TRIBHUWAN UNIVERSITY

INSTITUTE OF ENGINEERING

PULCHOWK CAMPUS

A PRACTICAL REPORT ON

CONCRETE TECHNOLOGY

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Practical - I

1. Sieve Analysis of Coarse Aggregates

Theory

Sieve Analysis is the name given to the operation of dividing a sample of aggregates into various fractions each consisting of particles of the same size. The sieve analysis is conducted to determine the *particle size distribution* in a sample of aggregate, which we call gradation.

A convenient system of expressing the gradation is one in which the consecutive sieve openings are constantly doubled, such as 10 mm, 20 mm, 40 mm, etc. Under such a system, employing a logarithmic scale, lines can be spaced at equal intervals to represent the successive sizes.

The mass retained on each sieve is weighed and percentage of material on each sieve is given by:

$P_n = (m_n*100)/m$; where, m = total mass of sample, m_n = mass of aggregate retained on each sieve

The cumulative percentage of the material retained:

$C_n = p_1 + p_2 + \ldots\ldots + p_n$

Fineness Modulus (F.M.):- Fineness Modulus is a ready index of coarseness or fineness of the material. Fineness Modulus is an empirical factor obtained by adding the cumulative percentages of aggregate retained on each of the standard sieves. The larger the figure, the coarser is the material.

$$\text{F. M. of aggregates} = \frac{\text{Summation of cumulative \% of wt. retained on I. S. sieve}}{100}$$

Higher the F.M., higher will be coarser particles.

Nominal maximum size is the sieve size through which 95% or more aggregates pass.

Uncrushed gravel or stone which is the result of natural disintegration and crushed gravel or stone are usually called the coarse aggregates. Coarse aggregates are those aggregates that are IS 4.75 mm sieve.

Procedure

1. The sieves of sizes 40 mm, 37.5 mm, 28 mm, 25 mm, 20 mm, 16 mm, 14 mm, 12.5 mm, 10 mm and 6.3 mm were stacked over one another with the largest sieve at the top.
2. A pan was kept at the bottom.
3. The coarse aggregates were taken in required quantity and sieved through the first sieve (the sieve with the largest openings).
4. Manual shaking was continued for about ten minutes.
5. Finally the amount of aggregates retained on each sieve was measured and the necessary calculations were performed.

Data

Mass of sample taken = 5 kg

I.S. Sieve (mm)	Weight retained (kg)	Cumulative weight retained (kg)	% of cumulative weight retained
40	0	0	0
37.5	0.159	0.159	3.18
28	0.117	0.276	5.52
25	1.791	2.067	41.34
20	2.325	4.392	87.84
16	0.48	4.872	97.44
14	0.063	4.935	98.7
12.5	0.034	4.969	99.38
10	0.012	4.981	99.62
6.3	0.008	4.989	99.78
Pan	0.011	5	100
	∑ = 5 kg		∑ = 732.8

Calculation

1. ***Fineness Modulus of Aggregates***

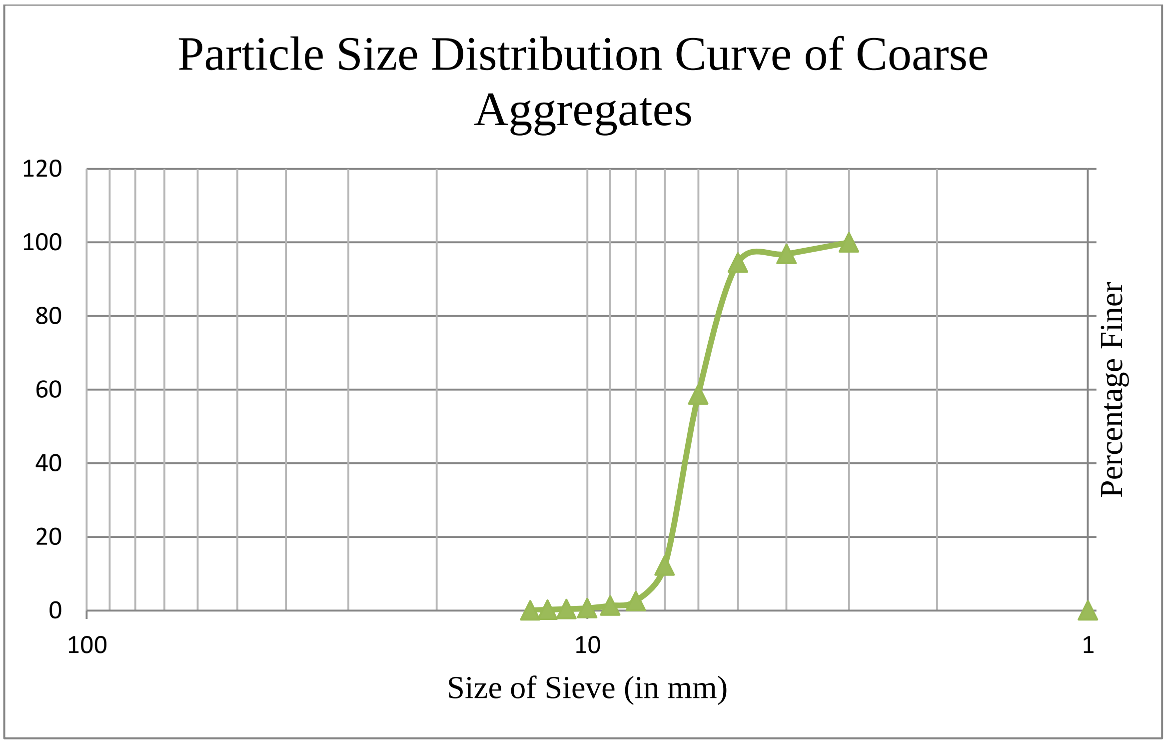
$$F.M.\ of\ Coarse\ Aggregates = \frac{\Sigma\ of\ cumulative\ \%\ of\ wt.retained\ on\ I.S.sieve}{100}$$

$$Hence, Fineness\ Modulus = \frac{732.8}{100} = 7.328$$

2. ***Particle Size Distribution Curve***

To draw the particle size distribution curve, an additional column is created in the above data table indicating the percentage of finer aggregates. The value is given by subtracting the cumulative percentage of aggregates retained from 100.

I.S. Sieve (mm)	Weight retained (kg)	Cumulative weight retained (kg)	% of cumulative weight retained	Percentage Finer
40	0	0	0	100
37.5	0.159	0.159	3.18	96.82
28	0.117	0.276	5.52	94.48
25	1.791	2.067	41.34	58.66
20	2.325	4.392	87.84	12.16
16	0.48	4.872	97.44	2.56
14	0.063	4.935	98.7	1.3
12.5	0.034	4.969	99.38	0.62
10	0.012	4.981	99.62	0.38
6.3	0.008	4.989	99.78	0.22
Pan	0.011	5	100	0
	∑ = 5 kg		∑ = 732.8	



2. Sieve Analysis of Fine Aggregates

Theory

Many a time, fine aggregates are designated as coarse sand, medium sand and fine sand. These classifications do not give any precise meaning. What the supplier terms as fine sand may be really medium or even coarse sand. To avoid this ambiguity fineness modulus could be used as a yardstick to indicate the fineness of sand.

The following limits may be taken as guidance:

Fine Sand : Fineness Modulus : 2.2 – 2.6

Medium Sand : F.M. : 2.6 – 2.9

Coarse Sand : F.M. : 2.9 – 3.2

Sand having a fineness modulus more than 3.2 will be unsuitable for making satisfactory concrete.

Procedure

1. The sieves of sizes 4.75 mm, 2 mm, 1.18 mm, 850 μm, 600 μm, 300 μm, 150 μm and 75 μm were stacked over one another with the largest sieve at the top.
2. A pan was kept at the bottom.
3. The fine aggregates were taken in required quantity and sieved through the first sieve (the sieve with the largest openings).
4. Manual shaking was continued for about ten minutes.
5. Finally the amount of aggregates retained on each sieve was measured and the necessary calculations were performed.

Data

Mass of sample taken = 2 kg

I.S. Sieve	Weight retained (kg)	Cumulative weight retained (kg)	% of cumulative weight retained	Percentage Finer
4.75 mm	0.058	0.058	2.9	97.1
2 mm	0.047	0.105	5.25	94.75
1.18 mm	0.136	0.241	12.05	87.95
850 μm	0.336	0.577	28.85	71.15
600 μm	0.323	0.9	45	55
300 μm	0.836	1.736	86.8	13.2
150 μm	0.192	1.928	96.4	3.6
75 μm	0.062	1.99	99.5	0.5
Pan	0.01	2	100	0
	$\sum = 2$		$\sum = 476.75$	

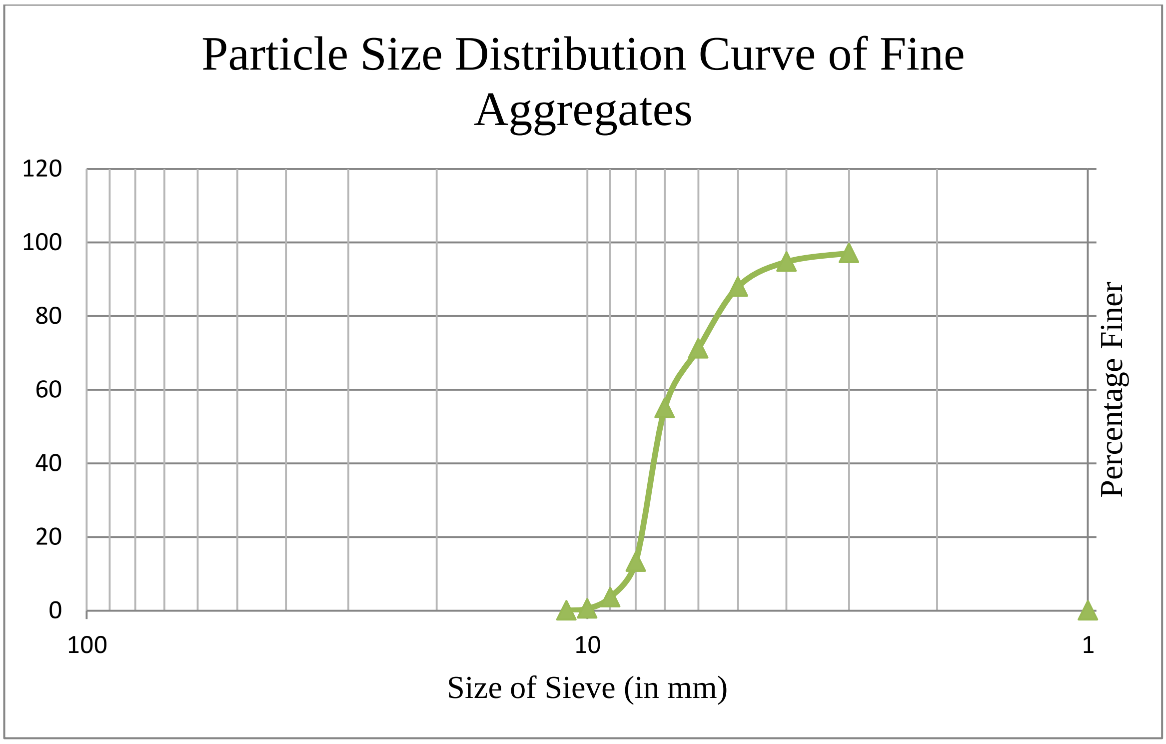
Calculation

1. ***Fineness Modulus of Aggregates***

$$F.M.\,of\ Fine\ Aggregates = \frac{\Sigma\ of\ cumulative\ \%\ of\ wt.retained\ on\ I.S.sieve}{100}$$

$$F.M. = \frac{476.75}{100} = 4.7675$$

2. ***Particle Size Distribution Curve***



3. Specific Gravity of Coarse Aggregates

Theory

The specific gravity of solid particles (G) is defined as the ratio of the mass of a given volume of solids to the mass of an equal volume of water at 4°C. Thus, $G = \frac{\rho_s}{\rho_w}$

The specific gravity of solids for most natural soils falls in the general range of 2.65 to 2.80; the smaller values are for the coarse-grained soils.

The pycnometer method can be used for the determination of the specific gravity of coarse and fine aggregates. The specific gravity of solids is determined using the relation:

$$G = \frac{M_2 - M_1}{(M_2 - M_1) - (M_3 - M_4)}$$

where, M_1 = mass of empty pycnometer,

M_2 = mass of pycnometer and dry coarse/fine aggregates,

M_3 = mass of pycnometer, aggregates and water,

M_4 = mass of pycnometer filled with water only

Procedure

1. The pycnometer was first cleaned and dried. Its empty mass (M_1) was taken on a weighing balance.
2. Required quantity of coarse aggregates was filled into the pycnometer and the mass was taken again (M_2).
3. Then, water was filled into a certain level in the pycnometer which then already had the aggregates in it. Its mass was measured again (M_3).
4. The water and aggregates were removed and the pycnometer was cleaned and dried by wiping with cloth.
5. The pycnometer was then filled with water upto the previous level and the mass was taken again (M_4).

Data

M_1 = mass of empty pycnometer = 0.227 kg

M_2 = mass of pycnometer and dry coarse aggregates = 0.443 kg

M_3 = mass of pycnometer, aggregates and water = 0.621 kg

M_4 = mass of pycnometer filled with water only = 0.488 kg

Calculation

$$G = \frac{M_2 - M_1}{(M_2 - M_1) - (M_3 - M_4)}$$

$$G = \frac{0.443 - 0.227}{(0.443 - 0.227) - (0.621 - 0.488)} = 2.60$$

Hence, the specific gravity of the coarse aggregate was determined to be ***2.60***.

4. Specific Gravity of Fine Aggregates

Theory

The specific gravity of solid particles (G) is defined as the ratio of the mass of a given volume of solids to the mass of an equal volume of water at 4°C. Thus, $G = \frac{\rho_s}{\rho_w}$

The specific gravity of solids for most natural soils falls in the general range of 2.65 to 2.80; the smaller values are for the coarse-grained soils.

The pycnometer method can be used for the determination of the specific gravity of coarse and fine aggregates. The specific gravity of solids is determined using the relation:

$$G = \frac{M_2 - M_1}{(M_2 - M_1) - (M_3 - M_4)}$$

where, M1 = mass of empty pycnometer,

M2 = mass of pycnometer and dry coarse/fine aggregates,

M3 = mass of pycnometer, aggregates and water,

M4 = mass of pycnometer filled with water only

Procedure

1. The pycnometer was first cleaned and dried. Its empty mass (M1) was taken on a weighing balance.
2. Required quantity of fine aggregates was filled into the pycnometer and the mass was taken again (M2).
3. Then, water was filled into a certain level in the pycnometer which then already had the aggregates in it. Its mass was measured again (M3).
4. The water and aggregates were removed and the pycnometer was cleaned and dried by wiping with cloth.
5. The pycnometer was then filled with water upto the previous level and the mass was taken again (M4).

Data

M1 = mass of empty pycnometer	= 67.23 grams
M2 = mass of pycnometer and dry fine aggregates	= 153.34 grams
M3 = mass of pycnometer, aggregates and water	= 222.16 grams
M4 = mass of pycnometer filled with water only	= 170.37 grams

Calculation

$$G = \frac{M_2 - M_1}{(M_2 - M_1) - (M_3 - M_4)}$$

$$G = \frac{153.34 - 67.23}{(153.34 - 67.23) - (222.16 - 170.37)} = 2.51$$

Hence, the specific gravity of the fine aggregate was determined to be 2.51.

5. Determination of Unit Weight of Coarse Aggregates

Theory

The volume-weight relationships are in terms of unit weights. The weight of aggregate per unit volume is known as unit weight (or specific weight).

The bulk density or unit weight of an aggregate gives valuable information regarding the shape and grading of the aggregate. For a given specific gravity, the angular aggregates show a lower bulk density. The bulk density of aggregate is measured by filling a container of known volume in a standard manner and weighing it.

Bulk density shows how densely the aggregate is packed when filled in a standard manner. The bulk density depends on the particle size distribution and shape of the particles. One of the early methods of mix design make use of this parameter bulk density in proportioning of concrete mix. The higher the bulk density, the lower is the void content to be filled by sand and cement. The sample which gives the minimum voids or the one which gives maximum bulk density is taken as the right sample of aggregate for making economical mix.

Procedure

For determination of bulk density of coarse aggregates, they were filled in a container and then they were compacted in a standard manner. The weight of the container was measured before and after filling with the coarse aggregates. Its height and inner diameter were measured with a scale.

Data

Mass of Cylinder, M_1 = 3.344 kg

Mass of Cylinder + Sample, M_2 = 19.008 kg

Height of Cylinder, H = 28 cm

Inner diameter of Cylinder, D = 21 cm

Calculation

$$\text{Mass of Sample only, M} = M_2 - M_1 = 19.008 - 3.344 = 15.664 \text{ kg}$$

$$\text{Volume of Cylinder, V} = \frac{\pi D^2 H}{4} = \frac{\pi (0.21)^2 . 0.21}{4} = 9.702 \text{ x } 10^{-2} \text{m}^3$$

$$\text{Hence, Unit weight of coarse aggregates} = \frac{M}{V} = \frac{15.664}{9.702 \text{ x } 10^{-3}} = 1614.51 \frac{\text{kg}}{\text{m}^3}$$

Hence, the unit weight of fine aggregates was found to be 1,614.51 kg/m3.

6. Determination of Unit Weight of Fine Aggregates

Theory

The volume-weight relationships are in terms of unit weights. The weight of aggregate per unit volume is known as unit weight (or specific weight).

The bulk density or unit weight of an aggregate gives valuable information regarding the shape and grading of the aggregate. For a given specific gravity, the angular aggregates show a lower bulk density. The bulk density of aggregate is measured by filling a container of known volume in a standard manner and weighing it.

Bulk density shows how densely the aggregate is packed when filled in a standard manner. The bulk density depends on the particle size distribution and shape of the particles. One of the early methods of mix design make use of this parameter bulk density in proportioning of concrete mix. The higher the bulk density, the lower is the void content to be filled by sand and cement. The sample which gives the minimum voids or the one which gives maximum bulk density is taken as the right sample of aggregate for making economical mix.

Procedure

For determination of bulk density of fine aggregates, they were filled in a container and then they were compacted in a standard manner. The weight of the container was measured before and after filling with the fine aggregates. Its height and inner diameter were measured with a scale.

Data

Mass of Cylinder, M_1 = 1.622 kg

Mass of Cylinder + Sample, M_2 = 6.482 kg

Height of Cylinder, H = 17 cm

Inner diameter of Cylinder, D = 14.8 cm

Calculation

$$\text{Mass of Sample only}, M = M_2 - M_1 = 6.482 - 1.622 = 4.86 \text{ kg}$$

$$\text{Volume of Cylinder}, V = \frac{\pi D^2 H}{4} = \frac{\pi(0.148)^2 . 0.17}{4} = 2.926 \text{ x } 10^{-3} \text{m}^3$$

$$\text{Hence, Unit weight of coarse aggregates} = \frac{M}{V} = \frac{4.86}{2.926 \text{ x } 10^{-3}} = 1660.97 \frac{\text{kg}}{\text{m}^3}$$

Hence, the unit weight of fine aggregates was found to be 1,660.97 kg/m3.

7. Moisture Content Test

Theory

Some of the aggregates are porous and absorptive. Porosity and absorption of aggregate will affect the water/cement ratio and hence the workability of concrete. The porosity of aggregate will also affect the durability of concrete when the concrete is subjected to freezing and thawing and also when the concrete is subjected to chemically aggressive liquids.

The water absorption of aggregate is determined by measuring the increase in weight of an oven dry sample when immersed in water for 24 hours. The ratio of the increase in weight to the weight of the dry sample expressed as percentage is known as absorption of aggregate.

But when we deal with aggregates in concrete, the 24 hours absorption may not be of much significance. On the other hand, the percentage of water absorption during the time interval equal of final set of cement may be of more significance. The aggregate absorbs water in concrete and thus affects the workability and final volume of concrete.

Procedure

Drying method is fairly simple method of determining moisture content in aggregates. Drying was carried out in an oven and the loss in weight before and after drying gave the moisture content of the aggregates.

The aggregate was kept in a can. The weight of the can was measured before and after filling with the aggregates. The final weight of the samples after drying in the oven for 24 hours was measured. It was made sure that after 24 hours, the sample was not full in can.

Data

FOR COARSE AGGREGATES:

Weight of can, W_1 = 10 grams

Weight of can + sample, W_2 = 83 grams

Weight of sample after drying, W_3 = 82 grams

FOR FINE AGGREGATES:

Weight of can, W_1 = 10 grams

Weight of can + sample, W_2 = 72 grams

Weight of sample after drying, W_3 = 71 grams

Calculation

Hence, moisture content of coarse aggregates $= \frac{83-82}{82-10} = 0.01389 = 1.389\ \%$

$$\text{moisture content of fine aggregates} = \frac{72-71}{72-10} = 0.0161 = 1.61\ \%$$

Practical – II

MIX DESIGN OF CONCRETE BY BRITISH MIX METHOD

Theory

Mix Design can be defined as the process of selecting suitable ingredients of concrete and determining their relative proportions with the object of producing concrete of certain minimum strength and durability as economically as possible. The purpose of designing, as can be seen from the above definition, is two-fold. The first object is to achieve the stipulated minimum strength and durability. The second object is to make the concrete in the most economical manner.

With the given materials, the four variable factors to be considered in connection with specifying a concrete mix are:

- Water-Cement ratio
- Cement content or cement-aggregate ratio
- Gradation of the aggregates
- Consistency

Water/Cement ratio expresses the dilution of the paste – cement content varies directly with the amount of paste. Gradation of aggregates is controlled by varying the amount of given fine and coarse aggregate. Consistency is established by practical requirements of placing.

DOE or British Method of Concrete Mix Design

The DOE Method was first published in 1975 and then revised in 1988. The DOE Method is applicable to concrete for most purposes, including roads, and replaces the traditional method of Road Research Laboratory, Road Note No. 4.

The DOE Method outlines a procedure for design of normal concrete mixes having 28-day cube compressive strength as high as 75 MPa for non-air-entrained concrete. It does not consider the use of combined aggregate grading curves, aggregate cement ratio and type of aggregate (rounded, angular or irregular) as was the case with the RRL Method.

Steps:

1. Find the target mean strength from the specified characteristic strength.
2. Target Mean Strength (f_t) = Characteristic Strength (f_{ck}) + k.s

   K = probability factor = 1.65 unless stated otherwise

   S = standard deviation

3. Calculate the water/cement ratio based on target strength. Use 28-day strength value unless stated otherwise.
4. Decide water content for the required workability, expressed in terms of slump or Vebe time, taking into consideration the maximum size of aggregates and their type.
5. Determine the water content based on durability consideration. Determine the cement content from the two w/c ratios obtained from steps (3) and (4). Find the minimum cement content. Use the highest value.

6. Find the relative density of combined aggregates and hence determine the wet density of fresh concrete mix. Hence, calculate the weight of aggregates required.

   Weight of aggregates = Wet Density of Concrete – Weight of Water – Weight of Cement

7. Proportion of the fine aggregate is determined by first determining the zone of fine aggregates. The zone is determined by knowing the percentage of fine aggregates passing through IS 600 micron sieve.

   Zone I - 15 – 34 %

   Zone II - 35 – 59 %

   Zone III - 60 – 79 %

   Zone IV - 80 – 100 %

8. Finally, determine the separate weights of fine and coarse aggregates.
9. The mix proportion is calculated.

The mix proportions are presented in terms of quantities of materials per unit volume of concrete.

Calculation

1. Target strength

$$f_t = f_{ck} + k.s = 20 + 1.65 \text{ x } 4 = 26.6 \frac{N}{mm^2}$$

2. Minimum water/cement ratio based on target strength

   From graph of water/cement ratio vs. 28-day cube compressive strength,

   W/C = 0.644

3. Approximate water content

   For,

   Maximum size of aggregates = 20 mm

   Type of aggregate = crushed

   Slump = 30 to 60 mm

   From table,

   Approximate water required = 210 kg for 1 m^3 concrete

   Hence, Cement required = 210/0.644 = 326.1 kg for 1 m^3 concrete

4. w/c based on durability consideration

   Maximum free w/c ratio for M20 concrete, mild exposure and RCC Walls:

   From table,

   Maximum free w/c = 0.55

Hence, weight of cement = 210/0.55 = 382 kg for 1 m^3 concrete

Also, from table,

Minimum cement content, kg/m^3 = 300 kg

Hence, final weight of cement to be taken = 382 kg (the maximum value)

5. Relative density of Combined Aggregates

$$\frac{G_{ca} + G_{fa}}{2} = 2.60$$

Hence, wet density of fresh concrete mix from graph = 2355 kg/m^3

Weight of aggregates required = 2355 – 210 – 382 = 1763 kg

6. For Sand

The sand lies in second zone.

From figure,

For maximum size of aggregates = 20 mm

% of fine aggregates = (42 + 32)/2 = 37% of fine aggregates

Hence, weight of fine aggregates = 37 % of 1763 = 652 kg for 1 m^3 concrete

Weight of coarse aggregates = 1763 – 652 = 1111 kg for 1 m^3 concrete

MIX PROPORTION:

CEMENT	SAND	GRAVEL	WATER	for 1 m^3 concrete
382	652	1111	210	
1	1.71	2.91	0.55	

1 : 1.71 : 2.91 @ 0.55

Volume Calculation:

1. 6 cubes each of dimensions 100 mm x 100 mm x 100 mm.
2. 2 cylinders each of dimensions 100 mm ϕ x 200 mm.
3. 1 prism of dimensions 75 mm x 75 mm x 300 mm.
4. Consideration for wastage – 25%

Hence, total volume = 0.0135 m^3

Hence, weight of concrete = 0.0135*2355 = 31.79 kg

Weight of cement = 5.15 kg

Weight of sand = 8.81 kg

Weight of gravel = 14.99 kg

Weight of water = 2.83 kg

Total weight = 31.78 kg ≈ 31.79 kg (total weight of concrete)

Compressive Strength Test:

7-day Cube Compressive Strength Test:

Cube No.	Mass of cube (kg)	Weight applied before failure (kN)	Compressive Strength (MPa)
1.	2.348	168	16.8
2.	2.408	142	14.2
3.	2.455	152	15.2

28-day Cube Compressive Strength Test:

Cube No.	Mass of cube (kg)	Weight applied before failure (kN)	Compressive Strength (MPa)
4.	2.391	268	26.8
5.	2.521	255	25.5
6.	2.490	225	22.4

Result and conclusion:

Hence the concrete of characteristic strength of M20 under given condition was designed by DOE mix design. The ratio of cement, sand, CA and water was found to be 1 : 1.71 : 2.91 @ 0.55 using which the sample of fresh concrete was prepared.

Practical – III

MIX DESIGN OF CONCRETE BY ACI METHOD

Theory

ACI method is the American method of mix design proposed by American Concrete Institute. This method is based on the fact that for a given size of well shaped aggregate, the water content determines the workability of mix. This means the method is largely independent of mix proportions. Fresh concrete of given slump and containing a well graded aggregate of given maximum size will have a practically constant total water content which are nearest interrelated. This method has gained popularity since it takes into consideration the requirement for workability, consistency, strength and durability.

This method also assumes optimum dry rodded volume of coarse aggregate per unit volume of concrete depend on its max size and fineness modulus of fine aggregate, regardless of the shape of particle.

In a nutshell:

- This method was suggested by ACI committee no. 211.
- This method takes into consideration the requirements for workability, consistency, strength and durability.
- Uses dry rodded density of coarse aggregates.
- Uses fineness modulus of fine aggregates.
- One method is based on the estimated weight of concrete per unit volume whereas the other is based on calculation of the absolute volume occupied by concrete ingredients.

Steps:

- Determination of free water cement ratio:
  For specified target characteristic strength the target mean strength is determined as:

  Target mean strength (f_{mean}) = specified characteristic strength + risk factor*std. deviation

  Then, from target mean strength and specified age of the concrete, the w/c ratio is calculated using provided diagram. The w/c ratio thus obtained is then compared with maximum w/c ratio specified depending upon the exposure condition and lower value is adopted.

- Determination of water content:
  From the table depending upon max size of coarse aggregate, slump required and non air entrained condition, the water content is determined

- Determination of cement content:

  Cement content= water content/ w/c ratio

  The minimum w/c ratio is either obtained from curve: strength- w/c ratio of from durability consideration.

  The value obtained is compared with the minimum cement content specified for durability consideration. If the computed cement is less than the optimum value in the table then the cement content from the table is taken.

It the cement content calculated is higher than the specified maximum, the specified strength and workability cannot be simultaneously met with the selected materials. So, we should retry by changing cement type and type of aggregate.

- Determination of coarse aggregate:
  From table, bulk volume of dry rodded coarse aggregate per unit volume of concrete is determined depending upon the maximum size of aggregate and fineness modulus of fine aggregate. Then the mass of coarse aggregate is calculated using formula:

  Mass of coarse aggregate per m³ of concrete= dry rodded unit weight of aggregate * volume

- Determination of amount of fine aggregate:
  After above step, all ingredients except fine aggregate have been estimated. If the weight of concrete per unit volume is assumed, the weight of fine aggregate is simply the difference between the weight of fresh concrete and the total weight of all other ingredients. An estimate of fresh concrete can be made either by using:

1. $W_c = 10\rho_a(100\text{-}A)+c(1\text{-}\rho_a/\rho_c)\text{-}W(\rho_a\text{-}1)$
   Where,

   W_c = weight of fresh concrete kg/m³

   ρ_a = weighted average specific gravity of combined fine and coarse aggregate

   ρ_c = specific gravity of cement

   C= cement requirement kg/m³

   W= mixing water requirement, kg/m³

   A=air content, percent

2. Absolute volume occupied by concrete ingredients, required volume of fine aggregate is obtained from the equation:
   Vol. of fine aggregates = 1- Vol of all ingredients

Calculation

1. Target strength

$$f_t = f_{ck} + k.s = 20 + 1.65 \text{ x } 4 = 26.6 \frac{N}{mm^2}$$

2. Approximate water content (kg/m^3)

   For slump = 30 – 60 mm, nominal size of aggregates = 20 mm

   (From Table 6)

Water required for 1 m^3 concrete = 179 kg

(Adopted for slump = 25 – 50 mm, size of aggregates = 19 mm for non air-entrained concrete)

3. Minimum w/c ratio based on target strength and durability requirements

Based on target strength, w/c ratio = 0.644

Hence, weight of cement required = 179/0.644 = 277.95 ≈ 278 kg/m^3

Due to durability considerations,

w/c ratio = 0.55

Hence, cement content = 300 kg/m^3

Hence, final cement quantity = 326 kg for 1 m^3 concrete

4. Relative density of combined aggregates

= 2.60

5. To find amount of coarse aggregates

For fineness modulus = 3.1 (generally < 3) from sieve analysis

And maximum size of coarse aggregates = 20 mm

Weight of coarse aggregates = 0.60 x dry rodded density

(Adopted for max. size of coarse aggregates = 19 mm and F.M. = 3.0)

= 0.60 x 1600 = 960 kg for 1 m^3 concrete

6. Wet density of fresh concrete

For max. Size 20 mm,

Wet density of concrete = 2355 kg/m^3

Hence, weight of fine aggregates = 2355 – 960 – 179 – 326 = 890 kg/m^3

MIX PROPORTION:

CEMENT	SAND	GRAVEL	WATER	for 1 m^3 concrete
326	890	960	179	
1	2.73	2.95	0.55	

1 : 2.73 : 2.95 @ 0.55

Volume Calculation:

1. 6 cubes each of dimensions 100 mm x 100 mm x 100 mm.
2. 2 cylinders each of dimensions 100 mm ϕ x 200 mm.
3. 1 prism of dimensions 75 mm x 75 mm x 300 mm.
4. Consideration for wastage – 25%

Hence, total volume = 0.0135 m^3

Hence, weight of concrete	= 0.0135*2355 = 31.79 kg
Weight of cement	= 4.40 kg
Weight of sand	= 12.00 kg
Weight of gravel	= 12.97 kg
Weight of water	= 2.42 kg
Total weight	= 31.79 kg (total weight of concrete)

Result and Conclusion

Hence the mix proportion was designed by the ACI Method for characteristics strength of 20 MPa. The ratio of cement, sand, coarse aggregate and water was found to be 1 : 2.73 : 2.95 @ 0.55. Using these proportions of ingredients, 31.79 kg of the concrete was prepared and casted on desired shape and tested for strength on 28 days.

Practical – IV

MIX DESIGN OF CONCRETE BY IS METHOD

Theory

IS method is the method of mix designing proposed by 'The National Council of Cement and Building Materials (NCCMB), New Delhi, India. The design method is based on the extensive test on Indian materials and cements. This method is applicable to design of normal concrete mixes (non-air –entrapped) for different grade of cements based on their 28-days strength.

Steps:

1. Determine target strength based on 28-day characteristic strength (same as for previous two methods of mix design).
2. Determine the minimum water cement ratio based on target strength and check for durability condition.
3. Determine the amount of entrapped air for the maximum size of aggregates.
4. The water content and percentage of sand in total aggregates are selected based on water cement ratio, workability and maximum size of aggregates.
5. Make the adjustment in water content and percentage of fine aggregates for other conditions.
6. Determine the cement content from water cement ratio and final water content after adjustment.
7. Determine the quantity of coarse and fine aggregates from these equations:

$$V = \left[W_w + \frac{W_c}{\rho_c} + \frac{1}{p}.\frac{W_s}{\rho_s}\right] * \frac{1}{1000}$$

$$V = \left[W_w + \frac{W_c}{\rho_c} + \frac{1}{1-p}.\frac{W_{CA}}{\rho_{CA}}\right] * \frac{1}{1000}$$

Where, V = net volume of fresh concrete
ρ_c = specific gravity of cement
ρ_s = specific gravity of sand
ρ_{CA} = specific gravity of coarse aggregates
W_c = weight of cement
W_{CA} = weight of coarse aggregates
W_s = weight of sand
W_w = weight of water
p = ratio of fine aggregates to total aggregates

8. Obtain the amount of water to be added after making correction for water absorption by aggregate and free moisture content.
9. Find the required proportions of all constituents or ingredients.

Calculation:

1. Target strength (f_{mean}) = 20+1.65×4=26.6 MPa.
2. Maximum amount of water required in the mix = 186 kg/m^3. (For strength of concrete upto M35; maximum size of coarse aggregates = 20 mm)
3. Minimum water cement ratio = 0.555 (for Hetaunda 53 Grade OPC Cement)
4. Amount of air entrapped for 20 mm size of aggregates = 2%. Also, amount of sand = 35% of total aggregates
5. Adjustments:

S.N.	Parameters	Adjustment required in	
		Water Content (%)	**% of sand in total**
1.	Decrease in w/c from 0.6 to 0.555	0	- 0.9%
2.	Decrease in compaction factor by 0.1	+3 %	0
3.	For sand conforming to zone III of IS 383-170	0	- 1.5%
4.	For crushed aggregate	0	0
	Total Adjustment:	+3 %	- 2.4 %

Percentage of sand in total aggregate = 35 – 2.4 = 32.6 %
Water required = 186 + 3% of 186 = 191.60 litres

6. Cement content = 191.60 / 0.555 = 345.23 kg/m^3
7. Absolute volume of fresh concrete = 1 - 0.02 = 0.98 m^2
   W_s = 495.475 kg/m^3
   W_{CA} = 1257.855 kg/m^3
8. Correction for moisture content:
   a. Fine – 0.0036*495 = 1.79 litres
   b. Coarse – 0.0026*12.57 = 3.27 litres

Actual Quantity:
Water = 191.60 – 1.79 – 3.27 = 186.54 litres
Sand = 495.475 – 1.79 = 493.685 kg
CA = 1257.855 – 3.12 = 1254.735 kg

The ratio is: 1 : 1.43 : 3.63 : 0.54

Weights taken:

Cement	= 7.95 kg
Sand	= 11.4 kg
Gravel	= 28.875 kg
Water	= 4.29 kg

Compacting Factor Test:

Weight of mould + concrete for partially compacted concrete (W_1) = 22.246 kg

Weight of mould + concrete for fully compacted concrete (W_2) = 24.516 kg

Hence, compacting factor = 22.246/24.516 = 0.9074

Result and Conclusion:

Hence the mix proportion was designed by the IS Method for characteristics strength of 20 MPa. The ratio of cement, sand, coarse aggregate and water was found to be 1 : 1.43 : 3.63 : 0.54.