II Jai Sri Gurudev II

ADICHUNCHANAGIRI UNIVERSITY

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CONCRETE AND HIGHWAY MATERIAL TESTING LAB

BGS INSTITUTE OF TECHNOLOGY

DEPARTMENT OF CIVIL ENGINEERING

II Jai Sri Gurudev II

BGS INSTITUTE OF TECHNOLOGY

Department of Civil Engineering

VISION

- Producing technically competent and Environmental friendly Civil Engineering Professionals to cope with the societal challenges.

MISSION

- Imparting quality education and professional ethics by proficient faculty.
- Providing infrastructure to meet the requirements of curriculum, research and consultancy.
- Motivating towards higher education and entrepreneurship.
- Promoting Interaction with design and construction industries.

PROGRAM EDUCATION OBJECTIVES (PEOs)

PEO 1: Graduates will be pursuing successful career & higher education.

PEO 2: Graduates will be able to design safe, economical & sustainable civil engineering structures conforming to standards.

PEO 3: Graduates will display professional ethics to work in a team & lead the team by effectively communicating the ideas.

PEO 4: Graduates will practice lifelong learning.

PROGRAM SPECIFIC OBJECTIVES (PSOs)

PSO 1: Graduates will be able to analyze, design and execute the civil engineering structures effectively for the sustainable development.

PSO 2: Graduates will acquire critical thinking abilities and technical skills for the usage of modern tools in development of civil engineering structures.

PSO 3: Graduates will be able to get opportunities for their professional growth, demonstrate communication and aptitude skills to face the challenges and needs of our society.

CONTENTS

1. INTRODUCTION

Cement:

Cement, in the general sense of the word, can be described as a material with adhesive and cohesive properties which make it capable of bonding mineral fragments into a compact whole. For constructional purposes, the meaning of the term ‘Cement’ is restricted to the bonding material used with stones, sand, bricks, building blocks etc. The principal constituents of this type of cement are compounds of lime, so that in building and civil engineering we are concerned with calcareous cement.

Ordinary Portland Cement is basically used for the different type of tests.

Manufacture of Ordinary Portland Cement:

There are two processes known as **“Wet Process”** and **“Dry Process”** depending upon whether the mixing and grinding of raw materials is done in wet or dry conditions. In **wet process** the lime stone is crushed to smaller fragments then mixed with clay with addition of water to get slurry. But in **dry process** the raw materials are crushed dry and fed in correct proportions into a grinding mill where they are dried and reduced to a very fine powder. The dry process is quite economical when compare to wet process.

Chemical Composition of Cement:

The raw material used for the manufacture of Portland cement consists mainly of lime, silica, alumina and iron oxide.

Name of oxide	Content in percentage
CaO	60.0-67.0
SiO_2	17.0-25.0
Al_2O_3	3.0-8.0
Fe_2O_3	0.5-6.0
MgO	0.5-4.0
Alkalies [K_2O, Na_2O]	0.3-1.2
SO_3	2.0-3.5

The four major "Bogue's Compounds" are listed in table.

Name of compound	Oxide composition	Abbrivated
Tricalcium silicate	$3\ CaO.SiO_2$	C_3S
Dicalcium silicate	$2\ CaO.SiO_2$	C_2S
Tricalcium aluminate	$3\ CaO.Al_2O_3$	C_3A
Tetracalcium aluminoferrite	$4\ CaO.Al_2O_3.Fe_2O_3$	C_4AF

C_3S and C_2S constitute about 70 to 80 percent of the Portland cement and contribute to its strength. C_3S hydrates rapidly and hence contributes to the early, and ultimate strength of cement. C_2S hydrates slowly and contributes to later age strength. C_3A hydrates rapidly contributing to early strength but reducing ultimate strength. C_4AF is the most undesirable compound and does not contribute to the strength.

Types of Cement:

(i) Ordinary Portland Cement
(ii) Rapid Hardening Cement
(iii) Extra Rapid Hardening Cement
(iv) Sulphate Resisting Cement
(v) Portland Slag Cement
(vi) Quick Setting Cement
(vii) Super Sulphated Cement
(viii) Low Heat Cement
(ix) Portland Pozzolana Cement
(x) Air Entraining Cement
(xi) Coloured Cement (or) White Cement
(xii) Hydrophobic Cement
(xiii) Expansive Cement
(xiv) Oil Well Cement
(xv) Rediset Cement
(xvi) Concrete Sleeper grade Cement
(xvii) High Alumina Cement
(xviii) Very High Strength Cement

Aggregates:

The aggregate is the matrix (or) principal structure consisting of relatively inert fine and coarse materials. Aggregates are the important constituents in concrete. They give body to the concrete, reduces shrinkage and effect economy. There are two types of aggregates namely "**Coarse Aggregate**" and "**Fine Aggregate**". The *coarse aggregate* is used primarily for the purpose of providing bulk to the concrete. To increase the density of resulting mix, the coarse aggregate is frequently used in two (or) more sizes. The most important function of the *fine aggregate* is to assist is producing workability and uniformity in mixture. The fine aggregate also assists the cement paste to hold the coarse aggregate particles in suspension. The aggregate provides about 75 percent of the body to concrete and hence its influence is extremely important.

Classification of Aggregate:

Naturally obtained aggregate is as follows: ***Sand, Gravel, Crushed, Rock such as Granite, Quartzite, Basalt, Sandstone*** and Artificially obtained aggregate is as follows: ***Broken Brick, Air-Cooled Slag, Sintered fly ash, Bloated clay***. Aggregates are further classified as ***(i) Normal weight aggregate (ii) Light weight aggregate (iii) Heavy weight aggregate.***

Water:

Water is an important ingredient of concrete as it actively participates in the chemical reaction with cement. Water reacts chemically with cement to form the binding matrix in which the inert aggregate are held in suspension until the matrix has hardened. Water serves also as a vehicle (or) lubricant between the fine and coarse aggregate in order that the concrete may be made more readily placeable in forms.

Percentage of salts in water	Percentage reduction in compressive strength
0.5 SO_4	4
1.0 SO_4	10
5.0 NaCl	30
CO_3	20

2. TEST ON CEMENT

Standard Consistency (or) Normal Consistency of Cement:-

Object: To find out the amount of water required to produce a cement paste.

Apparatus: Vicat Mould [80 mm diameter, 40 mm length], Vicat Plunger [10 mm diameter, 50 mm length], Vicat appartus, Glass plate, Measuring jar, Weighing balance.

Theory: The standard consistency of a cement paste is defined “as that consistency which will permit a Vicat plunger having 10 mm diameter and 50 mm length to penetrate to a depth of 35 mm from the top of the mould”. The Vicat Appartus is used to find out the percentage of water required to produce a cement paste of standard consistency. For finding out initial setting time, final setting time and soundness of cement a parameter known as standard consistency has to be used.

Procedure:

1. Take about 300 g of cement.
2. Add the weighed quantity of water say 24 %, in order to prepare a paste for first trail.
3. The paste must be prepared in a standard manner and filled into the Vicat mould within 3-5 minutes.
4. After completely filling the mould, shake the mould to expel air.
5. A standard plunger of 10 mm diameter and 50 mm length is attached to the Vicat apparatus.
6. The plunger is brought down in order to touch the surface of cement paste.
7. Note down the initial reading in mm.
8. Allow the plunger to penetrate through the cement paste by its own weight.
9. Note down the final reading in mm.
10. This gives the depth of penetration of the plunger in mm.
11. Similarly, conduct the second trail say 25 % of water and note down the depth of penetration in mm.
12. Conduct the trails with higher and higher water/cement ratios till the plunger penetrates to a depth of 35 mm from top. [Say 26 %, 27 %, 28 %, 29 %.........]
13. That particular percentage of water will be the amount of water required to make a cement paste of standard consistency.

14. This percentage is usually denoted as “P”.
15. Draw a graph between penetration of vicat needle along x-axis and water percentage by weight along y-axis.

Result:

Standard Consistency (or) Normal Consistency of given cement paste, P (%) =

Observation:

Weight of cement taken, A (g) =

Type of cement =

Name of cement =

Grade of cement =

Calculations:

Amount of water required (ml) = {P/100 *A}

Where, P = Percentage of water

A = Weight of cement taken

Tabular column:

Sl. No	Percentage of water	Water added (ml)	Initial reading (mm)	Final reading (mm)	Height not penetrate (mm)
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					

Initial Setting Time and Final Setting Time of Cement:-

Object: To determine the initial and final setting time of a given cement sample.

Apparatus: Vicat apparatus with vicat needles, Vicat mould, Gauging trowel, Measuring jar, Weighing balance, Stop watch, Plate, Rubber grooves, Glass plate.

Theory: An arbitrary division has been made for the setting time of cement as initial setting time and final setting time. It is difficult to draw a rigid line between these two arbitrary divisions. For convenience, initial setting time is regarded as the time elapsed between the moment that the water is added to the cement, to the time that the paste starts losing its plasticity. The final setting time is the time elapsed between the moment the water is added to the cement and the time when the paste has completely lost its plasticity and has attained sufficient firmness to resist certain definite pressure.

Procedure:

(a) Initial setting time:

1. Take about 300 g of cement.
2. Prepare a neat cement paste by gauging the cement with 0.85*P water, where P = Standard Consistency as found before.
3. The prepared cement paste should be filled within 3-5 minutes into the vicat mould.
4. After filling the mould shake the mould in order to expel the air.
5. Then level the top surface of the mould.
6. Replace the vicat plunger into vicat needle B.
7. Lower the needle gently and bring it in contact with the surface of the test block and quickly release.
8. After some time when the paste starts losing its plasticity, the needle may penetrate only to a depth of 35 mm from the top.
9. The period elapsing between the time when water is added to the cement and time at which the needle penetrates the test block to a depth equal to 35 mm from the top is taken as initial setting time of that cement paste.

(b) Final setting time:

1. Replace the needle of the vicat apparatus by the needle with an annular attachment C.
2. The cement is considered finally set when, upon applying the needle C gently to the surface of the test block, the needle makes an impression there on while the attachment fails to do so.
3. Draw the graph between penetration of vicat needle on x-axis and water percentage by weight on y-axis.
4. The above graph helps in determining the normal consistency of cement paste.

Result:

Initial setting time of given cement (min) =

Final setting time of given cement (min) =

Observation:

Weight of cement taken, A (g) =

Type of cement =

Name of cement =

Grade of cement =

Calculations:

Amount of water required (ml) = 0.85 * {P/100 *A}

Where, P = Percentage of water from Standard Consistency

A = Weight of cement taken

Tabular column:

Sl. No	Percentage of water	Water added (ml)	Time (min)	Initial reading (mm)	Final reading (mm)	Height not penetrated (mm)	Normal consistency (P)
1.							
2.							
3.							
4.							
5.							
6.							
7.							
8.							
9.							

Soundness of Cement:-

Object: To determine the soundness of given cement sample by Le-Chatelier method.

Apparatus: Le-Chatelier apparatus, Two glass plates, Temperature controlled water bath, Scale, China dish to mix the paste, Counter balance.

Theory: Excess of free lime and magnesia present in cement slake very slowly and cause appreciable change in volume after setting. In consequence cracks, distortion and disintegration results, thereby giving passage to water and atmospheric gases which may have injurious effect on concrete and reinforcement. This defect is known as unsoundness. The expansion is prevented by limiting the quantities of free lime and magnesia in cement. The test is designed to accelerate this slaking process by application of heat and to measures the extent of expansion and to see if this expansion is less than the specified limit.

Procedure:

1. Take about 100 g of cement.
2. Prepare a paste by gauging the cement with 0.78 * P water, where P = Standard Consistency as found before.
3. Place the Le-Chatelier apparatus on a glass plate and fill it with the paste and level the top surface.
4. Cover the mould with another glass plate and place a small weight on the glass plate.
5. Then immediately submerge the whole assembly in water at a temperature of 29±2° c and keep there for 24 hours.
6. After 24 hours take out the sample outside and measure the distance D_1 between the indicator points.
7. Again submerge the mould into water at the temperature of 29±2°c.
8. Bring the water to boiling point in 25 to 30 minutes and keep it boiling for 3 hours.
9. Remove the mould from the water, allow it to cool and measure the distance D_2 between the indicator points.
10. The difference between D_2- D_1 gives the expansion (or) soundness of cement.

Result:

Soundness of Cement [D_2- D_1] (mm) =

Observation:

Weight of cement taken, A (g) =

Type of cement =

Name of cement =

Grade of cement =

Calculations:

Amount of water required (ml) = 0.78 * {P/100 *A}

Where, P = Percentage of water from Standard Consistency

A = Weight of cement taken

Tabular column:

Items	Trail 1	Trail 2
Initial distance between indicator points, D_1 (mm)		
Final distance between indicator points, D_2 (mm)		
Cement expansion (or) Soundness of cement, [D_2- D_1] (mm)		

Compressive Strength of Cement:-

Object: To determine the compressive strength of 1:3 Cement-Sand Mortar cubes after 3 days, 7 days and 28 days.

Apparatus: Universal Testing Machine [UTM] (or) Compression Testing Machine [CTM], Cube moulds, Vibrating machine, Crucible for mixing cement and sand, Measuring jar, Trowels, Non-Porous plate, Weighing balance.

Theory: Compressive strength is the strength at which the specimen breaks (or) the strength which is taken by the specimen until its breaks. The compressive strength of cement mortar is determine in order to verify whether the cement conforms to IS specification {IS: 269-1976} and whether it will be able to develop the required compressive strength of concrete. According to IS: 269-1976, the ultimate compressive strength of cubes of cement-sand mortar of the ratio 1:3 is as follows:

(a) After 3 days, Not less than 16.0 N/mm^2
(b) After 7 days, Not less than 22.0 N/mm^2
(c) After 28 days, Not less than 35.0 N/mm^2

Procedure:

1. Calculate the material required.
2. Take about 200 g of cement.
3. Take about 600 g of sand.
4. Take about [P/4+3.0] percent of water, where P = Standard Consistency as found before.
5. Place the mixture of cement and sand in the proportions of 1:3 by mass on a non-pours plate and mix it dry with a trowel for one minute.
6. Pour the water to the mixture and mix it until the mixture become uniform colour.
7. The mould is oiled on the inner surface and also to the base plate.
8. Immediately after mixing the mortar as explained above, fill the entire quantity of mortar in the hopper of the cube.
9. Place the assembled mould on the table of vibrating machine and firmly hold it in position by means of suitable clamps.

10. The period of vibration shall be 2 minutes at the specified speed of 1200±400 cycles per minute.
11. Remove the mould from the machine and kept for air drying for 24 hours and the specimen is demoulded.
12. Remove the cubes from mould and immediately submerge it in clean water for 3 days, 7 days and 28 days.
13. Test the specimen at the required periods.
14. The compressive strength shall be average of the strengths of the three cubes for each period.

Result:

Average Compressive Strength at 3 days (N/mm^2) =

Average Compressive Strength at 7 days (N/mm^2) =

Average Compressive Strength at 28 days (N/mm^2) =

Observation:

Weight of cement taken, A (g) =

Weight of sand taken, B (g) =

Type of cement =

Name of cement =

Grade of cement =

Calculations:

Amount of water required (ml) = {P/4 + 3} * {A + B}/100

Where, P = Percentage of water from Standard Consistency

A = Weight of cement taken

B = Weight of sand taken

Observation:

Area of the specimen, A (mm^2) =

Calculations:

Compressive Strength (N/mm^2) = Load/Area (or) P/A

Where, P = Load in kN

A = Area of the specimen in mm^2

Tabular column:

Sl. No	Load (kN)	Area (mm^2)	Wet Compressive Strength (N/mm^2)	Average Wet Compressive Strength at 3 days (N/mm^2)
1.				
2.				
3.				

Tabular column:

Sl. No	Load (kN)	Area (mm^2)	Wet Compressive Strength (N/mm^2)	Average Wet Compressive Strength at 7 days (N/mm^2)
1.				
2.				
3.				

Tabular column:

Sl. No	Load (kN)	Area (mm^2)	Wet Compressive Strength (N/mm^2)	Average Wet Compressive Strength at 28 days (N/mm^2)
1.				
2.				
3.				

Fineness of Cement:-

Object: To determine the fineness of cement sample by sieving through a 90-micron IS sieve.

Apparatus: Standard IS Sieve No. 9 i.e, 90-micron, Rich plate, Weighing balance.

Theory: The fineness of cement has an important bearing on the rate of hydration and hence on the rate of gain of strength and also on the rate of evolution of heat. The degree of fineness of cement is a measure of the mean size of the grains in cement. The rate of hydration and hydrolysis, and consequent development of strength in cement mortar depends upon the fineness of cement. The finer cement has quicker action with water and gains early strength though its ultimate strength remains unaffected. Fineness of cement is tested in two ways: (a) By sieving and (b) By determination of specific surface by air-permeability apparatus.

Procedure:

1. Take about 100 g of cement.
2. Break the air-set lumps in the cement sample with fingers.
3. Place the sample on the standard IS sieve No. 9 i.e, 90-micron sieve.
4. Continuously sieve the sample giving circular motion for a period of 15 minutes.
5. Weight the residue retained on the sieve.
6. The fineness of cement should be between 0-10 percent.

Result:

Fineness of Cement (%) =

Observation:

Weight of cement taken, A (g) =

Type of cement =

Name of cement =

Grade of cement =

Calculations:

Fineness of Cement (%) = {Weight of residue/Weight of cement} * 100

Tabular column:

Items	Trail 1	Trail 2
Weight of cement taken on 90-micron sieve, (g)		
Weight of residue after sieving [retained on sieve], (g)		
Fineness of Cement, (%)		

Specific Gravity of Cement:-

Object: To determine the specific gravity of given cement sample.

Apparatus: Specific gravity bottle, Weighing balance, Kerosene, Distilled water.

Theory: Specific Gravity is normally defined as the ratio between the mass of a given volume of material and mass of an equal volume of water. One of the method of determining the specific gravity of cement is by the use of a liquid such as kerosene which does not react with cement.

Specific Gravity (G) = Mass of given volume of material / Mass of equal volume of water.

Procedure:

1. Take about 50 g of cement.
2. Weigh the empty specific gravity bottle. Let the mass of empty bottle be W_1 g.
3. Fill the bottle with distilled water and weigh the bottle filled with water. Let the mass be W_2 g.
4. Empty the specific gravity bottle and fill it with kerosene. Let the mass be W_3 g.
5. Pour some of the kerosene out and introduce a weighed quantity of cement into the bottle.
6. Roll the bottle in inclined position until no further air bubbles rise to the surface.
7. Fill the bottle to the top with kerosene and weigh. Let the mass be W_4 g.
8. From these data calculate the specific gravity of given cement sample.

Result:

Specific Gravity of Cement, G =

Observation:

Weight of cement taken, W_5 (g) =

Type of cement =

Name of cement =

Grade of cement =

Calculations:

Specific Gravity of Kerosene, G = $\{W_3 - W_1\} / \{W_2 - W_1\}$

Specific Gravity of Cement, G = $W_5 * \{W_3 - W_1\} / [\{W_5 + W_3\} - W_4] * \{W_2 - W_1\}$

Tabular column:

Items	Trail 1	Trail 2	Trail 3
Weight of empty bottle, W_1 (g)			
Weight of empty bottle + Water, W_2 (g)			
Weight of empty bottle + Kerosene, W_3 (g)			
Weight of empty bottle + Kerosene + Cement, W_4 (g)			
Weight of cement, W_5 (g)			
Specific Gravity, (G)			

3. TEST ON FRESH CONCRETE

Slump test for Concrete:-

Object: To determine the workability (or) consistency of fresh concrete of 1:1.5:3 proportion by slump test.

Apparatus: Iron pan to mix concrete, Weighing balance, Trowel, Slump cone apparatus, Scale, Tamping rod of 16 mm diameter and 0.6 m long with bullet point at the lower end.

Theory: Workability can be defined as "*that property of freshly mixed concrete (or) mortar which determines the ease and homogeneity with which it can be mixed, placed, compacted and finished*". Hundred percent compaction of concrete is an important parameter for contributing to the maximum strength. Lack of compaction will result in air voids whose damaging effect on strength and durability. Thus a higher water/cement ratio is required to make fully compacted concrete. Unsupported fresh concrete, flows to the sides and a sinking in height takes place. This vertical settlement is known as slump. Slump is a measure indicating consistency (or) 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, placed, compacted and finished*. A workable concrete should not show any segregation (or) bleeding. Segregation is said to occur when coarse aggregate tries to separate out from the fine material and a concentration of coarse aggregate at once place occurs. This results in large voids, less durability and strength. Bleeding of concrete is said to occur when excess water comes up to the surface of concrete. This causes small pores through the mass of concrete and is undesirable.

Degree of Workability	Slump (mm)	Name of Work
Low	25-75	Mass concrete foundation and concrete for road work
Medium	50-100	Concrete for R.C.C. beams and slabs
High	100-150	Pumping, placing, columns and retaining walls

Procedure:

1. Calculate the required quantity of materials and weigh the required quantity of materials i.e, Cement, Sand (Fine aggregate), Coarse aggregate and Water.
2. Mix the dry constituents thoroughly to get a uniform colour.
3. Clean the slump cone and oil it completely.
4. Place the slump cone on a smooth horizontal rigid surface i.e, on a non-absorbent surface.
5. Then add water to the dry mix and mix it completely to get a uniform colour.
6. Place the mixed concrete in the cleaned slump cone in 4 layers, each approximately ¼ of the height of the mould.
7. Tamp each 4 layers by 25 times with the tamping rod.
8. Strike off the extra heap of concrete on the top of the slump cone.
9. Remove the cone immediately; raise it slowly and carefully in the vertical direction.
10. Measure the subsidence of concrete from top of the mould in mm, which will give the slump of that fresh concrete.
11. Repeat the procedure for other trail mixes of different water cement ratios.

Result:

Slump Value of Concrete for (mm)

0.50 =

0.60 =

0.70 =

0.80 =

0.90 =

1.00 =

Observation:

Weight of cement taken (Kg) =

Weight of sand taken (Kg) =

Weight of coarse aggregate taken (Kg) =

Weight of water taken (Kg) =

Type of cement =

Name of cement =

Grade of cement =

Proportion of concrete =

Tabular column:

Items	Trail 1	Trail 2	Trail 3	Trail 4	Trail 5	Trail 6
Proportion of Concrete	1:1.5:3	1:1.5:3	1:1.5:3	1:1.5:3	1:1.5:3	1:1.5:3
Cement (Kg)						
Sand (Kg)						
Coarse Aggregate (Kg)						
Water/Cement Ratio						
Water added (ml)						3
Slump (mm)						

Tabular column:

Water-Cement Ratio	Slump (mm)
0.50	
0.60	
0.70	
0.80	
0.90	
1.00	

Compacting Factor test for Concrete:-

Object: To determine the workability (or) consistency of fresh concrete of 1:1.5:3 proportion by compacting factor test.

Apparatus: Compacting factor apparatus, Trowels, Iron pan to mix concrete, Weighing balance, Tamping rod of 16 mm diameter and 0.6 m long with bullet point at the lower end.

Theory: Compaction factor test is adopted to determine the workability of concrete, where nominal size of aggregate does not exceed 40 mm. It is based upon the definition, that workability is that property of the concrete which determines the amount of work required to produce full compaction. This test works on the principle of determining the degree of compaction achieved by a standard amount of work done by allowing the concrete to fall through a standard height. This method is better than the slump test.

Degree of Workability	Compacting Factor	Name of Work
Very Low	0.78-0.80	Concrete for road work
Low	0.85-0.87	Mass concrete foundation
Medium	0.92-0.935	R.C.C. beams and slabs
High	0.95-0.96	Pumping and placing

Procedure:

1. Calculate the required quantity of materials and weigh the required quantity of materials i.e, Cement, Sand (Fine aggregate), Coarse aggregate and Water.
2. Mix the dry constituents thoroughly to get a uniform colour.
3. Clean the compacting factor apparatus and oil it completely.
4. Weigh the empty cylinder. Let the mass be W_1 Kg.
5. Fix the cylinder below the hopper of the compacting factor apparatus.
6. Then add water to the dry mix and mix it completely to get a uniform colour.
7. Fill the freshly mixed concrete in upper hopper “A” gently and carefully without compacting.

8. After two minutes, release the trap door of the upper hopper “A”, so that concrete falls freely into the lower hopper “B”.
9. Immediately release the trap door of lower hopper “B” thus the concrete falls freely on the cylinder.
10. Strike off the excess concrete on the top of the cylinder.
11. Weigh the practically compacted concrete with the cylinder. Let the mass be W_2 Kg.
12. Refill the same concrete into the cylinder in 3 layers by tamping each layer by 25 times using tamping rod.
13. Weigh the fully compacted concrete with the cylinder. Let the mass be W_3 Kg.
14. Repeat the procedure for other trail mixes of different water cement ratios.

Result:

Compacting Factor Value of Concrete for

0.50 =

0.60 =

0.70 =

0.80 =

0.90 =

1.00 =

Observation:

Weight of cement taken (Kg) =

Weight of sand taken (Kg) =

Weight of coarse aggregate taken (Kg) =

Weight of water taken (Kg) =

Type of cement =

Name of cement =

Grade of cement =

Proportion of concrete =

Calculations:

Compacting Factor = $\{W_2 - W_1\} / \{W_3 - W_1\}$

Where, $(W_2 - W_1)$ = Weight of partially compacted concrete

$(W_3 - W_1)$ = Weight of fully compacted concrete

Tabular column:

Items	Trail 1	Trail 2	Trail 3	Trail 4	Trail 5	Trail 6
Proportion of Concrete	1:1.5:3	1:1.5:3	1:1.5:3	1:1.5:3	1:1.5:3	1:1.5:3
Cement (Kg)						
Sand (Kg)						
Coarse Aggregate (Kg)						
Water/Cement Ratio						
Water added (ml)						
Compacting Factor						

Tabular column:

Items	Trail 1	Trail 2	Trail 3	Trail 4	Trail 5	Trail 6
Weight of empty cylinder, W_1 (Kg)						
Weight of partially compacted concrete with cylinder, W_2 (Kg)						
Weight of fully compacted concrete with cylinder, W_3 (Kg)						
Weight of partially compacted concrete, (W_2-W_1) (Kg)						
Weight of fully compacted concrete, (W_3-W_1) (Kg)						
Compacting Factor = $\{W_2- W_1\} / \{W_3- W_1\}$						

Tabular column:

Water-Cement Ratio	Slump (mm)
0.50	
0.60	
0.70	
0.80	
0.90	
1.00	

Vee-Bee Consistometer test for Concrete:-

Object: To determine the workability (or) consistency of fresh concrete of 1:1.5:3 proportion by vee-bee consistometer test.

Apparatus: Vee-Bee consistometer apparatus, Iron pan to mix concrete, Weighing balance, Trowels, Tamping rod of 16 mm diameter and 0.6 m long with bullet point at the lower end.

Theory: Vee-Bee Consistometer is used to determine the consistency and indirectly the workability of a fresh concrete. The time required to transform by vibration a concrete specimen in the shape of a conical frustum into a cylinder is a measure of workability of the mix. The time required for complete remoulding in seconds is considered as a measure of workability and is expressed as the number of Vee-Bee seconds. This method is suitable for dry concrete.

Workability	Vee-Bee Time (sec)
Extremely Dry	32-18
Very Stiff	18-10
Stiff	10-15
Stiff-Plastic	5-3
Plastic	3-0
Flowing	--

Procedure:

1. Calculate the required quantity of materials and weigh the required quantity of materials i.e, Cement, Sand (Fine aggregate), Coarse aggregate and Water.
2. Mix the dry constituents thoroughly to get a uniform colour.
3. Clean the slump cone and the cylindrical container and oil it completely.
4. Place the slump cone on the cylindrical container.
5. Then add water to the dry mix and mix it completely to get a uniform colour.
6. Place the mixed concrete in the cleaned slump cone in 4 layers, each approximately ¼ of the height of the mould.

7. Tamp each 4 layers by 25 times with the tamping rod.
8. Strike off the extra heap of concrete on the top of the slump cone.
9. Move the glass disc attached to the swivel arm and place it on the top of the slump cone.
10. Note down the initial reading “a” on the graduated rod.
11. Remove the cone immediately; raise it slowly and carefully in the vertical direction and note down the final reading “b” on graduated rod.
12. Switch on the electrical vibrations and start the stop watch.
13. The vibration is carried out until the concrete completely remoulded.
14. Record the time required for complete remoulding in seconds, which measures the workability in Vee-Bee seconds.
15. Repeat the procedure for other trail mixes of different water cement ratios.

Result:

Vee-Bee time of Concrete for (sec)

0.50 =

0.60 =

0.70 =

0.80 =

0.90 =

1.00 =

Observation:

Weight of cement taken (Kg) =

Weight of sand taken (Kg) =

Weight of coarse aggregate taken (Kg) =

Weight of water taken (Kg) =

Type of cement =

Name of cement =

Grade of cement =

Proportion of concrete =

Tabular column:

Items	Trail 1	Trail 2	Trail 3	Trail 4	Trail 5	Trail 6
Proportion of Concrete	1:1.5:3	1:1.5:3	1:1.5:3	1:1.5:3	1:1.5:3	1:1.5:3
Cement (Kg)						
Sand (Kg)						
Coarse Aggregate (Kg)						
Water/Cement Ratio						
Water added (ml)						
Slump (mm)						

Tabular column:

Water-Cement Ratio	Slump (mm)
0.50	
0.60	
0.70	
0.80	
0.90	
1.00	

Tabular column:

Items	Trail 1	Trail 2	Trail 3	Trail 4	Trail 5	Trail 6
Water/Cement Ratio	0.50	0.60	0.70	0.80	0.90	1.00
Initial reading ‘a’ (mm)						
Final reading ‘b’ (mm)						
Slump (mm)						
Vee-Bee Time (sec)						

Tabular column:

Water-Cement Ratio	Vee-Bee Time (sec)
0.50	
0.60	
0.70	
0.80	
0.90	
1.00	

4. TEST ON HARDENED CONCRETE

Compressive Strength test for Concrete:-

Object: To determine the compressive strength of concrete cubes of 1:2:4 proportion for 3 days, 7 days and 28 days.

Apparatus: Cube moulds of 150 mm, Iron pan to mix concrete, Weighing balance, Trowels, Tamping rod of 16 mm diameter and 0.6 m long with bullet point at the lower end, Measuring jar, Compression Testing Machine [CTM].

Theory: Compression test is the most common test conducted on hardened concrete, partly because it is an easy test to perform, and partly because most of the desirable characteristics properties of concrete are qualitatively related to its compressive strength. One of the most important properties of concrete is its strength in compression. The strength in compression has a definite relationship with all the other properties of concrete i.e, these properties are improved with the improvement in compressive strength, hence the importance of test. The standard specimen measures are

(a) Cubes = 100 * 100 * 100 mm (or) 150 * 150 * 150 mm
(b) Cylinder = 150 mm diameter and 300 mm long
(c) Beam = 250 * 150 * 100 mm

Procedure:

1. Calculate the required quantity of materials and weigh the required quantity of materials i.e, Cement, Sand (Fine aggregate), Coarse aggregate and Water.
2. Mix the dry constituents thoroughly to get a uniform colour.
3. Clean the cube moulds and oil it completely.
4. Then add water to the dry mix and mix it completely to get a uniform colour.
5. Pour the concrete into the cube moulds in two layers and tamping each layer by 35 times using tamping rod.
6. Struck off the concrete on the top of the mould.
7. After casting keep the cube moulds for air drying for about 24 hours.
8. Then remove the concrete cubes from the moulds and keep it for curing about 28 days.

9. The specimens are tested for required number of period for about 3 days, 7 days and 28 days.
10. The volume of materials required for casting is as follows:

    Cement = 18 Kg

    Sand (Fine Aggregate) = 36 Kg

    Coarse aggregate = 72 Kg

    Water = 10.8 Kg

    Water/Cement Ratio = 0.6

Result:

Average Compressive Strength at 3 days (N/mm^2) =

Average Compressive Strength at 7 days (N/mm^2) =

Average Compressive Strength at 28 days (N/mm^2) =

Observation:

Weight of cement taken (Kg) =

Weight of sand taken (Kg) =

Weight of coarse aggregate taken (Kg) =

Weight of water taken (Kg) =

Type of cement =

Name of cement =

Grade of cement =

Proportion of concrete =

Water/Cement Ratio =

Observation:

Area of the specimen, A (mm^2) =

Calculations:

Compressive Strength (N/mm^2) = Load/Area (or) P/A

Where, P = Load in kN

A = Area of the specimen in mm^2

Tabular column:

Sl. No	Load (kN)	Area (mm^2)	Wet Compressive Strength (N/mm^2)	Average Wet Compressive Strength at 3 days (N/mm^2)
1.				
2.				
3.				
4.				

Tabular column:

Sl. No	Load (kN)	Area (mm^2)	Wet Compressive Strength (N/mm^2)	Average Wet Compressive Strength at 7 days (N/mm^2)
1.				
2.				
3.				
4.				

Tabular column:

Sl. No	Load (kN)	Area (mm^2)	Wet Compressive Strength (N/mm^2)	Average Wet Compressive Strength at 28 days (N/mm^2)
1.				
2.				
3.				
4.				

Tabular column:

Items	Trail 1	Trail 2	Trail 3
Proportion of concrete	1:2:4	1:2:4	1:2:4
Water/Cement Ratio	0.60	0.60	0.60
Age (days)	03	07	28
Load (kN)			
Area (mm^2)			
Average Wet Compressive Strength (N/mm^2)			

Split Tensile Strength test for Concrete:-

Object: To determine the split tensile strength of concrete cylinder of 1:2:4 proportion for 7 days and 28 days.

Apparatus: Cylinder moulds of 150 mm * 300 mm, Iron pan to mix concrete, Weighing balance, Trowels, Measuring jar, Tamping rod of 16 mm diameter and 0.6 m long with bullet point at the lower end, Compression Testing Machine [CTM].

Theory: The tensile strength is one of the basic and important properties of the concrete. The concrete is not usually expected to resist the direct tension because of its low tensile strength and brittle nature. However, the determination of tensile strength of concrete is necessary to determine the load at which the concrete members may cracks. The cracking is a form of tension failure. The splitting test are well known indirect tests used for determining the tensile strength of concrete sometimes referred to as split tensile strength of concrete. The tensile strength is about 10 % of compressive strength.

Procedure:

1. Calculate the required quantity of materials and weigh the required quantity of materials i.e, Cement, Sand (Fine aggregate), Coarse aggregate and Water.
2. Mix the dry constituents thoroughly to get a uniform colour.
3. Clean the cylinder moulds and oil it completely.
4. Then add water to the dry mix and mix it completely to get a uniform colour.
5. Pour the concrete into the cylinder moulds in four layers and tamping each layer by 35 times using tamping rod.
6. Struck off the concrete on the top of the mould.
7. After casting keep the cylinder moulds for air drying for about 24 hours.
8. Then remove the concrete cylinder from the moulds and keep it for curing about 28 days.
9. The specimens are tested for required number of period for about 7 days and 28 days.
10. The volume of materials required for casting is as follows:
    Cement = 5.25 Kg
    Sand (Fine Aggregate) = 10.5 Kg
    Coarse aggregate = 21 Kg
    Water = 3.15 Kg

Water/Cement Ratio = 0.6

Result:

Average Split Tensile Strength at 7 days (N/mm^2) =

Average Split Tensile Strength at 28 days (N/mm^2) =

Observation:

Weight of cement taken (Kg) =

Weight of sand taken (Kg) =

Weight of coarse aggregate taken (Kg) =

Weight of water taken (Kg) =

Type of cement =

Name of cement =

Grade of cement =

Proportion of concrete =

Water/Cement Ratio =

Calculations:

Split Tensile Strength (N/mm^2) = 2P/3.142*D*L

Where, P = Load in kN

D = Diameter of the specimen in mm

L = Length of the specimen in mm

Observation:

Length of the specimen (mm) =

Diameter of the specimen (mm) =

Tabular column:

Items	Trail 1	Trail 2
Length (mm)		
Diameter (mm)		
Load (kN)		
Split Tensile Strength at 7 days (N/mm^2)		
Average Split Tensile Strength at 7 days (N/mm^2)		

Tabular column:

Items	Trail 1	Trail 2
Length (mm)		
Diameter (mm)		
Load (kN)		
Split Tensile Strength at 28 days (N/mm^2)		
Average Split Tensile Strength at 28 days (N/mm^2)		

Tabular column:

Items	Trail 1	Trail 2
Proportion of Concrete	1:2:4	1:2:4
Water/Cement Ratio	0.60	0.60
Age (days)	07	28
Length (mm)		
Diameter (mm)		
Load (kN)		
Average Split Tensile Strength (N/mm^2)		

Flexural Strength test for Concrete:-

Object: To determine the flexural strength of concrete beam of 1:2:4 proportion for 28 days.

Apparatus: Beam mould, Iron pan to mix concrete, Weighing balance, Trowels, Measuring jar, Tamping rod of 16 mm diameter and 0.6 m long with bullet point at the lower end, Universal Testing Machine [UTM].

Theory: Concrete as we know is relatively strong in compression and weak in tension. In reinforced concrete members, little dependence is placed on the tensile strength of concrete since steel reinforcing bars are provided to resist all tensile forces. However, tensile stresses are likely to develop in concrete due to drying shrinkage, rusting of steel reinforcement, temperature gradients and many other reasons.

Procedure:

1. Calculate the required quantity of materials and weigh the required quantity of materials i.e, Cement, Sand (Fine aggregate), Coarse aggregate and Water.
2. Mix the dry constituents thoroughly to get a uniform colour.
3. Clean the beam moulds and oil it completely.
4. Then add water to the dry mix and mix it completely to get a uniform colour.
5. Pour the concrete into the beam moulds in two layers and tamping each layer by 35 times using tamping rod.
6. Struck off the concrete on the top of the mould.
7. After casting keep the beam moulds for air drying for about 24 hours.
8. Then remove the concrete beams from the moulds and keep it for curing about 28 days.
9. The specimens are tested for required number of period for 28 days.
10. The volume of materials required for casting is as follows:
    Cement = 18 Kg
    Sand (Fine Aggregate) = 36 Kg
    Coarse aggregate = 72 Kg
    Water = 10.8 Kg
    Water/Cement Ratio = 0.6

Result:

Flexural Strength at 28 days (N/mm^2) =

Observation:

Weight of cement taken (Kg) =

Weight of sand taken (Kg) =

Weight of coarse aggregate taken (Kg) =

Weight of water taken (Kg) =

Type of cement =

Name of cement =

Grade of cement =

Proportion of concrete =

Water/Cement Ratio =

Calculations:

Flexural Strength, F (N/mm^2) = 3PL/2*b*d^2

Where, P = Load in kN

L = Distance between central lines of supporting roller in mm

b = Width of the beam in mm

d = Thickness of the beam in mm

Observation:

Length of the specimen (mm) =

Width of the specimen (mm) =

Thickness of the specimen (mm) =

Tabular column:

Items	Trail 1
Length (mm)	
Width (mm)	
Thickness (mm)	
Load, P (kN)	
Flexural Strength at 28 days (N/mm^2)	

Tabular column:

Items	Trail 1
Proportion of Concrete	1:2:4
Water/Cement Ratio	0.60
Age (days)	28
Length (mm)	
Width (mm)	
Thickness (mm)	
Load, P (kN)	
Flexural Strength (N/mm^2)	

5. TEST ON COARSE AGGREGATE

Aggregate Crushing Value Test for Coarse Aggregate:-

Object: To determine the crushing value of given coarse aggregate.

Apparatus: Cylindrical measure of diameter 11.5 cm and height of 18 cm, Steel cylinder of diameter 15.2 cm and height of 14 cm, Square base plate, Plunger having piston of diameter 15 cm and height of 11.5 cm, Steel tamping rod of 1.6 cm diameter, Weighing balance, Compressive Testing Machine [CTM].

Theory: The principal mechanical properties required in road stones are

(i) Satisfactory resistance to crushing under the roller during construction

(ii) Adequate resistance to surface abrasion under traffic.

Crushing strength of road stones may be determined either on aggregate (or) on cylindrical specimens cut out of rocks. Aggregate used in road construction, should be strong enough to resist crushing under traffic wheel loads. If the aggregate are weak the stability of the pavement structure is likely to be adversely affected. Aggregate are the important constituents in concrete. They give body to the concrete, reduces shrinkage and effect economy. Aggregate can be classified as:

(a) Normal Weight Aggregate
(b) Light Weight Aggregate
(c) Heavy Weight Aggregate

Procedure:

1. Sieve the aggregate through 12.5 mm and retained on 10 mm IS sieve for standard test.
2. The aggregate should be in dry condition.
3. Then fill the aggregate into cylindrical measure in three layers of approximately equal depth, each layer being tamped 25 times by the tamping rod.
4. Struck off the excess aggregate on the top of the cylindrical measure using tamping rod.
5. Note down the mass of aggregate along with the cylindrical measure. Let the mass be W_2 g.

6. Transfer the aggregate from the cylindrical measure into the cylinder of 15 cm diameter.
7. The test cylinder should be filled by the aggregate in three layers by tamping 25 times for each layer.
8. After filling the aggregate level the surface of the cylinder.
9. The plunger is placed on the level surface of the cylinder.
10. The test cylinder along with the plunger is placed on compression testing machine.
11. Load is then applied through the plunger at a uniform rate of 4 tonnes per minute until the total load is 40 tonnes, and releases the load.
12. Aggregate after crushing are removed from the cylinder and is sieved through 2.36 mm IS sieve.
13. Weigh the sample which is passed through the 2.36 mm IS sieve. Let the mass be W_3 g.
14. Weigh the empty cylindrical measure. Let the mass be W_1 g.
15. Repeat the above procedure for two more samples.
16. Aggregate crushing value is expressed in terms of percentage.

Result:

Average Aggregate Crushing Value (%) =

Observation:

Weight of empty cylindrical measure, W_1 (g) =

Weight of empty cylindrical measure along the aggregate, W_2 (g) =

Weight of dry aggregate, (W_2- W_1), W_d (g) =

Weight of aggregate passing through 2.36 IS sieve W_3 (g) =

Calculations:

Aggregate Crushing Value = $\{W_3/W_d\} * 100$

Where, W_3 = Weight of aggregate passing through 2.36 mm IS sieve

W_d = Weight of dry aggregate

Tabular column:

Items	Trail 1	Trail 2
Weight of empty cylindrical measure, W_1 (g)		
Weight of empty cylindrical measure along with aggregate, W_2 (g)		
Weight of dry aggregate, (W_2- W_1), W_d (g)		
Weight of aggregate passing through 2.36 mm IS sieve, W_3 (g)		
Aggregate Crushing Value, (%)		
Average Aggregate Crushing Value, (%)		

Los-Angeles Abrasion Value Test for Coarse Aggregate:-

Object: To determine the abrasion value of given coarse aggregate using Los-Angeles testing machine with an abrasive charge.

Apparatus: Los-Angeles testing machine, 1.75 mm IS sieve, Weighing balance, Oven, Set of sieves 80 mm, 63 mm, 50 mm, 40 mm, 25 mm, 20 mm, 12.5 mm, 10 mm, 6.3 mm, 4.75 mm, 2.36 mm.

Theory: The principle of Los-Angeles abrasion test is to find the percentage wear due to the relative rubbing action between the aggregate and the steel balls used as abrasive charge; pounding action of these balls also exist while conducting the test. Abrasion test on aggregate are generally carried out by any one of these methods:

(i) Los-Angeles Abrasion Test
(ii) Deval Abrasion Test
(iii) Dorry Abrasion Test

Abrasion test is carried out to test the hardness property of aggregates and to decide whether they are suitable for different pavement construction.

Type of Pavement Layer	Los-Angeles Abrasion Value (%)
Water Bound Macadam [WBM], Sub-base course	60
WBM base course with bituminous surfacing	50
Bituminous Macadam base course	50
Built-up spray grout base course	50
WBM surfacing course	40
Bituminous Macadam binder course	40
Bituminous Penetration Macadam	40
Built-up spray grout binder course	40
Bituminous carpet surface course	35
Bituminous surface dressing, single (or) two coat	35

Bituminous surface dressing, using pre-coated aggregate	35
Cement concrete surface course	35
Bituminous/Asphaltic concrete surface course	30
Cement concrete pavement surface course	30

Procedure:

1. Arrange the set of sieves i.e, 80-63, 63-50, 50-40, 40-25, 25-20, 20-12.5, 12.5-10, 10-6.3, 6.3-4.75, 4.75-2.36.
2. Pour the given coarse aggregate and sieve it for about 15 minutes.
3. Take 5 Kg of sample for the grading, A, B, C (or) D and 10 Kg of sample for the grading, E, F (or) G after sieving.
4. Pour the required quantity of sample into the Los-Angeles machine with different numbers of spheres which is specified in below table for different grading i.e, A, B, C, D, E and F.
5. Place the cover plate on the mouth of the machine.
6. The machine is rotated at a speed of 30-33 revolutions per minute.
7. The machine is rotated 500 revolutions for grading A, B, C (or) D and 1000 revolutions for grading E, F (or) G.
8. At the completion of the required revolutions, discharge the material carefully from the machine to tray.
9. Sieve the material through 4.75 mm sieve first.
10. Then sieve the finer portion through 1.70 mm IS sieve.
11. Collect the material which is retained on 1.70 mm IS sieve.
12. The material retained on 1.70 mm IS sieve is washed, dried in an oven at 105-110°C.
13. The Los-Angeles abrasive value is expressed in terms of percentage.

Result:

Average Los-Angeles Value (%) =

Grading	Weight in grams of each test sample in the size range, (mm)										Number of sphere
	80-63	63-50	50-40	40-25	25-20	20-12.5	12.5-10	10-6.3	6.3-4.75	4.75-2.36	
A	--	--	--	1250	1250	1250	1250	--	--	--	12
B	--	--	--	--	--	2500	2500	--	--	--	11
C	--	--	--	--	--	--	--	2500	2500	--	8
D	--	--	--	--	--	--	--	--	--	5000	6
E	2500	2500	5000	--	--	--	--	--	--	--	12
F	--	--	5000	5000	--	--	--	--	--	--	12
G	--	--	--	5000	5000	--	--	--	--	--	12

Observation:

Weight of dry sample taken, W_1 (g) =

Number of spheres used =

Calculations:

Los-Angeles Abrasion Value (%) = $\{W_1 - W_2\} / W_1 * 100$

Where, W_1 = Original mass of the test sample

W_2 = Final mass of the test sample

Tabular column:

Items	Trail 1	Trail 2
Original mass of the test sample, W_1 (g)		
Final mass of the test sample, W_2 (g)		
Loss in mass, (W_1- W_2) (g)		
Los-Angeles Abrasion Value (%)		
Average Los-Angeles Abrasion Value (%)		

Aggregate Impact Value Test for Coarse Aggregate:-

Object: To determine the aggregate impact value of a given aggregate sample.

Apparatus: Impact Testing Machine, Cylinder of diameter 7.5 cm and depth of 5 cm, Tamping rod, 12.5 mm, 10 mm, and 2.36 mm IS sieves, Weighing balance, Oven.

Theory: Toughness is the property of a material to resist impact. Due to traffic loads, the road stones are subjected to the pounding action (or) impact and there is possibility of stones breaking into smaller pieces. The road stones should therefore be tough enough to resist fracture under impact. Impact test may either be carried out on cylindrical stone specimens as in *"Page Impact Test"* (or) on stone aggregate as in *"Aggregate Impact Test"*. Aggregate Impact Values is as follows:

(a) < 10 % Exceptionally strong
(b) 10-20 % Strong
(c) 10-30 % Satisfactorily for road surface
(d) > 35 % Weak for road surfacing

Type of Pavement Layer	Aggregate Impact Value (%)
WBM, Sub-base course	50
Cement concrete, base course	45
WBM base course with bitumen surfacing	40
Built-up spray grout, base course	40
Bituminous Macadam, base course	35
WBM, surfacing course	30
Built-up spray grout, surfacing course	30
Bituminous Penetration Macadam	30
Bituminous Macadam, binder course	30
Bituminous surface dressing	30
Bituminous carpet	30
Bituminous/Asphaltic concrete	30
Cement concrete, surface course	30

Procedure:

1. Sieve the aggregate through 12.5 mm and retained on 10 mm IS sieves for standard test.
2. The aggregate should be in dry conditions.
3. Note down the empty mass of the cylindrical measure. Let the mass be W_1 g.
4. Fill the cylindrical measure with aggregate in three layers with 25 times tamping for each layer.
5. Struck off the excess aggregate on the top of the cylindrical measure.
6. Weigh the aggregate along the cylindrical measure. Let the mass be W_2 g.
7. Pour the aggregate from the cylindrical measure into the cup in three layers by tamping it by 25 times for each layer which is firmly fixed in the impact testing machine.
8. Hammer is raised up and allowed to fall freely on the aggregate.
9. The test sample is subjected to a total of 15 such blows.
10. Then collect the sample from the cup and sieve it through 2.36 mm IS sieve.
11. Weigh the sample which is passing through 2.36 mm IS sieve. Let the mass be W_3 g.
12. Repeat the procedure for two more samples.
13. Aggregate impact value is expressed in terms of percentage.

Result:

Average Aggregate Impact Value (%) =

Observation:

Weight of empty cylindrical measure, W_1 (g) =

Weight of empty cylindrical measure along the aggregate, W_2 (g) =

Weight of dry aggregate, (W_2-W_1), W_d (g) =

Weight of aggregate passing through 2.36 mm IS sieve, W_3 (g) =

Calculations:

Aggregate Impact Value (%) = $\{W_3/W_d\} * 100$

Where, W_3 = Weight of aggregate passing through 2.36 mm IS sieve

W_d = Weight of dry aggregate

Tabular column:

Items	Trail 1	Trail 2
Weight of empty cylindrical measure, W_1 (g)		
Weight of empty cylindrical measure along the aggregate, W_2 (g)		
Weight of dry aggregate, (W_2-W_1), W_d (g)		
Weight of aggregate passing through 2.36 mm IS sieve, W_3 (g)		
Aggregate Impact Value, (%)		
Average Aggregate Impact Value, (%)		

Flakiness Index Value Test for Coarse Aggregate:-

Object: To determine the flakiness indices of a given aggregate sample.

Apparatus: Standard thickness gauge, IS sieve of sizes 63 mm, 50 mm, 40 mm, 31.5 mm, 25 mm, 20 mm, 16 mm, 12.5 mm, 10 mm and 6.3 mm, Weighing balance.

Theory: *The flakiness index of aggregate is the percentage by weight of particles whose least dimensions (thickness) is less than 3/5 (0.6) of their mean dimension*. The test is not applicable to sizes smaller than 6.3 mm. The particle shape of aggregate is determined by the percentages of flaky and elongated particles contained in it. Thus evaluation of shape of the particles, particularly with reference to flakiness, elongation and angularity is necessary. Flakiness test is conducted on coarse aggregate to assess the shape of aggregate.

Type of Pavement Construction	Maximum Flakiness Index (%)
Bituminous carpet	30
Bituminous/Asphaltic concrete	25
Bituminous Penetration Macadam	25
Bituminous surface dressing	25
Bituminous Macadam	15
WBM, base and surfacing courses	15

Procedure:

1. Arrange the set of sieves i.e, 63-50, 50-40, 40-31.5, 31.5-25, 25-20, 20-16, 16-12.5, 12.5-10, 10-6.3.
2. Pour the given coarse aggregate and sieve it for about 10 minutes.
3. Collect 20 pieces of aggregate from each fraction of sieves which are retained and weight it separately.
4. Note down the mass of 20 pieces of aggregates from each fractions as W_1, W_2, W_3.....
5. The obtained aggregate samples are passed through the thickness gauge which is present in the flakiness index apparatus.
6. Collect the aggregates which passed through the thickness gauge separately.

7. Note down the mass of aggregates separately which are passed through the gauges of flakiness index apparatus as X_1, X_2, X_3.......
8. Flakiness index is expressed in terms of percentage.

Result:

Flakiness Indices of given sample of aggregate (%) =

Observation:

Total weight of aggregate from each fraction of sieves, ΣW (g) =

Total weight of aggregate which passed through the thickness gauge, ΣX (g) =

Calculations:

Flakiness Index (%) = $\{X_1+X_2+X_3+....../W_1+W_2+W_3+......\}$ (or) $\{\Sigma X/\Sigma W\}$

Where, ΣX = Total weight of aggregate which passed through thickness gauge

ΣW = Total weight of aggregate from each fraction of sieves

Tabular column:

Size of Aggregate		ΣX	ΣW
Passing through IS sieve (mm)	Retained on IS sieve (mm)	$= X_1+X_2+X_3...$	$= W_1+W_2+W_3...$
63	50		
50	40		
40	31.5		
31.5	25		
25	20		
20	16		
16	12.5		
12.5	10		
10	6.3		
	Total =		

Elongation Index Value Test for Coarse Aggregate:-

Object: To determine the elongation indices of a given aggregate sample.

Apparatus: Standard Metal Length gauge, IS sieve of sizes 63 mm, 50 mm, 40 mm, 31.5 mm, 25 mm, 20 mm, 16 mm, 12.5 mm, 10 mm and 6.3 mm, Weighing balance.

Theory: The elongation index of an aggregate is the property by weight of particles whose greatest dimensions (length) is greater than one and four fifth times (1.8 times) their mean dimension. The elongation test is not applicable to size smaller than 6.3 mm.

Procedure:

1. Arrange the set of sieves i.e, 63-50, 50-40, 40-31.5, 31.5-25, 25-20, 20-16, 16-12.5, 12.5-10, 10-6.3.
2. Pour the given coarse aggregate and sieve it for about 10 minutes.
3. Collect 20 pieces of aggregate from each fraction of sieves which are retained and weight it separately.
4. Note down the mass of 20 pieces of aggregates from each fractions as W_1, W_2, W_3.....
5. The obtained aggregate samples are passed through the length gauge which is present in the elongation index apparatus.
6. Collect the aggregates which are not passed through the length gauge separately.
7. Note down the mass of aggregates separately which are not passed through the gauges of elongation index apparatus as X_1, X_2, X_3.......
8. Elongation index is expressed in terms of percentage.

Result:

Elongation Indices of given sample of aggregate (%) =

Observation:

Total weight of aggregate from each fraction of sieves, ΣW (g) =

Total weight of aggregate which passed through the thickness gauge, ΣX (g) =

Calculations:

Elongation Index (%) = $\{X_1+X_2+X_3+....../W_1+W_2+W_3+......\}$ (or) $\{\Sigma X/\Sigma W\}$

Where, ΣX = Total weight of aggregate which are not passed through length gauge

ΣW = Total weight of aggregate from each fraction of sieves

Tabular column:

Size of Aggregate		ΣX	ΣW
Passing through IS sieve (mm)	Retained on IS sieve (mm)	= $X_1+X_2+X_3$...	= $W_1+W_2+W_3$...
63	50		
50	40		
40	31.5		
31.5	25		
25	20		
20	16		
16	12.5		
12.5	10		
10	6.3		
	Total =		

Angularity Number Test for Coarse Aggregate:-

Object: To determine the angularity number of a given aggregate sample.

Apparatus: Metal cylinder of capacity 3 litres which is closed at one end, Tamping rod, IS sieves of sizes 20 mm, 16 mm, 12.5 mm, 10 mm, 6.3 mm and 4.75 mm, Weighing balance.

Theory: The angularity number of an aggregate is the amount by which the percentage voids exceeds 33 after being compacted in a prescribed manner. Angularity (or) absence of the rounding of the particles of an aggregate is a property which is of important because it affects the ease of handling a mixture of aggregate and binders (or) the workability of the mix. The minimum allowable combined index of aggregates used in surface course in different types of pavement is 30 %.

Procedure:

1. Arrange the set of sieves i.e, 20-16, 16-12.5, 12.5-10, 10-6.3, 6.3-4.75.
2. The sample should be in dry conditions.
3. Pour the aggregate sample and sieve it for 10 minutes.
4. Collect the single sized aggregate retained between the specified pair of sieves.
5. Note down the mass of empty cylinder as W_1 (g).
6. Pour the aggregate sample into the cylinder in three layers with 100 blows for each layer.
7. Struck off the excess aggregate on the top of the cylinder.
8. Note down the mass of empty cylinder along the aggregate as W_2 (g).
9. Then cylinder is calibrated by determining the weight of water required to fill it.
10. Note down the weight of water required to fill the cylinder.
11. Repeat the procedure for two more samples.

Result:

Average Angularity Number of given sample of aggregate (%) =

Observation:

Weight of empty cylinder, W_1 (g) =

Weight of empty cylinder along the aggregate, W_2 (g) =

Mean weight of aggregate, (W_2-W_1), W =

Weight of water required to fill the cylinder, C (g) =

Specific Gravity of aggregate, G =

Calculations:

Angularity Number = 67-{100 * W/C * G}

Where, W = Mean weight of aggregate

C = Weight of water required to fill the cylinder

G = Specific Gravity of aggregate

Tabular column:

Items	Trail 1	Trail 2
Empty weight of cylinder, W_1 (g)		
Weight of empty cylinder along the aggregate, W_2 (g)		
Mean weight of aggregate, (W_2-W_1), W (g)		
Weight of water required to fill the cylinder, C (g)		
Specific Gravity of aggregate, G		
Angularity Number		
Average Angularity Number		

Specific Gravity and Water Absorption Test for Coarse Aggregate:-

Object: To determine the specific gravity and water absorption of a given aggregate sample.

Apparatus: Weighing balance, Oven, Wire basket, Container to store water and also to suspend the basket, Air tight container, Shallow tray, Absorbent clothes.

Theory: The specific gravity of an aggregate is considered to be measure of strength (or) quality of the material. Stones having low specific gravity are generally weaker than those with higher specific gravity values. The specific gravity test helps in identification of stone. Water absorption gives an idea of strength of rock. Stones having more water absorption are more porous in nature and are generally considered unsuitable unless they are found to be acceptable based on strength, impact and hardness tests.

Procedure:

1. Take about 5 Kg of aggregate sample.
2. It is thoroughly washed to remove the finer particles and dust adhering to the aggregate.
3. Pour the aggregate sample into the wire basket.
4. Immerse the wire basket along the aggregate into the container which is filled with water.
5. In order to remove the entrapped air the wire basket is lifted up and down for 25 times within the container.
6. Then wire basket along the aggregate is kept in water container for about 24 hours.
7. After 24 hours weigh the basket along the aggregate while suspended in water. Let the mass be W2 g.
8. Remove the basket from water container.
9. Transfers the aggregate samples to one of the dry absorbent clothe.
10. Weigh the empty wire basket. Let the mass be W1 g.
11. Then transfer the aggregate sample into another dry cloth and allow it dry for 10 minutes.
12. Note down the mass of surface dried aggregate. Let the mass be W3 g.
13. Thus the aggregate are placed in a shallow tray.
14. The shallow tray is then kept in a oven for 24 hours at a temperature of 110°C.
15. After 24 hours remove the shallow tray from the oven and cool it for 10 minutes.

16. Note down the mass of oven dry aggregate. Let the mass be W4 g.
17. Repeat the procedure for two more samples.

Result:

Average Specific Gravity of given sample of aggregate, G =

Average Water Absorption of given sample of aggregate, W =

Observation:

Weight of aggregate taken, W (g) =

Empty weight of wire basket, W_1 (g) =

Calculations:

Specific Gravity (G) = $\{W_4/W_3-(W_2-W_1)\}$

Water Absorption (W) (%) = $\{(W_3-W_4)/W_4\} * 100$

Where, W_4 = Weight of oven dry aggregate

W_3 = Weight of surface dried aggregate

W_1 = Weight of empty basket

W_2 = Weight of aggregate along the wire basket

Tabular column:

Items	Trail 1	Trail 2
Weight of empty wire basket, W_1 (g)		
Weight of empty wire basket along the aggregate, W_2 (g)		
Weight of saturated aggregate in water, (W_2-W_1), W (g)		
Weight of surface dried aggregate, W_3 (g)		
Weight of oven dry aggregate, W_4 (g)		
Specific Gravity, G		
Average Specific Gravity, G		
Water Absorption, W (%)		
Average Water Absorption, W (%)		

6. TESTS ON BITUMINOUS MATERIALS

Penetration Test for Bitumen:-

Object: To determine the consistency (or) penetration value of the given bitumen sample.

Apparatus: Cylindrical metallic container of 55 mm diameter and 35 mm (or) 57 mm in height, Needle, Water bath, Penetrometer, Transfer tray.

Theory: The consistency of bituminous materials vary depending upon several factors such as constituents, temperature etc... The consistency of bitumen is determined by penetration test which is very simple test. The penetration test determines the consistency of these materials for the purpose of grading them, by measuring the depth (in units are tenth of a millimetre (or) one hundredth of a centimetre) to which a standard needle will penetrate vertically under specified conditions of standard load, duration and temperature. The basic principle of the penetration test is the measurement of the penetration (in units of one tenth of a mm) of a standard needle in a bitumen sample maintained at 25°C during 5 seconds, the total weight of the needle assembly being 100 g. The penetration test is widely used world over for classifying the bitumen into different grades.

Bitumen Grade	A 25	A 35 & S 35	A 45 & S 45	A 65 & S 65	A 90 & S 90	A 200 & S 200
Penetration Value (mm)	20-30	30-40	40-50	60-70	80-100	175-225

Note: A = Assam product and S = other source.

Procedure:

1. The bitumen sample should be heated to a temperature of 75 to 100°C at which the bitumen softens.
2. The sample is thoroughly stirred to make it homogenous and free from air bubbles.
3. Pour the sample into the cylindrical metallic container to a depth of 15 mm.
4. The sample along the cylindrical metallic container is cooled in air for one hour and also in water bath for one hour.
5. After cooling place the cylindrical metallic container below the needle of the penetrometer.
6. The weight of assembly should be 100 g.

7. Draw down the needle of the penetrometer such that the needle should touches the top surface of the bitumen sample.
8. Note down the initial reading from the graduated scale when it touches the top surface.
9. Release the needle exactly for a period of 5 seconds by priming the knob and take the final reading from the graduated scale.
10. Repeat the same procedure for three different sides of the same sample.
11. The penetration value is measured in terms of milimeter.

Result:

Penetration Value of given bitumen sample (mm) =

Observation:

Pouring Temperature, °C =

Period of cooling in atmosphere, (min) =

Period of cooling in water bath, (min) =

Room Temperature, °C =

Tabular column:

Items	Trail 1	Trail 2	Trail 3	Trail 4
Initial reading (mm)				
Final reading (mm)				
Penetration Value (mm)				
Average Penetration Value (mm)				

Ductility Test for Bitumen:-

Object: To determine the ductility value of the given bitumen sample.

Apparatus: Briquette mould, Ductility machine, A constant water bath inside the machine.

Theory: In the flexible pavement construction where bitumen binders are used, it is of significant importance that the binders from ductile thin films around the aggregate. Ductility is the property of bitumen that permits it to undergo great deformation (or) elongation. Ductility is expressed in centimetres to which a standard briquette of bitumen can be stretched before the thread breaks.

Bitumen Grade	A 25	A 35	A 45	A 65	A 90	A 200	S 35	S 45	S 65	S 90
Ductility Value (cm)	5	10	12	15	15	15	50	75	75	75

Note: A = Assam product and S = other source.

Procedure:

1. The bitumen sample should be heated to a temperature of 75 to 100°C at which the bitumen softens.
2. The sample is thoroughly stirred to make it homogenous and free from air bubbles.
3. Pour the bitumen sample into the briquette mould with the side clips.
4. The sample along the mould is cooled in air for about 30 to 40 minutes and also cooled in water bath for about 30 minutes.
5. The sample and mould assembly are removed from water bath and excess bitumen is cut off by levelling the surface using hot knife.
6. After trimming the specimen, the mould assembly containing sample is replaced in water bath maintained at 27°C for 85 to 95 minutes.
7. The side clips are removed carefully.
8. Two or more specimens are prepared in order to conduct the trails.
9. The pointer of the machine is set to zero.
10. The machine is started and the two clips are thus pulled apart horizontally.
11. The ductility value is measured in terms of centimetre.

Result:

Ductility Value of given bitumen sample (cm) =

Observation:

Pouring Temperature, °C =

Period of cooling in atmosphere, (min) =

Period of cooling in water bath before trimming, (min) =

Period of cooling in water bath after trimming, (min) =

Room Temperature, °C =

Tabular column:

Items	Trail 1	Trail 2
Ductility Value (cm)		
Average Ductility Value (cm)		

Softening Point Test for Bitumen:-

Object: To determine the softening point of the given bitumen sample.

Apparatus: Steel balls, Brass rings, Metallic support, Bath, Stirrer.

Theory: *The softening point is the temperature at which the substance attains particular degree of softening under specified condition*. For bitumen, it is usually determined by *Ring and Ball test*. A brass ring containing the test sample of bitumen is suspended in liquid like water (or) glycerine at a given temperature.

Bitumen Grade	Softening Point, °C
A 25 & A 35	55-70
S 35	50-65
A 45, A 45 & A 65	45-60
S 65	40-55
A 90 & S 90	35-50
A 200 & S 200	30-45

Note: A = Assam product and S = other source.

Procedure:

1. The bitumen sample should be heated to a temperature of 75 to 100°C at which the bitumen softens.
2. The sample is thoroughly stirred to make it homogenous and free from air bubbles.
3. To avoid sticking of the bitumen to metal plate and rings coating is done with a solution of glycerine.
4. Pour the bitumen sample in heated rings placed on metal plate.
5. Then cool the rings in air for 30 minutes.
6. After cooling excess bitumen is trimmed off and the rings are placed in the support.
7. Start heating the water which is stored in ring ball apparatus by keeping the support in it.
8. Heating is continued until the bitumen sample softens and the balls sink to the bottom plate.
9. Note down the temperature at which balls touches the bottom plate.
10. This temperature will give the softening point of that bitumen sample.

11. Repeat the procedure for two more samples.

Result:

Softening Point Value of given bitumen sample (°C) =

Observation:

Bitumen Grade =

Liquid used in the bath =

Period of cooling in atmosphere, (min) =

Period of cooling in water bath, (min) =

Tabular column:

Items	Trail 1	Trail 2	Trail 3
Temperature at which ball one touches the bottom plate, (°C)			
Temperature at which ball two touches the bottom plate, (°C)			
Average, (°C)			

Specific Gravity Test for Bitumen:-

Object: To determine the specific gravity of the given bitumen sample.

Apparatus: Pycnometer, Weighing balance, Bitumen sample, Distilled water.

Theory: The density of a bitumen binder is a fundamental property frequently used as an aid in classifying the binders for use in paving jobs. In most applications, the bitumen is weighed, but finally in use with aggregate system, the bitumen content is converted on volume basis. Thus an accurate density value is required for conversion of weight to volume. The specific gravity is generally influenced by the chemical composition of binder. Increased amount of aromatic type compounds cause an increase in the specific gravity. *The specific gravity is defined as the ratio of the mass of a given volume of the bituminous material to the mass of an equal volume of water, the temperature of both being specified as 27°C.* Pure bitumen has a specific gravity in the range 0.97 to 1.02. The Indian Standard Institution specifies that the minimum specific gravity values of paving bitumen at 27°C shall be 0.99 for grades A 25, A 35, A 45, A 65, S 35, S 45 and S 65, 0.98 for A 90 and S 90 and 0.97 for A 200 and S 200.

Procedure:

1. Weigh the empty pycnometer. Let the mass of empty bottle be “a” g.
2. Fill the bottle with distilled water and weigh the bottle filled with water. Let the mass be “b” g.
3. The bitumen sample should be heated to a temperature of 75 to 100°C at which the bitumen softens.
4. Fill half the bitumen sample to the pycnometer.
5. The sample along the bottle is cooled for half an hour.
6. Note down the mass of half filled bitumen sample in the pycnometer. Let the mass be “c” g.
7. Remaining portion of the bottle is filled with distilled water and weigh it. Let the mass be “d” g.
8. Repeat the procedure for two more samples.

Result:

Specific Gravity Value of given bitumen sample G =

Observation:

Bitumen Grade =

Calculations:

Specific Gravity, (G) = {c-a}/{b-a}-{d-c}

Where, a = Weight of specific gravity bottle

b = Weight of the specific gravity bottle filled with water

c = Weight of specific gravity bottle half filled with bitumen

d = Weight of specific gravity bottle half filled with bitumen and with water

Tabular column:

Items	Trail 1	Trail 2	Trail 3
Weight of empty bottle, “a” (g)			
Weight of empty bottle + Water , “b” (g)			
Weight of empty bottle + Half filled bitumen, “c” (g)			
Weight of empty bottle + Half filled bitumen + Water, “d” (g)			
Specific Gravity, G			
Average Specific Gravity, G			

Viscosity Test for Bitumen:-

Object: To determine the viscosity of the given bitumen sample.

Apparatus: Orifice Viscometer consists of cup, Valve, Water bath, Sleeves, Stirrer, Receiver, Thermometer.

Theory: *Viscosity is defined as the inverse of fluidity*. Viscosity thus defines the fluid property of bituminous material. The degree of fluidity at the application temperature greatly influences the ability of bituminous material to spread, penetrate into the voids and also coat the aggregates and hence affects the strength characteristics of the resulting paving mixes.

Orifice size (mm)	4.0	4.0	10	10	10	10
Test Temperature (°C)	25	25	25	25	40	40
Viscosity range (sec)	25-75	30-150	10-20	25-75	14-45	60-140

Procedure:

1. Pour some amount of water into the viscosity appartus.
2. Pour the bitumen sample into the viscosity tube which is immersed in the water bath.
3. Heat the bitumen sample at a temperature of 20°C above the specified test temperature.
4. Heating is continued until the bitumen sample softens.
5. Place a cup below the orifice hole of the viscosity appartus in which a 10 cc of soap solution is already present in that cup.
6. Then lift the stirrer which is placed on the top of the orifice hole.
7. When the bitumen sample flows readily from the orifice hole start the stop watch at that time.
8. Thus a 50 cc of bitumen sample is filled into the cup then stop the watch and note down the time in seconds.
9. This gives the viscosity of that bitumen sample in seconds.
10. Repeat the procedure for two more samples.

Result:

Viscosity Value of given bitumen sample (sec) =

Observation:

Bitumen Grade =

Specified test temperature, °C =

Size of the orifice hole, (mm) =

Actual test temperature, °C =

Tabular column:

Items	Trail 1	Trail 2	Trail 3
Viscosity (sec)			
Average Viscosity (sec)			

Flash and Fire Point Test for Bitumen:-

Object: To determine the flash and fire point of the given bitumen sample.

Apparatus: Pensky-Martens closed tester, Pensky-Martens open tester.

Theory: The *flash point* of a material is the lowest temperature at which the vapour of substance momentarily takes fire in the form of a flash under specified conditions of test. The *fire point* is the lowest temperature at which the material gets ignited and burns under specified condition of test.

Procedure:

1. Pour the bitumen sample into the brass cup.
2. Place the thermometer on the surface of bitumen sample in which the thermometer is coated with glycerine.
3. Start heating the bitumen sample.
4. While heating to a certain temperature the bitumen sample causes a bright flash which gives the flash point of that bitumen sample.
5. Heating is continued until the bitumen sample catches fire which gives the fire point of that bitumen sample.
6. Repeat the procedure for two more different samples.

Result:

Flash Point of given bitumen sample (°C) =

Fire Point of given bitumen sample (°C) =

Observation:

Bitumen Grade =

Tabular column:

Items	Trail 1	Trail 2	Trail 3
Flash Point (°C)			
Fire Point (°C)			

Marshall Stability Test for Bitumen:-

Object: To determine the maximum stability, maximum bulk density and percent air voids of the given bitumen sample.

Apparatus: Mould assembly, Sample extractor, Compaction pedestal and hammer, breaking head, Loading machine, Flow meter, Oven on hot plate, Mixing apparatus, Water bath, Thermometer.

Theory: Bruce Marshall, formerly bituminous engineer with Mississippi State Highway Department, USA formulated Marshall method for designing bituminous mixes. Marshall's test procedure was later modified and improved upon by U.S. Corps of Engineers through their extensive research and correlation studies. In this method, the resistance to plastic deformation of cylindrical specimen of bituminous mixture is measured when the same is loaded at the periphery at 5 cm per minute. This test procedure is used in designing and evaluating bituminous paving mixes. There are two major features of the Marshall method of designing mixes namely (i) density-voids analysis (ii) stability flow test. The *Marshall stability of mix is defined as a maximum load carried by a compacted specimen at a standard test temperature at 60°C.*

Procedure:

1. First weigh the required quantity of dry materials i.e, coarse aggregate, fine aggregate and filler material.
2. The aggregates and filler material are mixed together in the desired proportion as per the design requirements and fulfilling the specified gradation.
3. The required quantity of the mix is taken so as to produce a compacted bituminous mix specimen of thickness 63.5 mm approximately.
4. Take about 1200 g of aggregates and filler are taken and heated to a temperature of 175° to 195°C.
5. The compaction mould assembly and rammer are cleaned and kept pre-heated to a temperature of 100° to 145°C.
6. The bitumen sample is heated to temperature of 121° to 138°C.
7. Add the heated bitumen to the heated aggregate say 3.5 % by weight and mixed using mechanical mixer (or) by hand mixing using trowel.

8. The mix is placed in a mould and compacted by a rammer with 50 blows on either side.
9. The compacted specimen should have a thickness of 63.5 mm.
10. Prepare two more samples of the same mix.
11. Five graphs are plotted with values of bitumen content against the values of:
    - (i) Density
    - (ii) Marshall stability
    - (iii) Voids in total mix
    - (iv) Flow value
    - (v) Voids filled with bitumen

Result:

Maximum Stability of bitumen sample =

Maximum Bulk Density of bitumen sample =

Percent air voids of bitumen sample =

Observation:

Bitumen grade =

Proving Ring Calibration factor =

Number of blows on either side =

Type of grading aggregate =

Calculations:

Specific Gravity, $G_t = \{100/(W_1/G_1)+(W_2/G_2)+(W_3/G_3)+(W_4/G_4)\}$

Where, W_1 = percent by weight of coarse aggregate

W_2 = percent by weight of fine aggregate

W_3 = percent by weight of filler

W_4 = percent by weight of bitumen in total mix

Bulk Density is calculated be means of weight and volume. The specimens are also weighed in air and then in water. Soon after the compacted bituminous mix specimens have cooled to room temperature, the weight, average thickness and diameter of the specimen are noted.

Voids analyses are made as given below:

$$V_v\ (\%) = \{100 * (G_t - G_b)/G_t\}$$

$$V_b\ (\%) = G_b * \{W_4/G_4\}$$

$$VMA\ (\%) = V_v + V_b$$

$$VFB\ (\%) = \{100 * V_b\}/VMA$$

7. TEST ON SOIL

Sand Replacement Test for Soil:-

Object: To determine the density, voids ratio and degree of saturation of given soil sample by sand replacement method.

Apparatus: Sand pouring cylinder, Square metal tray of size 30 * 30 * 40 cm with 10 cm diameter hole, Sand, Weighing balance, Knife, Steel scale, Oven.

Theory: Density is defined as the mass of the soil per unit volume. Density is used in calculating the stress in the soil due to its overburden pressure. It is needed in estimating the bearing capacity of soil foundation system, settlement of footing, earth pressure behind the retaining walls, dams, embankments. Permeability of soils depends upon its density. The density of natural soils can be determined by the following methods:

(a) Core cutter method
(b) Sand replacement method
(c) Water displacement method
(d) Rubber balloon method.

The density can be expressed in terms of g/cm^3 (or) Kg/m^3. Sand replacement method is also used to find the density of soil next to core cutter method.

Procedure:

(a) Determination of density of sand:

1. Measure the height and diameter of the calibrating container.
2. Fill the pouring cylinder with sand within about 1 cm of the top.
3. Note down the mass of pouring cylinder along the sand. Let the mass be W_1 g.
4. Place the pouring cylinder on the top of the calibrating container.
5. Open the shutter of the pouring cylinder till the calibrating container is filled and closes the shutter.
6. Note down the mass of poring cylinder along with sand after pouring to calibrating container. Let the mass be W_2 g.
7. Place the pouring cylinder on the glass plate and open the shutter.
8. When pouring of sand is stopped then close the shutter of the pouring cylinder.

9. Note down the mass of pouring cylinder along the sand after pouring on glass plate. Let the mass be W_3 g.
10. Thus bulk density of sand is obtained.

(b) <u>Determination of density of soil:</u>

1. First select the clean and level ground.
2. Place the metal tray with the central hole over the portion of soil to be tested.
3. Excavate the soil through that hole up to a depth of 15 cm.
4. Collect the soil sample which is excavated to a tray.
5. Note down the mass of excavated soil. Let the mass be W g.
6. Fill the pouring cylinder with sand within about 1 cm of the top.
7. Note down the mass of pouring cylinder along the sand. Let the mass be W_1 g.
8. Place the pouring cylinder over the hole which is excavated and open the shutter.
9. Close the shutter when pouring is stopped.
10. Note down the mass of pouring cylinder along the sand after pouring into that hole. Let the mass be W_2 g.
11. Again place the pouring cylinder on the glass plate and open the shutter.
12. Close the shutter after pouring and note down the mass of pouring cylinder along the sand after pouring on glass plate. Let the mass be W_3 g.
13. Thus bulk density of soil is obtained.
14. Determine the water content of the excavated soil.

Result:

Bulk Density of Sand, γ_{bsand} (g/cm^3) =

Bulk Density of Soil, γ_{bsoil} (g/cm^3) =

Dry Density of Soil, γ_{dsoil} (g/cm^3) =

Voids Ratio, e =

Degree of Saturation, S (%) =

Observation:

Internal diameter of calibrating container, d (cm) =

Internal height of calibrating container, h (cm) =

Cross-Sectional area of container, A (cm^2) = {3.14 * d^2/4}

Volume of calibrating container, V (cm^3) = {A * h}

Specific Gravity of soil, G = 2.70 [Given (or) Assumed]

Calculations:

Bulk Density of Sand, γ_{bsand} (g/cm^3) = {W'_6/V}

Bulk Density of Soil, γ_{bsoil} (g/cm^3) = {W/W_6} * γ_{bsand}

Dry Density of Soil, γ_{dsoil} (g/cm^3) = {γ_{bsoil}/(1+w)}

Voids Ratio, e = {G_s * γ_w/ γ_{dsoil}}-1

Degree of Saturation, S (%) = {G_s * w/ e} * 100

Where, W'_6 = Mass of sand in cylinder

W = Mass of excavated sand

W_6 = Mass of sand in the hole

γ_w = 9.81 (or) 1

G_s = Specific Gravity of soil

w = Water Content

e = Voids Ratio

Tabular column:

Items	Trail 1	Trail 2
Mass of pouring cylinder + Sand [Before Pouring], W_1 (g)		
Mass of pouring cylinder + Sand [After Pouring], W_2 (g)		
Mass of pouring cylinder + Sand [Pouring on Glass Plate], W_3 (g)		
Mass of sand for filling the calibrating cylinder and cone, (W_1-W_2), W_4 (g)		
Mass of sand for making the cone only, (W_2-W_3), W_5 (g)		
Mass of sand in the calibrating cylinder only, (W_4-W_5), W'_6 (g)		
Bulk Density of Sand, γ_{bsand}, (g/cm^3)		
Average Bulk Density of Sand, γ_{bsand}, (g/cm^3)		

Tabular column:

Items	Trail 1	Trail 2
Mass of pouring cylinder + Sand [Before Pouring], W_1 (g)		
Mass of pouring cylinder + Sand [After Pouring], W_2 (g)		
Mass of pouring cylinder + Sand [Pouring on Glass Plate], W_3 (g)		
Mass of sand used in hole and cone, (W_1-W_2), W_4 (g)		
Mass of sand used in cone only, (W_2-W_3), W_5 (g)		
Mass of sand used in hole only, (W_4-W_5), W_6 (g)		
Mass of excavated soil, W (g)		
Bulk Density of soil, γ_{bsoil} (g/cm^3)		
Dry Density of soil, γ_{dsoil} (g/cm^3)		
Voids Ratio, e		
Degree of Saturation, S (%)		

Tabular column:

Items	Trail 1	Trail 2
Mass of crucible, W_1 (g)		
Mass of crucible + Wet soil, W_2 (g)		
Mass of crucible + Dry soil, W_3 (g)		
Mass of Water, (W_2-W_3), W_w (g)		
Mass of Dry Soil, (W_3-W_1), W_d (g)		
Water Content, (W_w/W_d) *100, w (%)		

-

California Bearing Ratio Test for Soil:-

Object: To determine the California bearing ratio of the given soil sample.

Apparatus: Loading machine, Plunger of diameter of 50 mm, Cylindrical moulds, Compaction rammers, Annular weights, Adjustable stem, Perforated plate, Tripod, Dial gauge Annular weight.

Theory: The California Bearing Ratio (CBR) test was developed by the California Division of Highway as a method of classifying and evaluating soil-sub grade and base course materials for flexible pavements. The CBR is a measure of resistance of a material to penetration of standard plunger under controlled density and moisture conditions. The test procedure should be strictly adhered if high degree of reproducibility is desired. The CBR test may be conducted in re-moulded (or) undisturbed specimen in the laboratory. The test is simple and has been extensively investigated for field correlations of flexible pavement thickness requirement.

Penetration (mm)	Standard Load (Kg)	Unit standard load (Kg/cm^2)
2.5	1370	70
5.0	2055	105
7.5	2630	134
10.0	3180	162
12.5	3600	183

Procedure:

1. The soil is sieved through 20 mm sieve and 5 kg of soil is weighed accurately.
2. Add water to it to bring the moisture content to about 4 % for coarse grained soil and 8 % for fine grained soils.
3. Clean the mould and fix it to the base.
4. The spacer disc is placed at the bottom of the mould over the base plate and a coarse filter paper is placed over the spacer disc.
5. For IS heavy compaction (or) the modified proctor compaction, the soil is divided into five equal parts; the soil is compacted in five equal layers, each of compacted by applying 56 evenly distributed blows of the rammer.

6. After compacting the last layer, the collar is removed and the excess soil above the top of the mould is evenly trimmed off by means of the straight edge.
7. The clamps are removed and the mould with the compacted soil is lifted leaving below the perforated base plate and the spacer disc which is removed.
8. The mould with the compacted soil is weighed.
9. A filter paper is placed on the perforated base plate, the mould with compacted soil is inverted and placed in position over the base plate (such that the top of the soil is now placed over the base plate) and the clamps of the base plate are tightened.
10. Another filter paper is placed on the top surface of the sample and the perforated plate with adjustable stem is placed over it.
11. Surcharge weights of 2.5 (or) 5.0 Kg weight are placed over the perforated plate and the whole mould with the weights is placed in a water tank for soaking.
12. Soaking of the soil specimen for four full days (or) 96 hours.
13. The mould is taken out of the water tank and the sample is allowed to drain in a vertical position for 15 minutes.
14. The mould with the specimen is clamped over the base plate and the same surcharge weights are placed on the specimen centrally such that the penetration test could be conducted.
15. The mould with the base plate is placed under the penetration plunger of the loading machine.
16. The penetration plunger is seated at the centre of the specimen and is brought in contact with top surface of the soil sample by applying a seating of 4 Kg.
17. Dial gauge for measuring the penetration values of the plunger is fitted in position.
18. The dial gauge of the proving ring and the penetration dial gauge are set to zero.
19. The load is applied to penetration plunger at a uniform rate of 2.15 mm/min.
20. The load readings are recorded at penetration reading of 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, 5.0, 7.5, 10.0 and 12.5 mm.
21. The proving ring calibration factor is noted so that the load dial values can be converted into load in Kg.
22. Repeat the procedure for two more different samples.
23. Plot a graph of penetration (mm) on x-axis and load (Kg/cm^2) on y-axis in order to find the unit load carried by the soil sample.

Result:

California Bearing Ratio Value of given soil sample (%) =

Observation:

Compacting moisture content =

Condition of test specimen =

Proving ring constant (N/Div) = {Load/Divisions}

Method used for compaction =

Calculations:

California Bearing Ratio, (%) = {unit load carried by soil sample at defined penetration level/unit load carried by standard crushed stones at above penetration level} * 100.

Note: California Bearing Ratio is found only for 2.5 and 5.0 mm penetration values.

Tabular column:

Penetration (mm) (1)	Proving ring reading (2)	Dial gauge reading (3)	Load on plunger (Kg) (4)	Corrected load (Kg) (5) * PRC	Unit load (Kg/cm^2) (6)/19.635
0.0					
0.5					
1.0					
1.5					
2.0					
2.5					
3.0					
4.0					
5.0					
7.5					
10.0					
12.5					

Note: The load values noted for each penetration level are divided by the area of the loading plunger **(19.635 cm2)** to obtain the **pressure (or) unit load** values on the loading plunger. The unit load values corresponding 2.5 and 5.0 mm penetration values are found from the graph.

8. Definitions

Absorption (air dry basis). The percentage of water absorbed by an air dried aggregate, when immersed in water at 20°C for period of 24 hours.

Absorption (oven dry basis). The percentage of water absorbed by an aggregate when immersed in water at 27°C for 24 hours, the aggregate being previously dried in an oven to a constant mass.

Accelerator. An admixture, which increases the rate of hardening. The early strength admixture is calcium chloride which is used at the rate of 1 Kg/bag.

Admixture. A material other than aggregates, cement and water added in small quantities to the concrete immediately before (or) during its mixing (or) during the manufacture of cement to produce some desired modifications in one (or) more of its properties.

Aggregate Crushing Test. A test of resistance offered by an aggregate to crushing under specified conditions.

Aggregate Impact Test. A test of resistance offered by an aggregate to impact under specified conditions of the test.

Air Entraining Agent. An admixture to the concrete which causes small quantity of air to be entrained in the form of small discrete air voids in the concrete during mixing operation, thus increasing its workability and its resistance to the action of frost.

Air Voids. Voids in concrete resulting from incomplete compaction. In hardened volume excluding the natural voids in the aggregate particles.

Apparent Specific Gravity. It is the ratio of the mass of oven dry aggregate to its absolute volume excluding the natural voids in the aggregate particles.

Bleeding. The formations of thin layer of water cement slurry on the exposed surface of concrete after compaction.

Bulk Density. The mass of a material per unit volume.

Bulking. The increase in volume of a mass of sand (or) other fine granular material due to variation in moisture contents.

Compaction. The process of removing air from concrete after deposition.

Concrete. A mixture of inert aggregates, cement and water with (or) without admixtures.

Crushing Strength. The load sustained per unit cross-sectional area of concrete specimen in a compression test carried out under standard conditions.

Flexural Strength. The strength of the material of a beam subjected to bending stress, generally expressed as the modulus of rupture.

Ordinary Portland Cement. A hydraulic cement made by heating to a high temperature a mixture of clay and limestone, and grinding the resulting clinker to a fine powder.

Segregation. It is the separation of particles of different sizes (or) different materials in concrete, resulting from gravitation, centrifugal (or) other forces during handling.

Slump. The vertical distance through which the top of the unsupported moulded mass of freshly mixed concrete sinks on removal of the mould, under specified conditions of the test.

Water-cement Ratio. The ratio of the mass of water in a concrete mix, exclusive of that absorbed by the aggregate, to the mass of cement.

Workability. That property of freshly mixed concrete, which determines the ease with which it can be placed and amount of internal energy required to produce complete compaction.

Initial Setting Time. The time required by freshly mixed paste of water and cement to acquire an arbitrary degree of stiffness as determined by a specific test.

Final Setting Time. The time required by a freshly mixed paste of water and cement to acquire an arbitrary degree of stiffness greater than that at initial setting time as determined by specific test.

Specific Surface. Total surface area per unit mass of cement (or) of an aggregate. The surface area affects the amount of mixing water and cement to obtain required workability and also degree of compaction.

Creep. A slow plastic deformation (or) movement of material under stress.

Bulk Specific Gravity. Ratio of the mass of aggregate dried to a constant mass in an oven at 100°C to its absolute volume including the natural voids in the aggregate.

Hydration of Cement. The chemical reactions that take place between cement and water is referred as hydration of cement.

Heat of Hydration. The reaction of cement with water is exothermic. The reaction liberates a considerable quantity of heat. This liberation of heat is called heat of hydration.

Factors Affecting Workability. Water Content, Mix Proportions, Size of Aggregates, Shape of Aggregates, Surface Texture of Aggregates, Grading of Aggregate and Use of Admixtures.

Measurement of Workability. Slump Test, Compacting Factor Test, Flow Test, Kelly Ball Test and Vee-Bee Consistometer Test.

Segregation. Can be defined as the separation of the constituent materials of concrete.

Bleeding. Is sometimes referred as water gain. It is particular form of segregation, in which some of the water from the concrete comes out to the surface of the concrete.

Process of Manufacture of Concrete. Batching, Mixing, Transporting, Placing, Compacting, Curing and Finishing.

Effect of Maximum size of Aggregate on Strength.

Relation Between Compressive and Tensile Strength.

Relation between Modulus of Elasticity and Strength.

Factors Affecting Modulus of Elasticity.

Creep. Can be defined as the time-dependent part of the strain resulting from stress.

Factors Affecting Creep. Influence of Aggregate, Influence of Mix Proportions, Influence of Age, Effects of Creep.

Shrinkage. Plastic Shrinkage, Drying Shrinkage, Autogeneous Shrinkage and Carbonation Shrinkage.

Durability. The durability of cement concrete is defined as its ability to resist weathering action, chemical attack, abrasion (or) any other process of deterioration.

Grading of Fine Aggregate:-

The grading of a fine aggregate when determined in accordance with IS : 2386 (Part I)-1963 shall be within the limits given in Table below.

IS Sieve designation	Percentage passing for			
	Grading Zone I	Grading Zone II	Grading Zone III	Grading Zone IV
10 mm	100	100	100	100
4.75 mm	90-100	90-100	90-100	95-100
2.36 mm	60-95	75-100	85-100	95-100
1.18 mm	30-75	55-90	75-100	90-100
600 micron	15-34	35-59	60-79	80-100
300 micron	5-20	8-30	12-40	15-50
150 micron	0-10	0-10	0-10	0-10

General Characteristics of Aggregates:-

Aggregate	Bulk Density (Kg/liter)
Fine sand	1.44
Medium Sand	1.52
Coarse Sand	1.60
Crushed Stone	1.60
Crushed Granite	1.68
Shingle	1.60
Stone Screening	1.44
Broken Bricks	1.45
Brick Dust (Surkhi)	1.01
Slag	0.70

Items	Sand	Gravel	Granite
Specific Gravity	2.65	2.66	2.80

9. Indian Standards

[1]. IS : 269-1976 (Third revision) Specifications for ordinary and low heat Portland cements.

[2]. IS : 383-1970 (Second revision) Specifications for coarse and fine aggregate from natural sources for concrete.

[3]. IS : 455-1976 (Third revision) Specifications for portland slag cement.

[4]. IS : 456-1978 (Third revision) Code of practice for plain and reinforced concrete.

[5]. IS : 460 (Part I)-1978 (Second revision) Test Sieves : Part I-wire cloth test sieves.

[6]. IS : 460 (Part II)-1978 (Second revision) Test Sieves : Part II-perforated plate test sieves.

[7]. IS : 516-1959 Methods of test for strength of concrete.

[8]. IS : 650-1966 (Reaffirmed 1980) Standard sand for testing of cement.

[9]. IS : 1199-1959 Methods of sampling and analysis of concrete.

[10]. IS : 1343-1980 (First revision) Code of practice for pre-stressed concrete.

[11]. IS : 1489-1976 (Second revision) Specification for portland pozzolana cement.

[12]. IS : 2386 (Part I)-1963 Methods of test for aggregates for concrete : Part I-particle size and shape.

[13]. IS : 2386 (Part II)- 1963 Methods of test for aggregate for concrete : Part II-estimation of deleterious materials and organic impurities.

[14]. IS : 2386 (Part IV)- 1963 Methods of test for aggregates for concrete : Part IV-mechanical properties.

[15]. IS : 2386 (Part V)- 1963 Methods of test for aggregates for concrete : Part V-soundbess.

[16]. IS : 2386 (Part VI)-1963 Methods of test for aggregates for concrete : Part VI-measuring mortar making properties of fine aggregate.

[17]. IS : 2386 (Part VIII)- 1963 Methods of test for aggregates for concrete : Part VII-alkali aggregate reactivity.

[18]. IS : 2430-1969 Sampling of aggregates.

[19]. IS : 2686-1977 (First revision) Specifications for cinder aggregate for use in lime concrete.

[20]. IS : 2770 (Part I)- 1967 Method of testing bond in reinforced concrete : Part I-pull out test.

[21]. IS : 3370 (Part I)- 1965 Code of practice for concrete structures for storage of liquids : Part I-general requirements.

[22]. IS : 3812 (Part II)- 1981 Specifications for fly ash : Part II-for use as additive.

[23]. IS : 4031-1968 Methods of physical tests for hydraulic cement.

[24]. IS : 4032-1968 Methods of chemical analysis of hydraulic cement.

[25]. IS : 4634-1968 Method for testing performance of batch type concrete mixer.

[26] IS : 4845-1968 (Redffirmed 1980) Definitions and terminology relating to hydraulic cement.

[27]. IS : 5640-1970 Method of test for determining aggregate impact value of soft coarse aggregate.

[28]. IS : 5816-1970 Method of test for splitting tensile strength of concrete cylinders.

[29]. IS : 6441 (Part I) - 1972 Methods of test for autoclaved cellular concrete products : Part I-determination of unit weight (or) bulk density and moisture content.

[30]. IS : 6441 (Part II) – 1972 Methods of test for autoclaved cellular concrete products : Part II-determination of drying shrinkage.

[31]. IS : 10262-2000 Recommended guidelines for concrete mix design.

[32]. IS : 9399-1979 Apparatus for flexural testing of concrete.

10. Viva Questions

1. What is cement? What are the factors affecting the strength of cement?
2. Name the various physical properties of cement along with its values. Give their importance.
3. Name the ingredients used in the manufacturing of cement and give the roles played by them.
4. Why cement is known as hydraulic cement? What are exothermic and hydroscopic reactions?
5. Explain initial and final setting times of cement and give their importance.
6. What is normal (or) standard consistency of cement? Why it is required?
7. What are causes and effects of unsoundness of cement? How are they determined and rectified?
8. Name different types of cements and give their uses.
9. What are the standard tests conducted on cements and give their significance?
10. Explain briefly the process of hardening of cement?
11. What is the significance of fineness of cement? How it is expressed? How it is determined?
12. Why the compressive strength of cement is determined using mortar cubes? What is its significance?
13. How do you determine the tensile strength of cement? Give its importance.
14. What are aggregates? Why are they used in concrete and give the roles played by them.
15. How aggregates are classified?
16. Why a semi-log graph is used in plotting the grading curves of aggregates?
17. What is meant by gradation of aggregate and why is it required?
18. What is fineness modulus? What is its importance? Give the fineness modulus of various aggregate.
19. What are the tests conducted on aggregate and give their importance?
20. What is flakiness index?
21. What is elongation index?
22. What is soundness of aggregate?
23. What is concrete? Discuss briefly the roles played by the constituents of the concrete.
24. What is modular ratio? Give the modular ratio as per IS : 456 ¾ 1978.

25. Define workability and optimum workability of concrete.
26. What are accelerators and retarders? What are their applications?
27. What is compaction of concrete? What are the various methods of compaction of concrete?
28. What is modulus of rupture? How is it determined? What are its practical applications?
29. Define segregation of concrete.
30. Define bleeding of concrete.
31. What are the practical application of CBR test on soils and other pavement materials?
32. What are the desirable properties of road aggregates? Mention their relative importance.
33. What is stripping of bitumen? How does it occur?
34. Mention the various tests on bitumen and the objects of each.
35. What is meant by softening point of bitumen? What is the importance of this test?
36. How are tars classified? Kist the common tests on tar.
37. What are the desirable properties of road aggregates in general?
38. What are the uses and applications of the aggregate crushing test?
39. What are the applications of aggregate crushing test?
40. Discuss the importance of specific gravity test on road aggregates.
41. Define true and apparent specific gravity of aggregate.
42. What are the applications of shape tests?
43. What is the significance of shape of aggregate in pavement construction?
44. How is penetration value of bitumen expressed?
45. What are the factors affecting the ductility tests results?
46. What are the applications of ring and ball test results?
47. What are the factors which affect the ring and ball test results?
48. What are the applications of specific gravity of bitumen and results?
49. Explain the term viscosity.
50. What are the uses of viscosity test?
51. Define flash and fire points.
52. Differentiate between flash and fire point.
53. What are the essential properties of bituminous mixes?
54. What is the significance of flow value in Marshall test?
55. What is filler?

56. List out various tests on Cement?
57. List out various tests on Fine Aggregate?
58. List out various tests on Coarse Aggregate?
59. What do you know about NDT?
60. List out various equipment used in NDT?
61. Explain about Admixtures?
62. Vicat Apparatus is used for?
63. Initial Setting Time of OPC?
64. Final Setting Time of OPC?
65. List out Grades of Cement available in Market?
66. Apparatus used for Soundness of Cement?
67. Which equipment is used to test Compression Strength of Concrete?
68. Explain about grading of aggregate?
69. Workability Means?
70. List out Workability Tests?
71. Slump value required for RCC Slab?
72. What is Segregation of concrete?
73. List out various sizes of Coarse Aggregate used in Concrete?
74. Equipment used to test Compression Strength of Concrete?
75. Size of Concrete Cubes?
76. What is the standard w/c value for nominal mix of concrete?
77. Density of Concrete?
78. No. of Cube samples required for testing Compression Strength for 100 m^3 of concrete?
79. What is Concrete Maturity?
80. Aggregate Impact value of material A is 15 and that of B is 35. Which one is better?
81. Explain aggregate crushing value. How would you express?
82. Aggregate crushing value of material A is 40 and that of B is 25. Which one is better and why?
83. How is aggregate impact value expressed?
84. Nominal Mix vs Design Mix?
85. How to increase initial setting time of concrete?
86. Explain about the influence of W/C ratio?
87. List out some of Admixtures available in market?

88. Plasticizers are used for?
89. Size of cube used for testing of Compression Strength of Cement?
90. Mix proportions of M30 grade concrete?
91. Define specific gravity?
92. Equipment used for Abrasion Test?
93. Equipment used for Attrition Test?
94. List out Shape Tests on Coarse Aggregate?
95. The abrasion value found from Los Angeles test for two aggregates A and B are 50% and 38% respectively. Which aggregate is harder?
96. Two materials have abrasion values 3 and 10 respectively. Which one is harder and why?