Concrete Mix Design

- Grade designation = M20
- Type and grade of cement = OPC 43 grade
- Maximum nominal size of aggregate = 20mm
- Minimum cement content = 220 kg/m^3 [Refer Table 5 of (IS 456, 2000)]
- Maximum water cement ratio = 0.6 [Refer Table 5 of (IS 456, 2000)]
- Workability in terms of slump = 100mm [Clause 7.1 of (IS 456, 2000)]
- Standard deviation = 4 N/mm^2 [Refer Table 1 of (IS 10262, 2019)]
- Exposure condition [Refer Table 4 & 5 of (IS 456, 2000)]
- Type of coarse aggregate = Gravel with crushed particles
- Maximum cement content = 450kg/m^3

Test data of material [Obtained from Experimental Setup]

- Specific gravity of cement = 3.13 g/cc
- Specific gravity of coarse aggregate (Naubise) = 2.65
- Specific gravity of coarse aggregate (Recycled) = 2.37
- Specific gravity of fine aggregate = 2.63
- Fine aggregates confirm to Zone II of (IS:383, 1970)

Procedure

- Find Target mean Strength

f'ck = fck + 1.65s ; where

f'ck = target mean compressive strength at 28 days in N/ mm^2

fck=characteristics compressive strength at 28 days in N/ mm^2

s = standard deviation N/mm^2 [Refer Table 1 of (IS 10262, 2019) or Table 8 of (IS 456, 2000)]

- Determination of water-cement ratio:

w/c = 0.6 (the maximum water-cement ratio for mild exposure conditions) [Refer Table 5 of (IS 456, 2000)]

Since no pretreatment was applied to the recycled aggregates adopting w/c =0.6

- Determination of water content:

Nominal maximum size of aggregate =20 mm

Maximum water content= 186 kg (for 50mm slump) [Refer Table 4 of (IS 10262, 2019)]

For every 25 mm, 3% was added [As per Clause 5.3 of (IS 10262, 2019)]

So maximum water content = 186 + 6% of 186 =197 kg

For gravel with some crushed particles = 197-20 = 177 kg

- Percentage Air contained For maximum size of aggregate = 20 mm

% entrapped air = 2%

- Determination of cement Content:

Cement content by water cement ratio = water content / (w/c ratio)

$$= 177/0.6$$

$$= 295 \text{ kg/ } m^3$$

The cementitious material content so calculated was checked against the minimum content for the requirements of durability [Refer Table 5 of (IS 456, 2000)] and greater of the two values adopted.

Cement content = 220 kg / m^3

Therefore, cement content of 295 kg/ m^3 is in compliance with the code.

- Determination of coarse aggregate proportion:

Volume of coarse aggregate per unit volume of total aggregate for Zones-II of fine aggregate = 0.62 (for w/c = 0.5) [Refer Table 5 of (IS 10262, 2019)]

$$= 0.62-2*0.01$$

$$= 0.6$$

Approximate values of aggregate volume were taken from table 3 of (IS 10262, 2019) for w/c = 0.5, which was suitably adjusted for other water-cement ratios by increasing coarse aggregate by 0.01 for a 0.05 decrease in water-cement ratio and vice versa. As the w/c ratio is higher by 0.12, the proportion of volume of coarse aggregate is decreased by 0.02.

- Determination of fine aggregate proportion:

Fine aggregate proportion = 1- coarse aggregate proportion

$$= 0.4$$

- Design Mix calculation

The mix design calculation of concrete shall be as follow:

a. Volume of concrete = $1m^3$

b. Volume of cement = mass of cement / (specific gravity of cement *1000)

= 295/ (3.13*1000)

= 0.094 m^3

c. Volume of water = mass of water / (specific gravity of water * 1000)

= 177/1000

= 0.177 m^3

d. Volume of entrapped air = 0.02 m^3

e. Volume of all aggregate = volume of concrete - (volume of cement + volume of water + volume of entrapped air)

= 1- 0.094 - 0.177 - 0.02

= 0.709 m^3

f. Mass of coarse aggregate = volume of all aggregate * proportion of coarse aggregate * specific gravity of coarse aggregate * 1000

Table 1: Coarse aggregate calculation

Description	Mass of CA (Naubise)	Mass of CA (Recycled)
For 0% RA	=0.709*0.6*2.65*1000 =1127.31 kg/m^3	
For 25% RA	=0.709*0.6*2.65*1000*0.75 =845.48 kg/m^3	=0.709*0.6*2.37*1000*0.25 =252.049 kg/m^3
For 30% RA	=0.709*0.6*2.65*1000*0.7 =789.117 kg/m^3	=0.709*0.6*2.37*1000*0.3 =302.45 kg/m^3

For 50% RA	=0.709*0.6*2.65*1000*0.5 =563.655 kg/m^3	=0.709*0.6*2.37*1000*0.5 =504.099 kg/m^3

g. Mass of fine aggregate = volume of all aggregate * proportion of fine aggregate * specific gravity of fine aggregate * 1000

= 0.709*0.4*2.63*1000

= 745.868 kg/ m^3

Then prepare the trial mixes.

One block = 15cm*15cm*15cm = 3.375 * 10^{-3} m^3

For one cube considering 10% wastage

Cement = (295 kg / m^3)*(3.375×10^{-3} m^3) * 1.1

= 0.9956 kg per block

Fine aggregate = (745.868 kg/ m^3)*3.375×10^{-3} m^3) * 1.1

= 2.517 kg per block

Table 2: Coarse aggregate per block

Description	Mass of CA (Naubise)	Mass of CA (Recycled)
For 0% RA	(1127.31 kg/m^3) * (3.375×10^{-3} m^3) * 1.1 = 3.804 kg per block	
For 25% RA	(845.48 kg/m^3) * (3.375×10^{-3} m^3) * 1.1 = 2.853 kg per block	(252.049 kg/m^3) * (3.375×10^{-3} m^3) * 1.1 = 0.85 kg per block
For 30% RA	(789.117 kg/m^3) * (3.375×10^{-3} m^3) * 1.1 = 2.663 kg per block	(302.45 kg/m^3) * (3.375×10^{-3} m^3) * 1.1 = 1.0208 kg per block

For 50% RA	(563.655 kg/m^3) * (3.375×10^{-3} m^3) * 1.1 = 1.902 kg per block	(504.099 kg/m^3) * (3.375×10^{-3} m^3) * 1.1 = 1.701 kg per block

Water = 0.6 * 0.9 = 0.597 liter per block