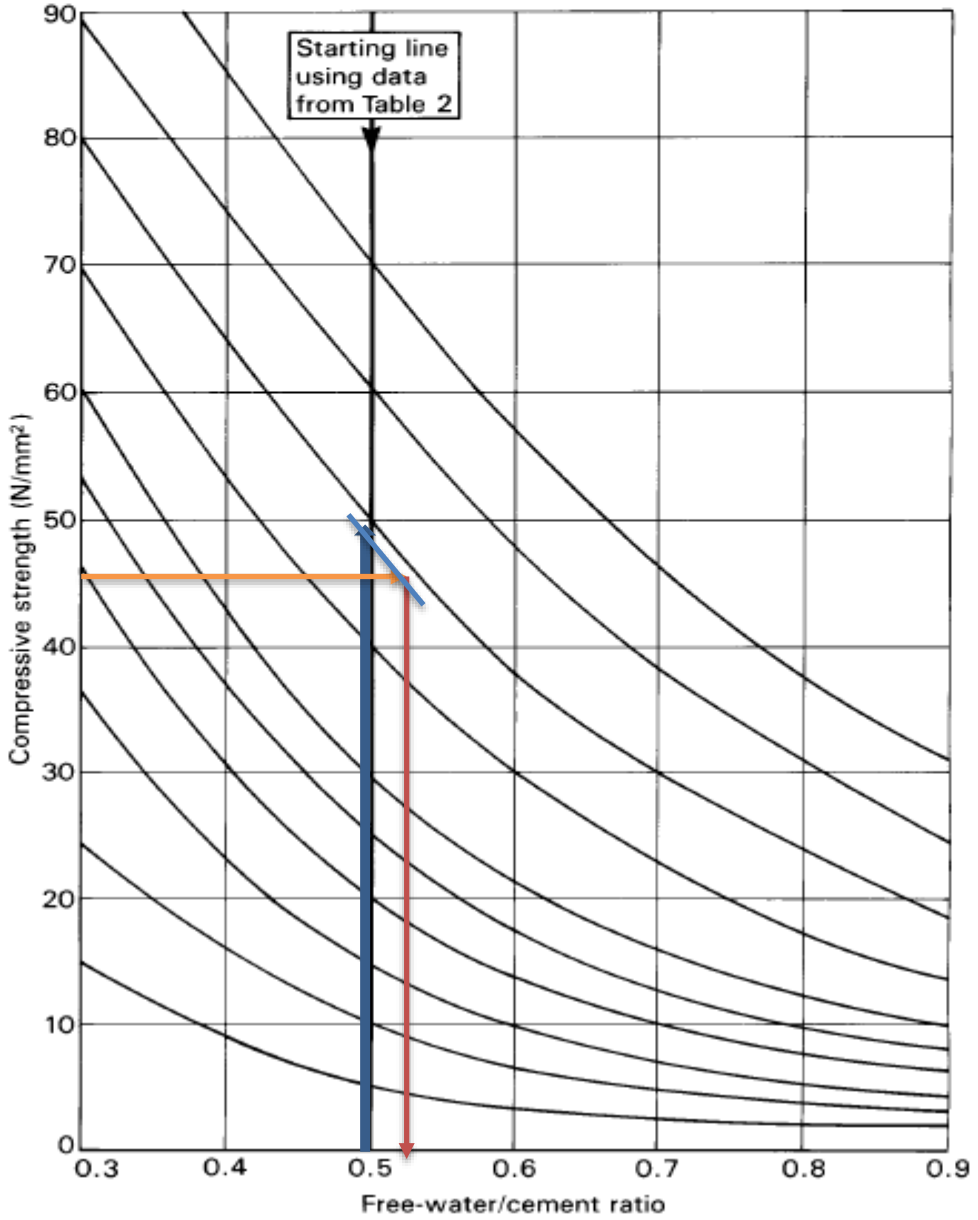

Figure 4
Relationship between compressive strength and free-water/cement ratio

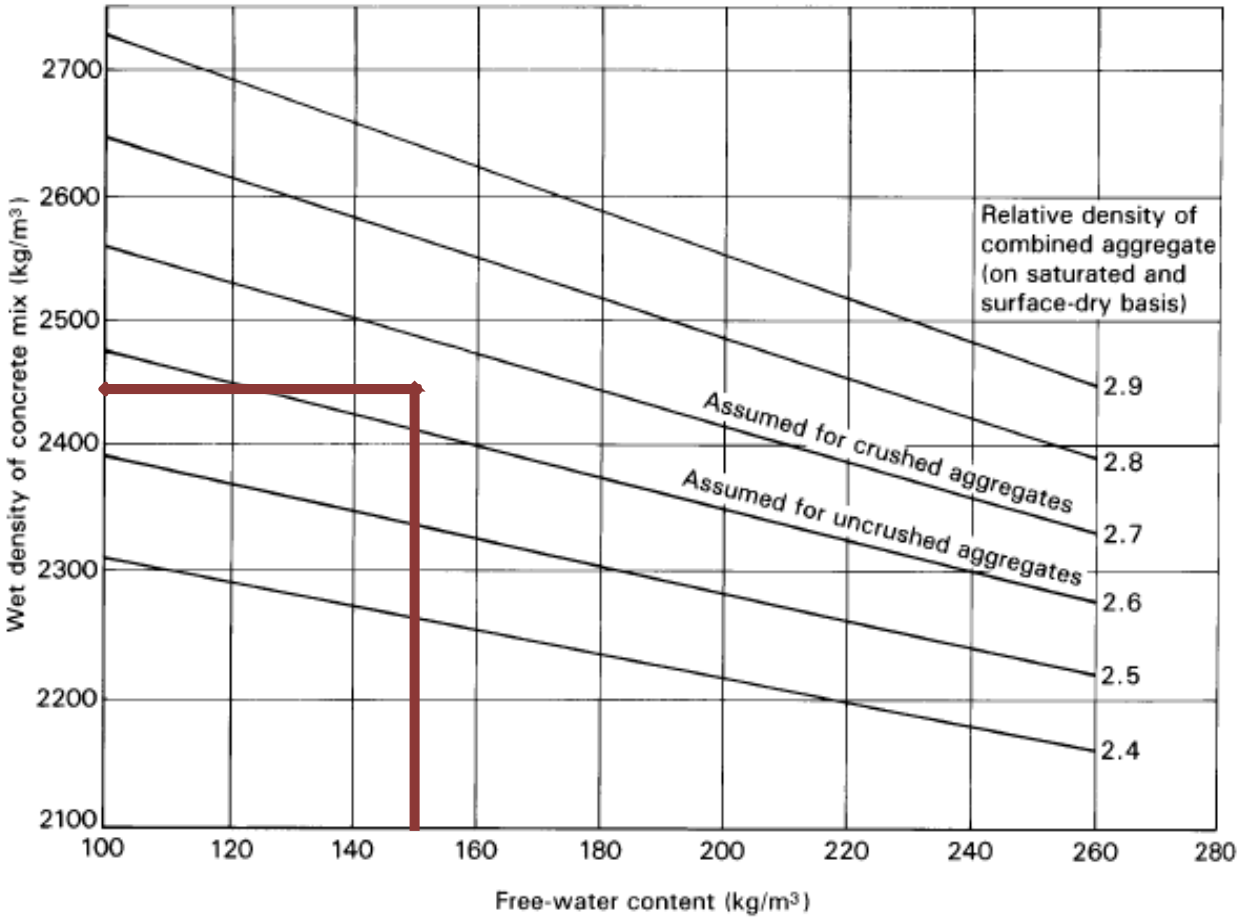

Figure 5 Estimated wet density of fully compacted concrete

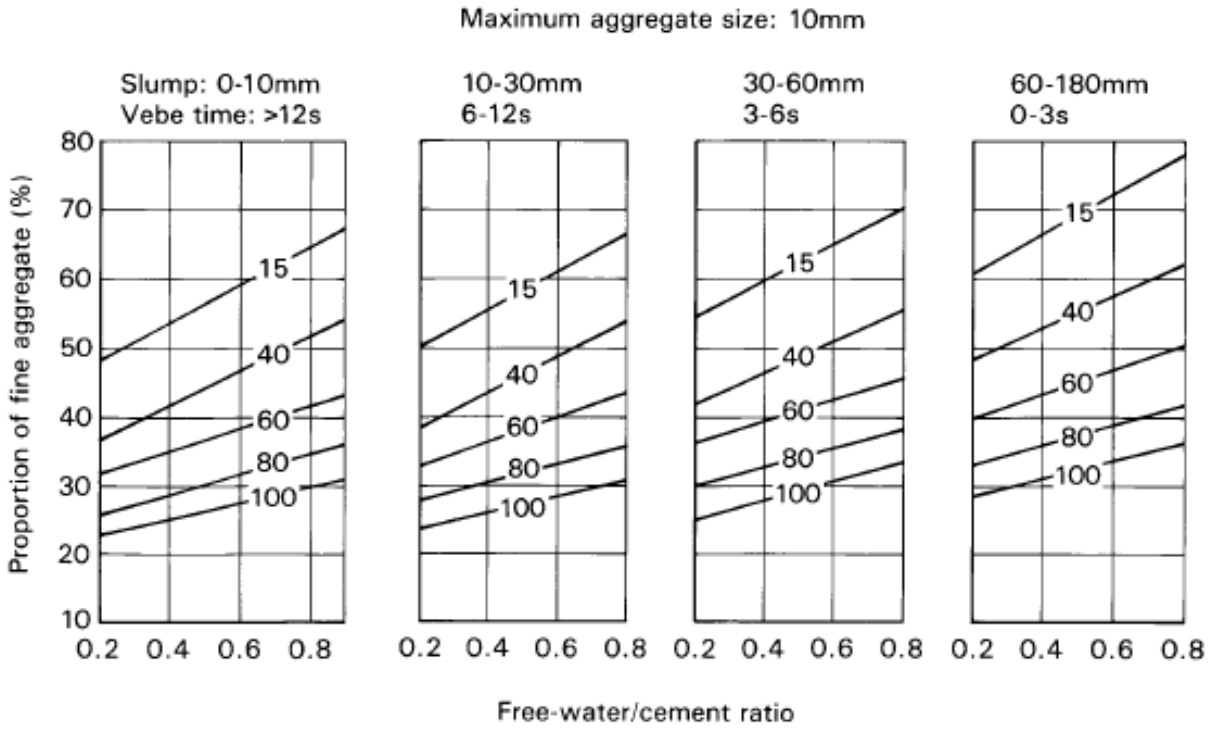

Figure 6 Recommended proportions of fine aggregate according to percentage passing a 600 µm sieve

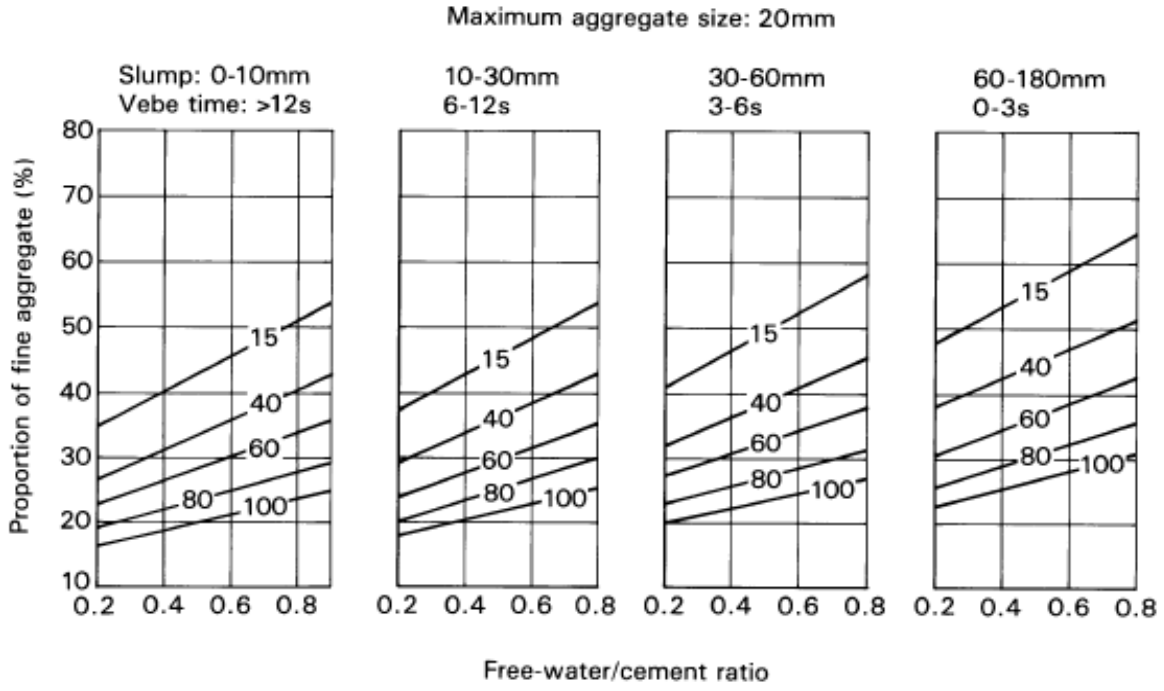

Figure 6 (continued)

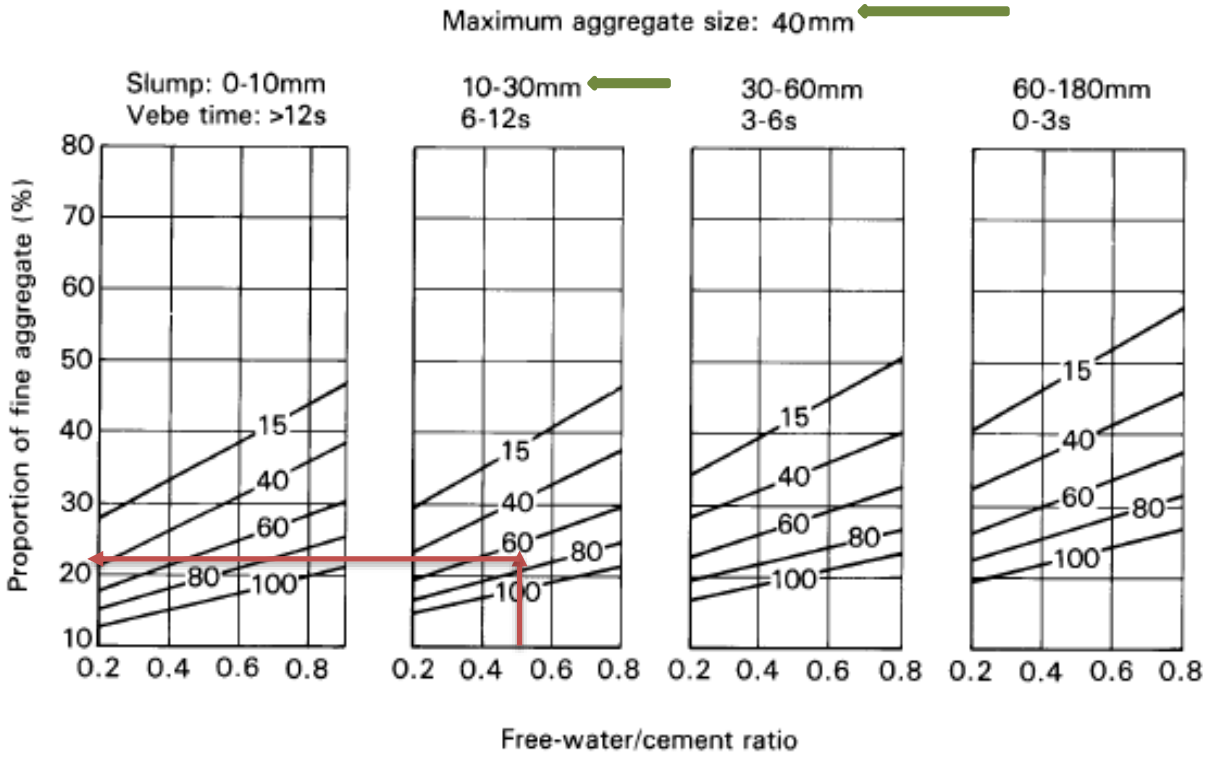

Figure 6 (continued)