DESIGN OF CONCRETE STRUCTURE

LABORATORY MANUAL

DEPARTMENT OF CIVIL ENGINEERING
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CONTENTS

EXPERIMENT NO.1

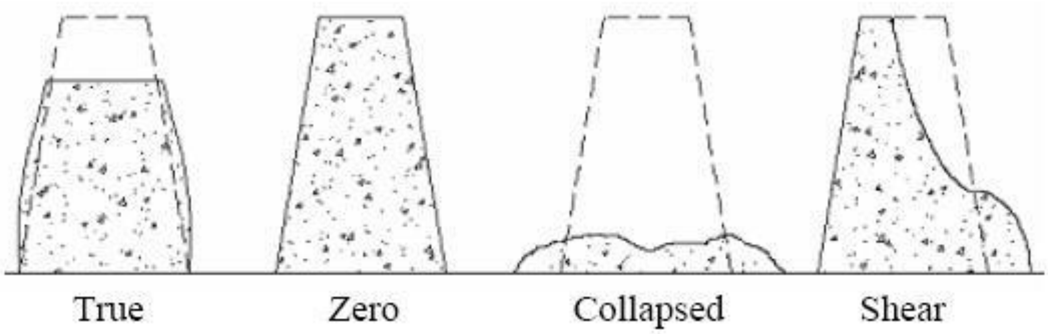
AIM OF THE EXPERIMENT: To determine the workability of fresh concrete by slump test.

THEORY:

Unsupported Concrete, when it is fresh, will flow to the sides and a sinking in height will take place. This vertical settlement is known as slump. Slump test is the most commonly used method of measuring workability of concrete which can be employed either in laboratory or at site of work. It is not a suitable method for very wet or very dry concrete. It does not measure all factors contributing to workability, nor it is always representative of the placeability of the concrete.

Slump is a measure indicating the workability of cement concrete. It gives an idea of water content needed for concrete to be used for different works. A concrete is said to be workable if it can be easily mixed, transported, placed, compacted and finished without segregation and bleeding. Segregation is said to occur when coarse aggregate tries to separate out from the finer material and we get concentration of coarse aggregate at one place. This results in large voids, less durability and less strength. Bleeding of concrete is said to occur when excess water comes up at the surface of concrete. This causes small pores through the mass of concrete and is undesirable. The factors on which workability of concrete depends upon are : (a) Water Content (b) Mix Proportions (c) Size of Aggregates (d) Shape of Aggregates (e) Surface Texture of Aggregate (f) Grading of Aggregate (g) Use of Admixtures.

Types of slumps:

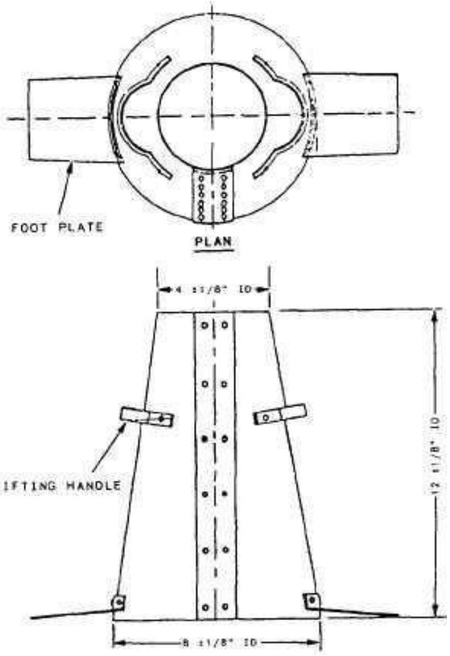


1. True Slump: In a true slump the concrete simply subsides, keeping more or less to shape. True slump is the only slump that can be measured in the test. The measurement is taken between the top of the cone and the top of the concrete after the cone has been removed.
2. Zero Slump: In Zero slump, concrete does not subside at all. This is the indication of very low water-cement ratio, which results in dry mixes. This type of concrete is generally used for road construction.
3. Collapsed Slump: This is an indication that the water-cement ratio is too high, i.e. concrete mix is too wet or it is a high workability mix, for which a slump test is not appropriate.
4. Shear Slump: In shear slump, the top portion of the concrete shears off and slips sideways. This indicates that the concrete mix is not appropriate, result is incomplete, and concrete is to be mixed and tested again.

APPARATUS REQUIRED:

1- Weights and weighing device.

2- Tools and containers for mixing, or concrete mixer
3- Tamper (16 mm in diameter and 600 mm length)
4- Ruler
5- Slump cone which has the shape of a frustum of a cone with the following dimensions: Base dia 20 cm, Top dia 10 cm, Height 30 cm and thickness of the metal is 1.6 mm.



SLUMP CONE APPARATUS

MATERIALS REQUIRED:

i) Cement
ii) Coarse aggregate
iii) Fine aggregate (sand)
iv) water

PROCEDURE:

i) The internal surface of the mould is thoroughly cleaned and applied with a light coat of oil.

ii) The mould is placed on a smooth, horizontal, rigid and non-absorbent surface.

iii) The mould is then filled in four layers with freshly mixed concrete, each approximately to one-fourth of the height of the mould.

iv) Each layer is tamped 25 times by the rounded end of the tamping rod (strokes are distributed evenly over the cross-section).

v) After the top layer is rodded, the concrete is struck off the level with a trowel.

vi) The mould is removed from the concrete immediately by raising it slowly in the vertical direction.

vii) The difference in level between the height of the mould and that of the highest point of the subsided concrete is measured.

viii) This difference in height in mm is the slump of the concrete.

OBSERVATIONS AND CALCULATIONS:

Slump= Height of the mould- highest point of the specimen being tested

Sl.No.	W/CRatio	Slump(mm)

RESULTS: The slump value of concrete is ______________

CONCLUSION: (Comment on the result by comparing with the standard values)

The concrete mix is suitable /unsuitable for ______________

DISCUSSION:

Sl No.	Placing Condition	Degree of workability	Slump (mm)
1	Shallow section, Blinding concrete, Pavement quality concrete using pavers	Very low	Not applicable (Compacting Factor)
2	Mass connecting, lightly reinforced such as in slabs, beams, walls, columns and floors. Hand placed pavements, Canal lining, Strip footing	Low	25-75
3	Heavily reinforced sections in slabs, beams, walls, columns	Low- Medium	50-75
4	Slip form work, pumped concrete	Medium	75-100
5	Trench fill: in situ piling	High	100-150
6	Tremie concrete	Very high	Not applicable (Flow value)

Signature

EXPERIMENT NO. 2

AIM OF THE EXPERIMENT: To determine the workability of fresh concrete by compacting factor test.

THEORY: The compacting factor test (CFT) is designed primarily for use in the laboratory but it can also be used in the field. It is more precise and sensitive than the slump test and is particularly useful for dry concrete mixes having very low workability which is defined as the ease of homogeneity with which it can be easily mixed, transported, placed, compacted and finished without segregation and bleeding. This test is normally used when concrete is to be compacted by vibration. The method applies to plain and air-entrained concrete, made with lightweight, normal weight or heavy aggregates having a nominal maximum size of 38 mm or less. This test is not applicable to the testing of aerated concrete and no-fines concrete.

Compacting factor method uses an inverse approach by determining the degree of compaction achieved by a standard amount of work by allowing the concrete to fall through a standard height rather than measuring the amount of work necessary to achieve full compaction.
The relationship between the degree of workability and compaction factor are :

Degree of workability	Very Low	Low	Medium	High
Compaction Factor	0.75-0.80	0.80-0.85	0.85-0.92	> 0.92

APPARATUS REQUIRED:

i) Compacting factor apparatus, which consists of a holder fixing two conical hoppers and a cylinder at the base.
ii) Trowels, Graduated cylinder of 100ml capacity, electronic weighing balance and tamping rod.
iii) Tools and containers for carrying and mixing the materials.

COMPACTIN FACTOR APPARATUS

MATERIALS REQUIRED:

i) Cement
ii) Coarse aggregate
iii) Fine aggregate (sand)
iv) water

PROCEDURE:

i) Prepare a concrete mix for testing workability. Consider a W/C ratio of 0.5 to 0.6 and design mix of proportion about 1:2:4 (it is presumed that a mix is designed already for the test). Weigh the quantity of cement, sand, aggregate and water correctly. Mix thoroughly. Use this freshly prepared concrete for the test.
ii) Place the concrete into the upper hopper up to its brim.
iii) Open the trapdoor of the upper hopper. The concrete will fall into the lower hopper.
iv) Open the trapdoor of the lower hopper, so that concrete falls into the cylinder below.
v) Remove the excess concrete above the level of the top of the cylinder; clean the outside of the cylinder.
vi) Weigh the concrete in the cylinder. This weight of concrete is the "weight of partially compacted concrete", (W1).
vii) Empty the cylinder and refill with concrete in layers, compacting each layer well (or the same may be vibrated for full compaction). Top surface may be struck off level.
viii) Find cut weight of the concrete in the fully compacted state. This weight is the “Weight of fully compacted concrete" (W2).

OBSERVATIONS AND CALCULTIONS:

Weight of partially compacted concrete (W1): __________ Kg
• Weight of fully compacted concrete (W2): __________ Kg
• Compaction factor (F) = $W1/W2$: __________.

RESULTS: The compaction factor of the given sample of concrete is ____________________

CONCLUSION:

Signature

EXPERIMENT NO. 3

AIM OF THE EXPERIMENT:

To determine the workability of fresh concrete by flow table test.

THEORY:

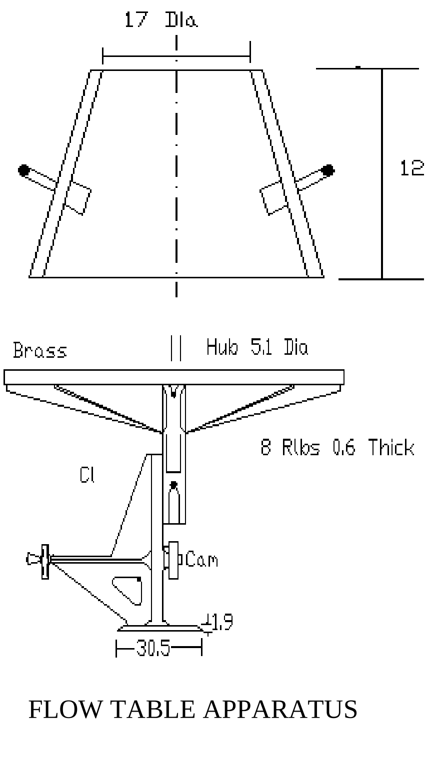
The flow table test measures the horizontal spread of a concrete cone specimen after being subjected to jolting. The test is applicable to a wide range of concrete workability, and is especially appropriate for highly fluid mixes that exhibit a collapsed slump. The results of the test can be correlated to slump, although it has been suggested that the initial horizontal spread, prior to jolting, correlates better to slump. Despite its simplicity, the test apparatus is large and must be placed on firm, level ground. The jolting of the concrete does not accurately simulate field practices and cannot easily be treated analytically.

APPRATUS REQIURED:

i) **Mould:** The mould shall made of a smooth metal casting in the form of the frustum of a cone with the following internal dimensions. A base 250mm in diameter, upper surface 170mm in diameter and height 120mm, the base and the top shall be open and at right angles to the axis of the cone. That shall be provided with handles.

ii) **Flow table:** Flow table shall conform to the design as shown in fig. And shall be mounted on and bolted to a concrete base having a height of 400 to 500mm and weighing not less than 140 kg.

iii) A tamping bar, Tools and containers for mixing and weighing device



FLOW TABLE APPARATUS

PROCEDURE:

The apparatus consists of flow table about 76cm. in diameter over which concentric circles are marked. A mould made from smooth metal casing in the form of a frustum of a cone is used with the following internal dimensions. The base is 25cm. in diameter upper surface 17cm. in diameter and height of the cone is 12cm.

1. The table top is cleaned of all gritty material and is wetted. The mould is kept on the center of the table, firmly held and is filled in two layers.
2. Each layer is rodded 25 times with a tamping rod 1.6cm in diameter and 61cm long rounded at the lower tamping end.
3. After the top layer is rodded evenly the excess of concrete which has overflowed the mould is removed.
4. The mould if lifted vertically upward and the concrete stands on its own without support. The table is then raised and dropped 12.5cm 15times in about 15 seconds.
5. The diameter of the spread concrete is measured in about 6 directions to the nearest 5mm and the average spread is noted. The flow of concrete is the percentage increase in the average diameter of the spread concrete over the base diameter of the mould.
6. The value could range anything from 0 to 150 per cent. A close look at the pattern of spread of concrete can also give a good indication of the characteristics of concrete such as tendency for segregation.

OBSERVATIONS AND CALCULATIONS:

The flow of the concrete shall be recorded as the percentage increase in diameter of the spread concrete over the base diameter of the moulded concrete, calculated from the following formula:

Flow (percent) = ((spread diameter in mm – 25)/25) * 100

RESULT:

Flow (percent) of the concrete is =

CONCLUSION:

Signature

EXPERIMENT NO. 4

AIM OF THE EXPERIMENT: To determine the compressive strength of cube concrete specimens.

THEORY:

One of the important properties of concrete is its strength in compression. The strength in compression has a definite relationship with all other properties of concrete i.e. these properties improved with the improvement in compressive strength. Thus, with this single test one judge that whether Concreting has been done properly or not. In India cubical moulds of size 15 cm × 15cm × 15 cm are commonly used.

The concrete is prepared with definite proportion is poured in the mould and tempered properly so as not to have any voids. After 24 hours these moulds are removed and test specimens are put in water for curing. The top surface of this specimen should be made even and smooth. This is done by putting cement paste and spreading smoothly on whole area of specimen. These specimens are tested by compression testing machine after 3, 7 or 28 days curing. Load should be applied gradually at the rate of 14 N/mm 2 per minute till the Specimens fails. Load at the failure divided by area of specimen gives the compressive strength of concrete. At least three specimens are tested at each selected age. The failure of the specimen is called as 'hour glass' type failure. This happens due to lateral restraint provided by the plates to the cubes.

Practically, the compression testing system develops a complex system of stresses due to end restraints provided by steel plates of compression testing machine (CTM). Under compression loading, due to "poisons effect", the cube specimen also undergoes lateral expansion. However, the steel plates don't undergo lateral expansion to the same extent that of concrete. Thus, there exist a differential tendency of lateral expansion between steel plates and concrete cube faces. As a result of this, tangential forces are induced between the end surfaces of the concrete specimen and the adjacent steel plates of CTM. Therefore, in addition to the applied compressive stress; lateral shearing stresses are also effective in these specimens. Effect of this shear decreases to words the centre of the cube. Thus, the cube has near vertical crack at cubes centre and sometimes, the cube may completely disintegrate leaving a relatively undamaged central core.

APPARATUS REQUIRED:

i) Cue moulds 150mm size, weighing machine, mixer, tamping rods
ii) Compressive testing machine.

PROCEDURE:

1. Calculate the material required for preparing the concrete of given proportions
2. Mix them thoroughly in mechanical mixer until uniform colour of concrete is obtained.
3. Pour concrete in the lightly greased cube moulds.
4. Fill concrete in two layers each of approximately 75 mm and ramming each layer with 35 blows evenly distributed over the surface of layer.
5. Struck off concrete flush with the top of the moulds.
6. Level the concrete at the top of the mould by means of trowel and give proper identification mark of the specimen.
7. Immediately after being made, they should be covered with wet mats.
8. Specimens are removed from the moulds after 24hrs and cured in water. Keep it for curing up to 28 days.

Testing of concrete cubes:

9. Take the cube out of water at the end of three days with dry cloth. Measure the dimensions of the surface in which the load is to be applied. Let be 'L' and 'B' respectively.
10. Place the cube in compressive testing machine and apply the load uniformly at the rate of 35N/mm^2.

11. Note the load at which the cube fails. Let it be ‘P’. Also note the type of failure and appearance of cracks
12. Calculate the compressive strength of the cube by using formula P/A. Where A is the area of loaded surface (i.e. L×B).
13. Repeat the same procedure (steps 9 to 12) for other two cubes.
14. Repeat the whole procedure (Step 9 to 13) to find the compressive strength of the cube at the end of 7 days and 28 days.

OBSERVATIONS AND CALCULATIONS:

(a) For 3 days strength:

Sl. No.	Length (in mm)	Breadth (in mm)	Load (in N)	compressive strength (in N/mm^2)	Remark

Average =

(b) For 7 days strength:

Sl. No.	Length (in mm)	Breadth (in mm)	Load (in N)	compressive strength (in N/mm^2)	Remark

Average =

(c) For 28 days strength:

Sl. No.	Length (in mm)	Breadth (in mm)	Load (in N)	compressive strength (in N/mm^2)	Remark

Average =

RESULTS:

The compressive strength of cement ate the end of

i) 3 days : ____________. N/mm^2

ii) 7 days : ____________. N/ mm^2

iii) 28 days : ____________. N/ mm^2

Signature

EXPERIMENT NO. 5

AIM OF THE EXPERIMENT:

To determine the splitting tensile strength of cylindrical concrete specimens.

THEORY:

Splitting tensile strength is generally greater than the direct tensile strength and lower than the flexural strength (modulus of rupture). Splitting tensile strength is used in the design of structural light weight concrete members to evaluate the shear resistance provided by concrete and to determine the development length of the reinforcement.

This test method consists of applying a diametrical force along the length of a cylindrical concrete at a rate that is within a prescribed range until failure. This loading induces tensile stresses on the plane containing the applied load and relatively high compressive stresses in the area immediately around the applied load. Although we are applying a compressive load but due to Poisson’s effect, tension is produced and the specimen fails in tension. Tensile failure occurs rather than compressive failure because the areas of load application are in a state of triaxial compression, thereby allowing them to withstand much higher compressive stresses than would be indicated by a uniaxial compressive strength test result. Thin, bearing strips are used to distribute the load applied along the length of the cylinder. The maximum load sustained by the specimen is divided by appropriate geometrical factors to obtain the splitting tensile strength.

Concrete Cylinder Specimen

APPARATUS REQUIRED:

1. Weights and weighing device.
2. Tools, containers and pans for carrying materials & mixing.
3. A circular cross-sectional rod (φl6mm & 600mm length).
4. Testing machine.
5. Three cylinders (150mm diameter & 300mm in height).

6- A jig for aligning concrete cylinder and bearing strips.

PROCEDURE:

1. Prepare three cylindrical concrete specimens following same steps as test No.3
2. After moulding and curing the specimens for seven days in water, they can be tested.
3. Two bearings strips of nominal (1/8 in i.e 3.175mm) thick plywood, free of imperfections, approximately (25mm) wide, and of length equal to or slightly longer than that of the specimen should be provided for each specimen.
4. The bearing strips are placed between the specimen and both upper and lower bearing blocks of the testing machine or between the specimen and the supplemental bars or plates.
5. Draw diametric lines on each end of the specimen using a suitable device that will ensure that they are in the same axial plane. Centre one of the plywood strips along the centre of the lower bearing block.
6. Place the specimen on the plywood strip and align so that the lines marked on the ends of the specimen are vertical and centered over the plywood strip.
7. Place a second plywood strip lengthwise on the cylinder, centered on the lines marked on the ends of the cylinder.
8. Apply the load continuously and without shock, at a constant rate within the range of 689 to 1380 kPa/min splitting tensile stress until failure of the specimen.
9. Record the maximum applied load indicated by the testing machine at failure. Note the type of failure and appearance of fracture.

OSERVATIONS AND CALCULATIONS:

- Length of Specimen (L) : _______ mm
- Diameter of the specimen (d) : _______ mm

Sl. No.	**Age of specimen**	**Maximum load (P) in N**	**Spitting tensile strength in MPa (T=2P/πLd)**	**Average spitting tensile strength (MPa)**
	7 Days			
	28 Days			

RESULT:

- The average 7 days tensile strength of concrete sample is : _______ MPa
- The average 28 days tensile strength of concrete sample is : _______ MPa

Signature

EXPERIMENT NO. 6

AIM OF THE EXPERIMENT: To determine the compressive strength of cylindrical concrete specimens.

THEORY:

One of the important properties of concrete is its strength in compression. The strength in compression has a definite relationship with all other properties of concrete i.e. these properties improved with the improvement in compressive strength. Thus, with this single test one judge that whether Concreting has been done properly or not. The compressive strength of concrete cylinders is determined by applying continuous load over the cylinder until failure occurs. The test is conducted on a compression-testing machine.

The cylinder specimens are cast in steel, cast iron or any mold made of non-absorbent material. Even under severe conditions, the moulds used must retain its original shape and dimensions. The mold must hold the concrete without any leakage. Before placing the concrete mix within the mold, the interior of the mold must be properly greased to facilitate easy removal of the hardened cylinder.

The mixed concrete is placed into the molds in layers not less than 5cm deep. The strokes per layer during the compaction must not be less than 30 in number. Compaction must reach the underlying layers allowing the majority of the air voids to escape. The specimens are stored undisturbed in a place with at least 90% relative humidity at a temperature of 27° ± 2°C for 24 hours. After this period, the samples are taken and submerged in clean and fresh water until the testing age is reached.

APPARATUS REQUIRED:

1- Weighing device.
2- Tools and containers and pans for mixing, or mixer.
3- A tamper (circular in cross-section) (16 mm in diameter and 600 mm in length).
4- Compressive testing machine.
5-Three cylinders (150mm in diameter and 300mm in height).

Procedure:

1- Prepare a concrete mix as mentioned in with the proportions suggested Such as: 1: 2: 4 with w/c = 55% by mechanical mixer.
2- The cylinder also must be clean, lightly oiled, well fixed with the base.
3- Filling the specimens will be also in three layers, rodding each layer by (25) strokes using the circular section rod.
4- Trowel off surplus concrete from the top of moulds.
5- Mark the specimens by a slip of paper on which is written the date and the Specimen identification. Leave the specimens in the curing room for 24 hours.
6- After that open the moulds and immerse the concrete cubes in a water basin for 7 days.
7- Before testing, ensure that all testing machine bearing surfaces are wiped clean.
8- Carefully center the cylinder on the lower platen and ensure that the load will be applied to two opposite cast faces of the cube.
9- Then the load is applied continuously, uniformly and without shock. The rate of loading should be 250KN/minute for cylinder. The load is increased till the specimen fails. Record the maximum load taken by each specimen during test. Also note the failure and appearance of cracks.

OBSERVATIONS AND CALCULATIONS:

Specimen no.	1	2	3	Average load
Load in Newtons on cylinder				

Cylinder strength = $\dfrac{\text{Average load}}{\text{Area of cross section of cylinder specimen}}$ = ---------- N/mm^2

RESULTS:

The average compressive strength of cylinder = ---------N/mm^2

Signature

EXPERIMENT NO. 7

AIM OF THE EXPERIMENT: To determine the quantities of aggregate and water for a concrete mix in accordance with Indian standard recommended guide lines (Using IS 10262:2009)

THEORY: Design of concrete mixes involves determination of the proportions of the given constituents, namely, cement, fine aggregates, coarse aggregates, water and admixture, if any, which would produce concrete possessing specified proportions both in fresh and hardened states with the maximum overall economy. Workability is specified as the important property of concrete in the fresh state and for hardened state compressive strength and durability are important. The mix design is generally carried out for a particular compressive strength of concrete with adequate workability so that fresh concrete can be properly placed and compacted to achieve the required durability.
The proportioning of concrete mixes is accomplished by the use of certain relationships established from experimental data which afford reasonably accurate guide to select the best combination of ingredients so as to achieve the desirable properties.

APPARATUS REQUIRED:

i) Weighing balance
ii) Measuring cylinder
iii) Trowels
iv) Moulds
v) Tamping rod
vi) Vibration table
vii) Universal testing machine

Data Required for Mix Design of Concrete:

i) Concrete Mix Design Date:

(a) Characteristic compressive strength of concrete required at end of 28 days = M 20

(b) Nominal maximum size of aggregate used = 20 mm

(c) Shape of Coarse Aggregate = Angular

(d) Required workability at site = 50-75 mm (slump Value)

(e) Quality control is done by as per IS: 456

(f) Type of exposure Condition of concrete (as defined in IS: 456) = Mild

(g) Type of cement used = PSC conforming IS: 456 – 2000

(h) Method of placing Concrete on Site = pumpable concrete

ii) Material testing data (determined in the laboratory):

(a) Specific gravity of cement = 3.15

(b) Specific gravity of FA = 2.64

(c) Specific gravity of CA = 2.84

(d) Aggregates are assumed to be having surface dry condition.

(e) Fine aggregates confirming to Zone II of IS – 383

PROCEDURE: (For M25 concrete mix design)

1. **Determination of Target Strength:**

Standard deviation is taken from IS:456 (against M 25 is 4.0.)

$$\mathbf{f_{target} = f_{ck} + 1.65 \times S}$$

$$= 25 + 1.65 \times 4.0 = 31.6 \text{ N/mm}^2$$

Where,
S = standard deviation in N/mm^2 = 4 (as per table -1 of IS 10262- 2009)

2. **Selection of water / cement ratio:**

From Table 5 of IS 456, (page no 20), Maximum water-cement ratio for Mild exposure condition = 0.55. Based on experience, adopt water-cement ratio as 0.5. 0.5<0.55, hence OK.

3. **Selection of Water Content:**

From Table- 2 of IS 10262 : 2009, Maximum water content = 186 Kg (for Nominal maximum size of aggregate- 20 mm)

Table for Correction in water content:

Parameters	Values as per Standard reference condition	Values as per Present Problem	Departure	Correction in Water Content
Slump	25-50 mm	50-75	25	(+3/25) x 25 = +3
Shape of Aggregate	Angular	Angular	Nil	–
			Total	+3

Estimated water content = 186+ (3/100) x 186 = 191.6 kg /m^3

4. **Selection of Cement Content:**

Water-cement ratio = 0.5, Hence Corrected water content = 191.6 kg /m^3

From Table 5 of IS 456,

Cement content = Minimum cement Content for mild exposure condition = 300 kg/m^3

383.2 kg/m^3 > 300 kg/m^3, hence, OK.

This value is to be checked for durability requirement from IS: 456.
In the present example against mild exposure and for the case of reinforced concrete the minimum cement content is 300 kg/m^3 which is less than 383.2 kg/m^3. Hence cement content adopted = 383.2 kg/m^3.
As per clause 8.2.4.2 of IS: 456

Maximum cement content = 450 kg/m^3.

5. **Estimation of Coarse Aggregate proportion:**
From Table 3 of IS 10262- 2009, For Nominal maximum size of aggregate = 20 mm, Zone of fine aggregate = Zone II and For w/c = 0.5, Volume of coarse aggregate per unit volume of total aggregate = 0.62

Table for correction in estimation of coarse aggregate proportion:

Parameter	Values as per Standard reference condition	Values as per present problem	Departure	Correction in Coarse Aggregate proportion	Remarks
W/c	0.5	0.5	Nil	–	See Note 1
Workability	–	pump able concrete	–	-10%	See Note 2
			Total	**-10%**	

Note 1: For every ±0.05 change in w/c, the coarse aggregate proportion is to be changed by 0.01. If the w/c is less than 0.5 (standard value), volume of coarse aggregate is required to be increased to reduce the fine aggregate content. If the w/c is more than 0.5, volume of coarse aggregate is to be reduced to increase the fine aggregate content. If coarse aggregate is not angular, volume of coarse aggregate may be required to be increased suitably, based on experience.

Note 2: For pump able concrete or congested reinforcement the coarse aggregate proportion may be reduced up to 10%.

Hence, Volume of coarse aggregate per unit volume of total aggregate = 0.62 x 90% = 0.558, Volume of fine aggregate = 1 – 0.558 = 0.442

6. **Estimation of the mix ingredients:**

a) Volume of concrete = 1 m^3
b) Volume of cement = (Mass of cement / Specific gravity of cement) x (1/100)

= (383.2/3.15) x (1/1000) = 0.122 m^3
c) Volume of water = (Mass of water / Specific gravity of water) x (1/1000)

= (191.6/1) x (1/1000) = 0.1916 m^3
d) Volume of total aggregates = a- (b + c) = 1 – (0.122 + 0.1916) = 0.6864 m^3
e) Mass of coarse aggregates = 0.6864 x 0.558 x 2.84 x 1000 = 1087.75 kg/m^3
f) Mass of fine aggregates = 0.6864 x 0.442 x 2.64 x 1000 = 800.94 kg/m^3

OBSERVATION & CALCULATION:

As per the material properties the mix proportions are determined following the above procedure.

Water cement ratio = 0.44

Weight of water content = 197.4 kg/m^3

Weight of Cement content = (197.4/0.44) = 448.6 kg/m^3

Volume of aggregate in total volume of concrete = 1 – [{448.6/(3.15 x 1000)} + (197.4/1000)] = 0.660 m^3

A reduction of 0.05 in w/c, we have to increase of coarse aggregate fraction by 0.01.

Coarse aggregate volume = 0.558 +0.01 =0.568

Volume of fine aggregate in mix = 1 – 0.568 = 0.432

Weight of coarse aggregate = 0.660 x 0.568 x 2.84 x 1000 = 1064.65 kg/m^3

Weight of fine aggregate = 0.660 x 0.432 x 2.64 x 1000 = 752.71 kg/m^3

Designation of specimen	1	2	3	Avearge
Load in kg after 28 days				
Strength in kg/cm^2				
Strength in N/mm^2				

RESULT:
The mix proportions is _ and average compressive strength of concrete after 28 days is

Signature

EXPERIMENT NO. 8

AIM OF THE EXPERIMENT: To determine the flexural strength (modulus of rupture) of concrete of given proportions.

THEORY: When concrete is subjected to bending, tensile and bending compressive stresses and in many cases, direct shear stresses are developed. The most common plain concrete structure subjected to flexure is a highway pavement and the strength of concrete for pavements is commonly evaluated by means of bending test. Flexural test intended to give the flexural strength of concrete in tension. The flexural test is also more easily carried out and may even be more convenient than the crushing test use in field, since in this test much smaller loads are required.

APPARATUS REQUIRED:

i) Steel prism moulds of size 100mm x 100mm x 500mm
ii) Flexural strength testing machine
iii) weighing machine, mixer, tamping rods

PROCEDURE:

i) Prepare a concrete mix as mentioned in with the proportions suggested Such as: 1: 1.5: 3 with w/c = 0.6 by mechanical mixer.
ii) Prepare three testing prisms; make sure that they are clean and greased or oiled thinly.
iii) Metal moulds should be sealed to their base plates to prevent loss of water.
iv) Fill the prism mould in two layers, tamping each layer with 100 times using a tamper, square in cross-section with 2.5 cm side and 40 cm length, weighing 1.818 kg.
v) While filling the moulds, occasionally stir and scrape together the concrete remaining in the mixer to keep the materials from separating.
vi) Fill the moulds completely, smooth off the tops evenly, and clean up any concrete outside the prisms
vii) Mark the specimens by a slip of paper on which is written the date and the Specimen identification. Leave the specimens in the curing room for 24 hours.
viii) After that open the moulds and immerse the concrete prisms in a water basin for 28 days. Specimens shall be tested immediately on removal from water while they are in wet condition. The dimensions of each specimens shall be noted before testing.
ix) The bearing surfaces of the supporting and loading rollers shall be wiped clean and any loose sand or other material removed from the surface of the specimens where they are make contact with the rollers. The specimen shall then be placed in the machine in such a manner that the load shall be applied to the upper most surface as cast in the mould, along two lines spaced 200mm 0r 133mm apart. The axis of the specimens shall be carefully aligned with the axis of the loading device. No packing shall be used between the bearing surfaces of the specimens and the rollers. The load shall be applied without shock and increasing continuously at a rate such that the extreme fibre stresses increases at 0.7 N/mm^2/mint that is at a rate of loading of 4KN/mint for 150 mm specimen and at a rate of 1.8KN/ mint for the 100mm specimens. The load shall be increased until the specimen fails and maximum load applied to the specimen during the test shall be recorded. The appearance of the

fractured faces of concrete and any unique features in the type of failure shall be noted.

OBSERVATIONS AND CALCULATIONS:

Specimen no.	**1**	**2**	**3**	**Average load**
Load in Newtons on cube				

The flexural strength of specimen shall be as the modulus of rupture and shall be calculated as follows:

$\sigma = \rho a / bd^2$----------(1)

$\sigma = 3\rho a/bd^2$ --------- (2)

Where ‘a’ equals the distance between the line of fracture and the nearer support, measured on the centre line of the tensile side of the specimen in mm.

Equation (1) is applicable when ‘a’ is greater than 133mm for 100mm specimen. Equation (2) is applicable when ‘a’ is less than 133mm but greater than 110mm for 100mm specimens.

b= measured width in mm of the specimen d=
measured depth in mm of the specimen
p= maximum load in N (kg) applied to the specimen

If ‘a’ is less than 110mm for a 100mm specimen, the Results of the test shall be discarded.

RESULT:

The average flexural strength (modulus of rupture) of prism specimen… .... N/mm^2

Signature