APPENDIX 1

TESTING OF AGGREGATES, MIX DESIGN AND TESTING OF CONCRETE

A1.1 COARSE AGGREGATE

Specific Gravity

Table A1.1 Specific Gravity of Coarse Aggregate

Weight of saturated aggregate in water (A)(kg)	Weight of saturated surface dry aggregate in air (B) (kg)	Weight of ovendried aggregate(C) (kg)	Specific gravity = B/(A-C)
2	1.986	1.259	2.9

Bulk density

Table A1.2 Loose and Compacted Bulk Density of Coarse Aggregate

Weight of loose coarse aggregate (kg)	Weight of compacted coarse aggregate (kg)	Volume of aggregate (m^3)	Bulk density of loose coarse aggregate kg/m^3	Bulk density of compacted coarse aggregate kg/m^3
7.05	7.7	5.6×10^{-3}	1258	1375

A1.2 FINE AGGREGATE

Specific Gravity

Table A1.3 Specific Gravity of Fine Aggregate

Weight of surface dry sample (A)	Weight of jar containing sample and filled with water (B)	Weight of jar filled with distilled water (C)	Weight of oven dried sample (D)	Specific gravity = D/(A-(B-C)	Water absorption =100 (A-D) / D
400g	920g	680g	390g	2.62	2.56 %

Bulk density

Table A1.4 Loose and Compacted Bulk Density of Fine Aggregate

Weight of loose fine aggregate (kg)	Weight of compacted fine aggregate	Volume of aggregate (m^3)	Bulk density of loose fine aggregate kg/ m^3	Bulk density of compacted fine aggregate (kg/ m^3)
6.58	7.06 kg	5.6×10^{-3}	1175	1260

A1.3 TESTING ON CEMENT

Table A1.5 Specific Gravity of Cement

Weight of sample(A) (gm)	Weight of jar containing sample and filled with kerosene (B) (gm)	Weight of jar filled with kerosene (C) (gm)	Weight of dried sample (D) (gm)	Specific gravity = D/(A-(B-C)
28	81	60	22	3.12

MIX DESIGN FOR M20 GRADE CONCRETE

Step: 1 Design Stipulations

- Characteristic compressive strength required in the field at 28 days = 20 N/ mm^2
- Maximum size of aggregate = 20 mm
- Degree of quality control = Good
- Type of exposure = Mild

Step: 2 Test Data for Materials

Cement used - Portland pozzlona cement (43 grade)

- Specific gravity of cement = 3.12
- Specific gravity of fine aggregate = 2.62
- Specific gravity of coarse aggregate = 2.90

Water absorption

- Coarse aggregate = 0.75 %
- Fine aggregate = 1.0 %

Step: 3 Target Mean Strength of Concrete

$f_{ck} = f_{ck} + t^* s$

where,

f_{ck} = Target average compressive strength at 28 days

f_{ck} = Characteristic compressive strength at 28 days

s = Standard deviation

t = A statistic depending upon the accepted proportion of low results

The values t and s are taken from the table 1 and table 2 of IS 10262 - 1982

fck = f ck + t* s

= 20 + (1.65 * 4.0) = 26.6 N/ mm^2

Step: 4 Selection of Water Cement Ratio

From fig: 1 of IS 10262 - 1982, the free water cement ratio required for the target mean strength of 26.6 N/ mm^2 is 0.50. This is lower than the maximum value of 0.55 prescribed for Mild exposure in Appendix A of IS 456-2000 adopt water cement ratio of 0.50.

Step: 5 Selections of Water and Sand Content

From Table 4 for 20 mm maximum size of aggregate sand conforming to grading zone III, water content per cubic meter of concrete = 186 kg and sand content as percentage of total aggregate by absolute volume = 35 percentage.

Changes in condition	Percentage adjustment required	
	Water content	Sand in aggregate
For decrease in water cement	0	-2.0
Increase in value of compaction factor by 0.10	+3	0
For sand contromingto Zone III of table 4 IS 383 - 1970	0	-1.5
Total	+3	-3.5

Therefore required sand content as percentage of total aggregate by absolute value

= 35 - 3.5 = 31.5 %

Requirement water content = 186 + 186 *0.315

= 191.61 lit/ m^3

Step: 6 Determination of cement content

Water - Cement ratio = 0.50

Water = 191.61 lit/ m^3

Cement = 191.61/0.50

= 382.32 kg/m^3

This is cement content is adequate for mild exposure condition

Step: 7 Determination of coarse aggregate and fine aggregate

From Table 3, for the specified maximum size of aggregate of 20 mm, the amount of entrapped air in the wet concrete is 2 percent. Taking this into account and applying equations from 3.5.1, (IS 10262-1982).

$V = [W + (C /Sc) + (1/ P)*(fa/S_{fa})] * 1/1000$

$0.98 = [191.6 + (382.32/ 3.12) + (1/0.315)*(fa/2.62)] * 1/1000$

$= [314.14 + 1.211\ fa] * 1/1000$

$fa = 554.88\ kg/m^3$

$V = [W + (C /Sc) + (1/1- p)*(Ca/S_{ca})] * 1/1000$

$0.98 = [191.6 + (382.32/ 3.12) + (1/1-0.315)*(Ca/2.9)] * 1/1000$

$= [314.14 + 0.5\ Ca] * 1/1000$

$Ca = 1070.49\ kg/m^3$

where

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

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

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

Sc = Specific gravity of cement.

P = Ratio of fine aggregate to total aggregate by absolute volume.

fa, ca = Total mass of fine 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.

Mix Proportion

Water (litres)	Cement (kg)	Fine aggregate (kg)	Coarse aggregate (kg)
191.61	382.32	554.88	1070.49
0.50	1	1.42	2.8

A1.4 TESTING OF CONCRETE

(i) Compression Strength of Concrete

Cube Specimen : 150 x 150 x 150 mm

Figure A1.1 Compression testing of cube

Table A1.6 Cube Compressive strength of concrete

Age of specimen	Cube		
	Load (kN)	Compressive strength (N/mm^2)	Average compressive strength (N/mm^2)
28 days	460	20.44	20.58
	485	21.55	
	445	19.77	

(ii) Tensile Strength of Concrete

Cylinder specimen : 150 mm diameter and 300 mm length.

Figure A1.2 Split tension test for cylinder

$$\text{Tensile strength} = \frac{\text{Compression load along axis}}{\text{Area in tension}} = \frac{2P}{\pi DL}$$

Table A1.7 Split Tensile Strength of Concrete

Specimen	Load (kN)	Tensile strength (N/mm^2)	Average tensile strength (N/mm^2)
Cylinder	290.5	4.10	3.83
	250.8	3.54	
	272.1	3.85	