HIGHWAY ENGINEERING

Chapter:-03

ROAD MATERIALS

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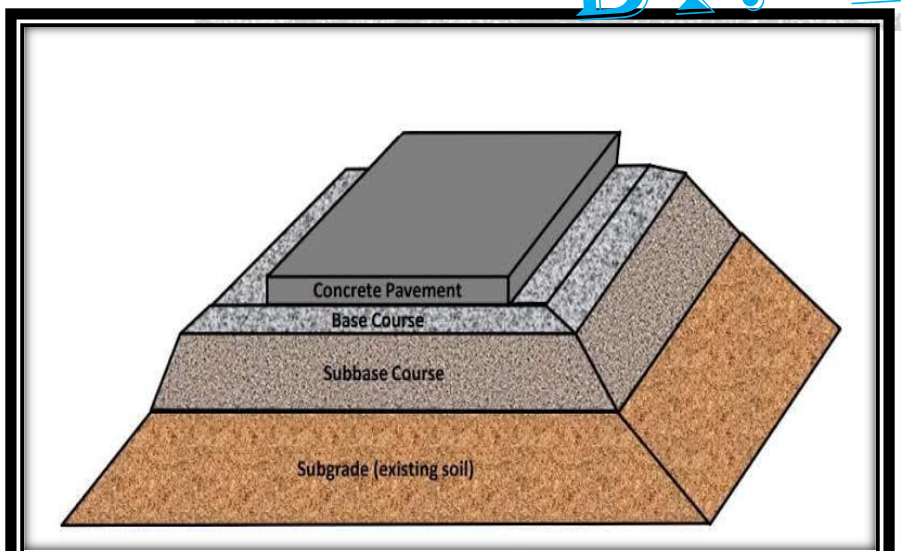

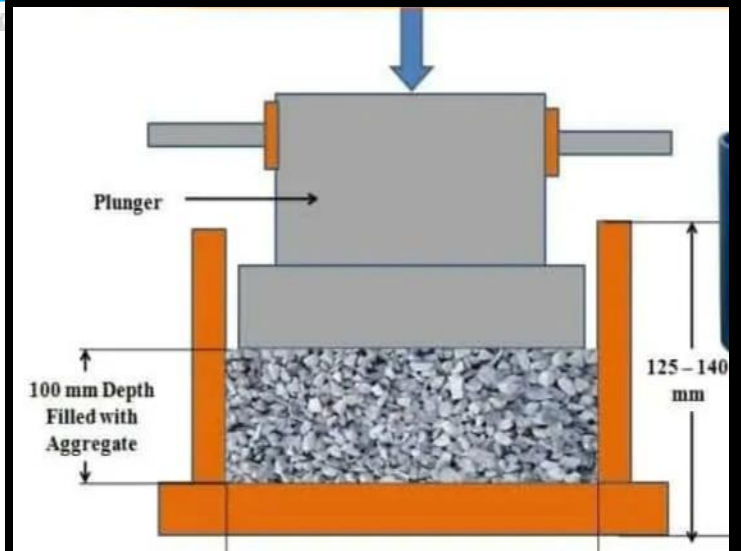

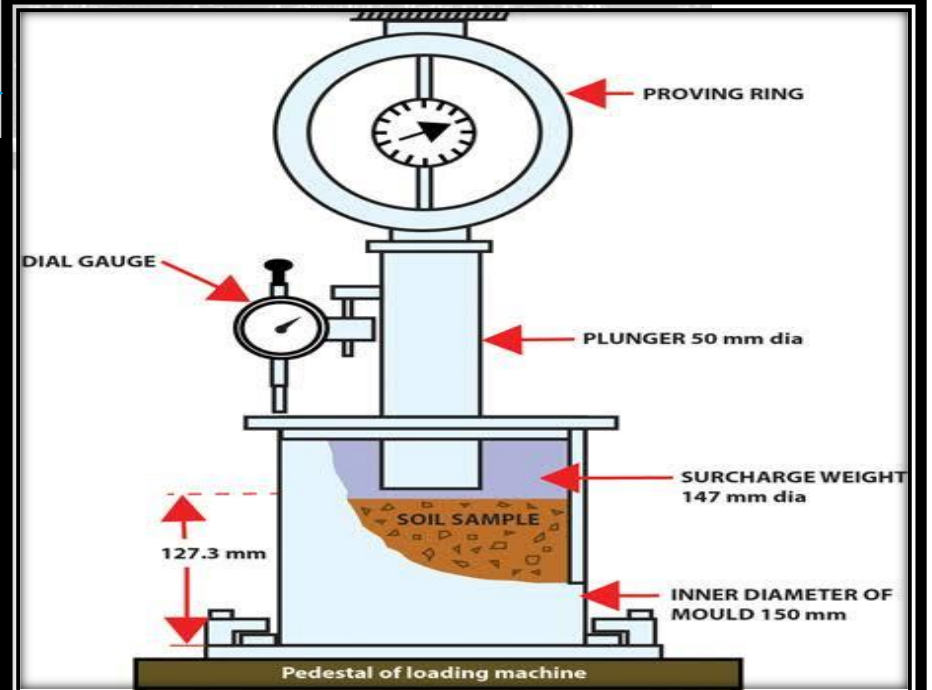

3 ROAD MATERIALS

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3.1 DIFFERENT TYPES OF ROAD MATERIALS IN USE: SOIL, AGGREGATES, AND BINDERS

INTRODUCTION

- The various materials used for constructing the road pavement are termed as "Road Materials".
- The different road materials in use such as soil, aggregate and binders must be tested as per IRC specifications before using them in road construction.
- The soil is considered as one of the principal highway materials used in road construction as they from the major portion of the pavement structure. They should be sufficiently strong to withstand the stresses due to traffic wheel loads.
- The bituminous materials like bitumen and tar or cements are principally used as binder for road aggregates and as water proofing materials.

- ***SOILS***

- A soil may be defined as "the top layer of ground consisting of a mixture of earthy materials with particles varying in size, shape, structure and chemical composition.“
- All road structure are supported by soils.”The science about soils dealing origin and formation of soils, soil properties, soil classification and identification, soil tests and soil surveys etc. required for road construction is termed as Road Soil Engineering”.
- "Highway Engineering soil studies is now a days picking up pace because total failure of the roads in majority of the cases have revealed after investigation that the failure was mainly due to the faulty subgrade rather than the pavement.
- The common most soils used in highway construction are: Clay,Silt,Sand,Loam (Mixture of Sand, Silt and Clay), Marl (Earthy mixture of minerals like quartz, calcite etc.)Shale (Compressed and laminated clay) etc.

Aggregate

- Stone aggregate, also known as mineral aggregate, is easily the most important component of road construction materials. It is made by breaking up naturally occurring rocks to form coarse aggregate (like gravel) or fine aggregate (like sand).
- Aggregates are used for granular bases, sub-bases, as part of bituminous mixes and cement concrete. They are also used as the primary material for relatively cheaper road, known as water-bound macadam.
- Like soil, aggregates must be tested by a road engineer to ascertain that they are strong enough and durable for a specific project. These properties are influenced by their origin, mineral components and the nature of bond between the components.

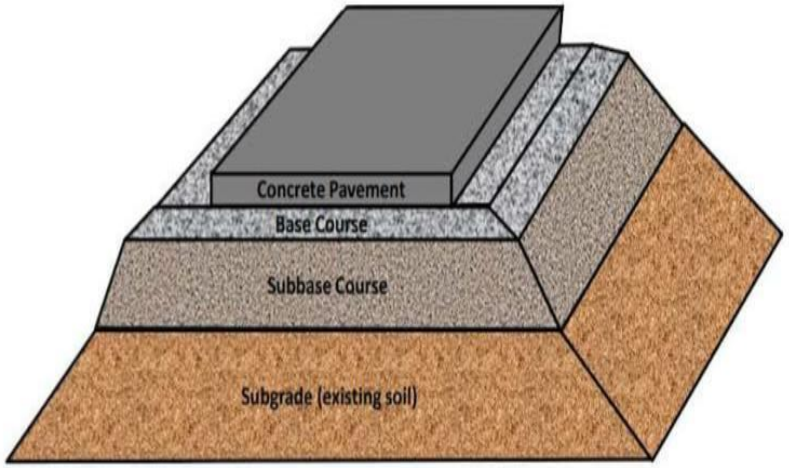
Asphalt and bitumen

- Asphalt and bitumen are often mistaken as being one and the same thing. However, while asphalt is a mixture of aggregates, binder and filler, used for constructing roads and their associated furniture, bitumen is actually the semi-solid binder that holds asphalt together.
- Bitumen, which is also known as mineral tar, is obtained through unfinished distillation of crude petroleum. It contains 87% carbon, 11% hydrogen and 2% oxygen.
- On the other hand, asphalt is manufactured in a factory that heats, dries and mixes aggregate, bitumen and sand into a composite mix. The material is then applied on site using a paving machine at a nominated or required thickness, depending on the type of project.
- When used for road construction, asphalt comes in the form of a composite material known as asphalt concrete. This material consists of 70% asphalt and 30% aggregate particles. Asphalt is 100% recyclable, which makes it a highly popular road construction material.

3.2 FUNCTION OF SOIL AS HIGHWAY SUBGRADE

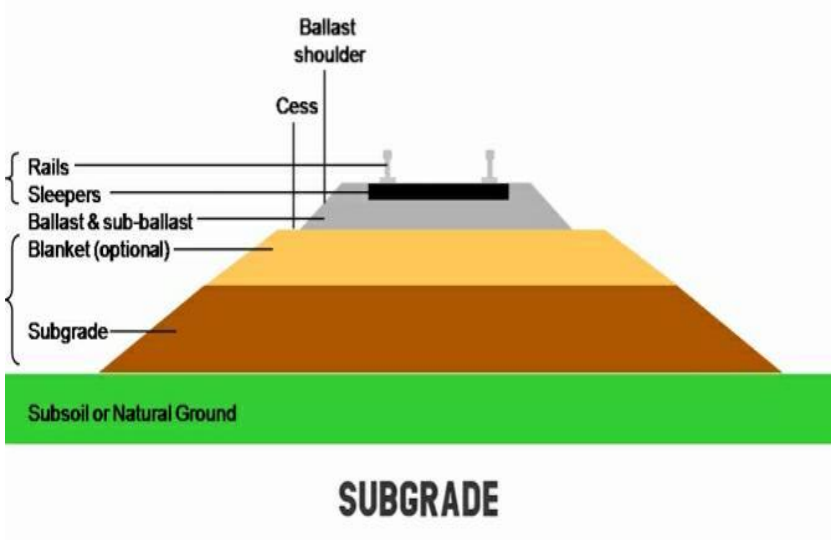
Subgrade:-

- Subgrade means that native soil is compacted to resist its overload formed by any cutting, snatching, or filling.
- This can be a natural, undisturbed material, although usually natural soil will be compacted to uniformity.
- Highway subgrade serves the following functions :-



1. To provide an adequate support to the road pavement.
2. To provide stability to the road pavement.
3. To provide good drainage of rain water percolating through the road pavement.
4. To prevent the various defects such as waves, corrugations, ruts, cracks, etc. occurring in the pavement.

- The subgrade soil should, therfore, be well compacted and stabilized so as to prevent these defects and to keep the road pavement stable and serviceable for a longer period.

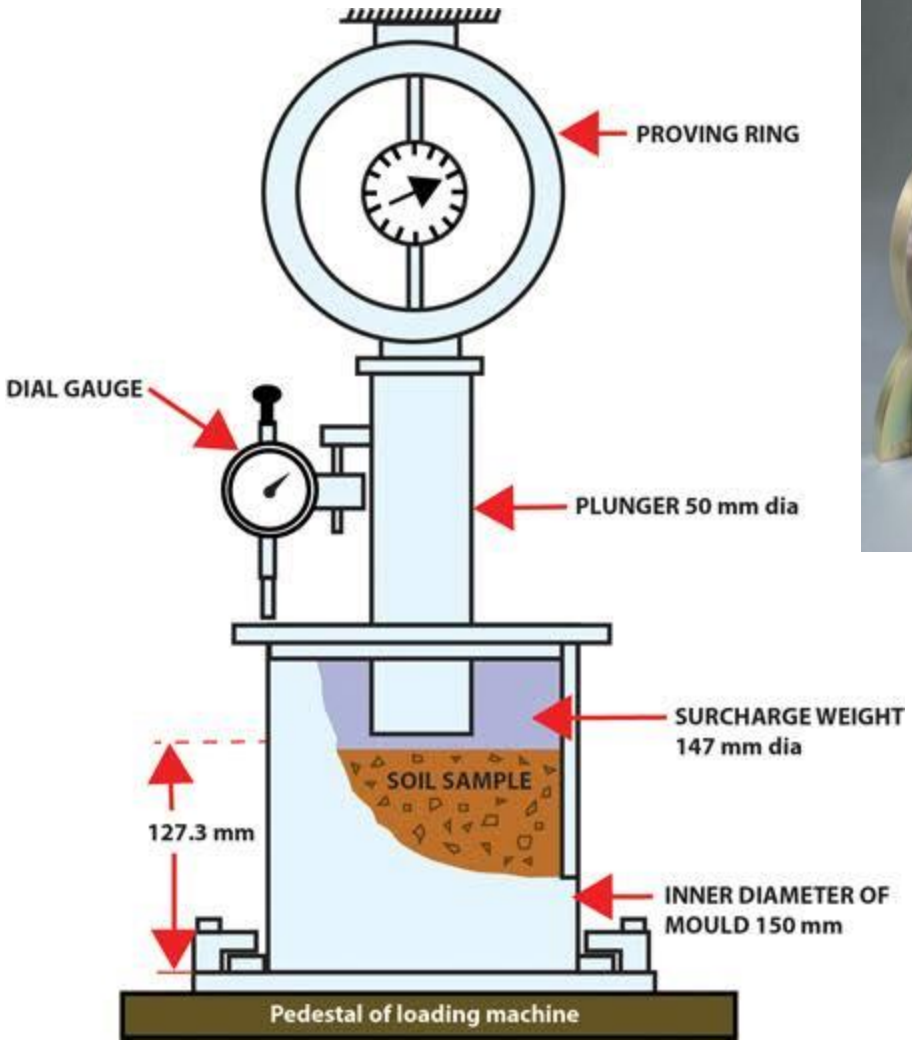


3.3 California Bearing Ratio: Methods of finding CBR valued in the laboratory and at site and their significance

- **Definition of CBR:**
- It is the **ratio of force per unit area** required to penetrate a soil mass with standard circular piston at the rate of 1.25 mm/min. to that required for the **corresponding penetration** of a standard material.
- The California Bearing Ratio Test (CBR Test) is a penetration test developed by ***California State Highway Department (U.S.A.)*** for evaluating the bearing capacity of subgrade soil for design of flexible pavement.
- Tests are carried out on natural or compacted soils in water soaked or un-soaked conditions and the results so obtained are compared with the curves of standard test to have an idea of the soil strength of the subgrade soil.

Apparatus

- Mould
- Steel Cutting collar
- Spacer Disc
- Surcharge weight
- Dial gauges
- IS Sieves
- Penetration Plunger
- Loading Machine
- Miscellaneous Apparatus



Procedure

Preparation Of Test Specimen:

1. Remoulded specimen: The material used in the remoulded specimen shall pass 19mm IS Sieve. Allowance for larger material shall be made by replacing it by an equal amount of material which passes a 19-mm IS Sieve but is retained on 4.75-mm IS Sieve.

2. The dry density for a remoulding shall be either the field density or the value of the maximum dry density estimated by the compaction test (Heavy Compaction Test as per IS 2720 (Part-8) - 1983, for Railway Formation). The water content used for compaction shall be the optimum water content or the field moisture as the case may be.

3. Dynamic Compaction: A representative sample of the soil weighing approximately 4.5 kg or more for fine grained soil and 5.5 kg or more for granular soil shall be taken and mixed thoroughly with water. If the soil is to be compacted to the maximum dry density at the optimum moisture content, the exact mass of the soil required shall be taken and the necessary quantity of water added so that the water content of the soil sample is equal to the determined optimum moisture content.

4. Fix the extension collar and the base plate to the mould. Insert the spacer disc over the base. Place the filter paper on the top of the spacer disc.

5. Apply Lubricating Oil to the inner side of the mould. Compact the mix soil in the mould using heavy compaction. i.e. compact the soil in 5 layers with 55 blows to each layer by the 4.89 kg rammer.

6. Remove the extension collar and trim the compacted soil carefully at the level of top of mould, by means of a straight edge. Any holes developed on the surface of the compacted soil by removal of the coarse material, shall be patched with the smaller size material. Remove the perforated base plate, Spacer disc and filter paper and record the mass of the mould and compacted soil specimen. Place a disc of coarse filter paper on the perforated base plate, invert the mould and compacted soil and clamp the perforated base plate to the mould with the compacted soil in contact with the filter paper.

7. Place a filter paper over the specimen and place perforated plate on the compacted soil specimen in the mould. Put annular weights to produce a surcharge equal to weight of base material and pavement, to the nearest 2.5 kg.

8. Immerse the mould assembly and weights in a tank of water and soak it for 96 hours. Mount the tripod for expansion measuring device on the edge of the mould and record initial dial gauge reading. Note down the readings every day against time of reading. A constant water level shall be maintained in the tank throughout the period.

9. At the end of soaking period, note down the final reading of the dial gauge and take the mould out of water tank.

10. Remove the perforated plate and the top filter paper. Weigh the soaked soil sample and record the weight.

Procedure For Penetration Test

1. Place the mould assembly with test specimen on the lower plate of penetration testing machine. To prevent upheaval of soil into the hole of the surcharge weights, 2.5 kg annular weight shall be placed on the soil surface prior to seating the penetration plunger after which the remainder of the surcharge weights shall be placed.
2. Seat the penetration piston at the center of the specimen with the smallest possible load, but in no case in excess of 4 kg so that full contact of the piston on the sample is established.
3. Set the load and deformation gauges to read zero. Apply the load on the piston so that the penetration rate is about 1.25 mm/min.
4. Record the load readings at penetrations of 0.5, 1.0, 1.5, 2.0, 2.5, 4.0, 5.0, 7.5, 10 and 12.5 mm.
5. Raise the plunger and detach the mould from the loading equipment. Take about 20 to 50 g of soil from the top 30 mm layer and determine the moisture content.

Calculation

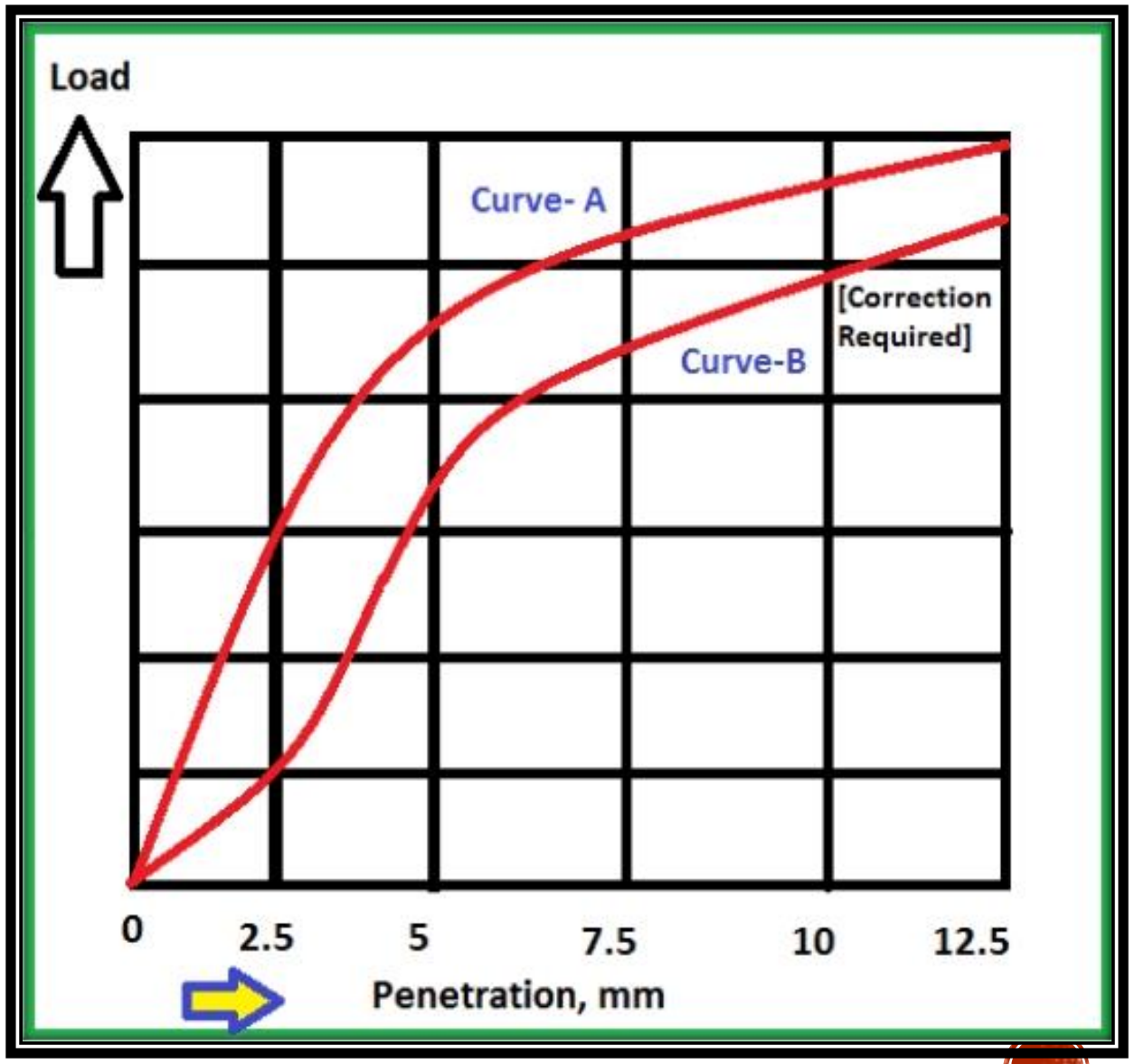
- If the initial portion of the curve is concave upwards, apply correction by drawing a tangent to the curve at the point of greatest slope and shift the origin. Find and record the correct load reading corresponding to each penetration.
  C.B.R. = (P_T/P_S) X 100

where P_T = Corrected test load corresponding to the chosen penetration from the load penetration curve.
P_S = Standard load for the same penetration taken from the table above.

  - C.B.R. of specimen at 2.5 mm penetration =
  - C.B.R. of specimen at 5.0 mm penetration =

- The C.B.R. values are usually calculated for penetration of 2.5 mm and 5 mm. Generally the C.B.R. value at 2.5 mm will be greater than at 5 mm and in such a case/the former shall be taken as C.B.R. for design purpose. If C.B.R. for 5 mm exceeds that for 2.5 mm, the test should be repeated. If identical results follow, the C.B.R. corresponding to 5 mm penetration should be taken for design.

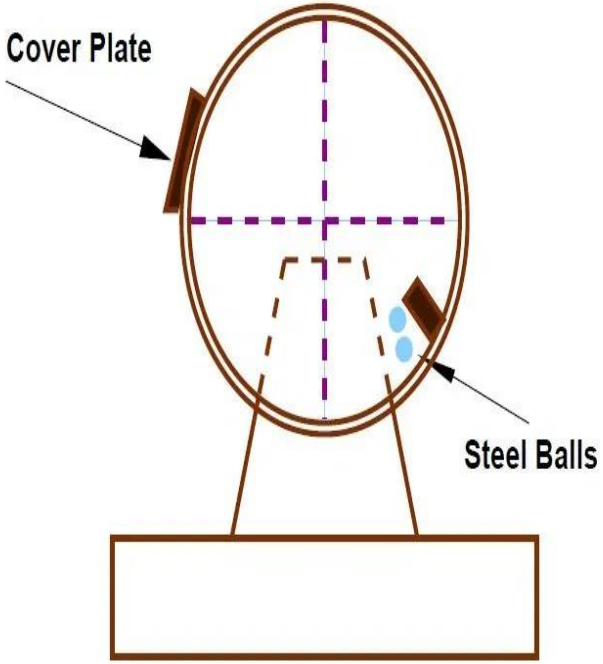
Penetration(mm)	Standard Load(kg)	Unit Standard Load(kg/cm2)
2.5	1370	70
5	2055	105
7.5	2630	134
10	3180	162
12.5	3600	183



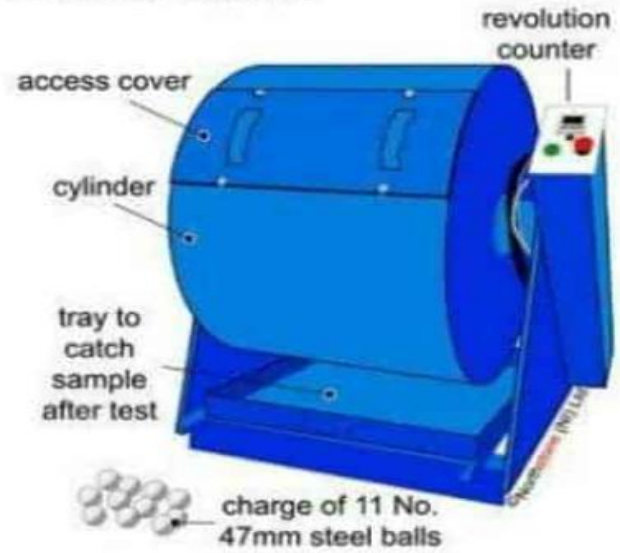
Uses and Significance of California Bearing Ratio Test:

- The **CBR test** is one of the most commonly used methods to evaluate the strength of a sub grade soil, sub base, and base course material for **design of thickness for highways** and **airfield pavement.**
- The California bearing ratio test is penetration test meant for the **evaluation of subgrade strength** of roads and pavements.
- The results obtained by these tests are used with the empirical curves to determine the thickness of pavement and its component layers. This is the most widely used method for the design of flexible pavement.
- This instruction sheet covers the laboratory method for the determination of **C.B.R**. of undisturbed and remolded /compacted soil specimens, both in soaked as well as un-soaked state.

- **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 works. Los Angeles abrasion test is a preferred one for carrying out the hardness property and has been standardized in India (**IS: 2386 part-IV**).
- The principle of Los Angeles abrasion test is to find the percentage wear due to relative rubbing action between the aggregate and steel balls used as abrasive charge.
- Los Angeles machine consists of circular drum of internal diameter 700 mm and length 520 mm mounted on horizontal axis enabling it to be rotated. An abrasive charge consisting of cast iron spherical balls of 48 mm diameters and weight 340-445 g is placed in the cylinder along with the aggregates.
- The number of the abrasive spheres varies according to the grading of the sample. The quantity of aggregates to be used depends upon the gradation and usually ranges from 5-10 kg. The cylinder is then locked and rotated at the speed of 30-33 rpm for a total of 500 -1000 revolutions depending upon the gradation of aggregates.
- After specified revolutions, the material is sieved through 1.7 mm sieve and passed fraction is expressed as percentage total weight of the sample. This value is called Los Angeles abrasion value.
- A maximum value of **40 percent** is allowed for **WBM base course** in Indian conditions. For **bituminous concrete**, a maximum value of **35 percent** is specified.

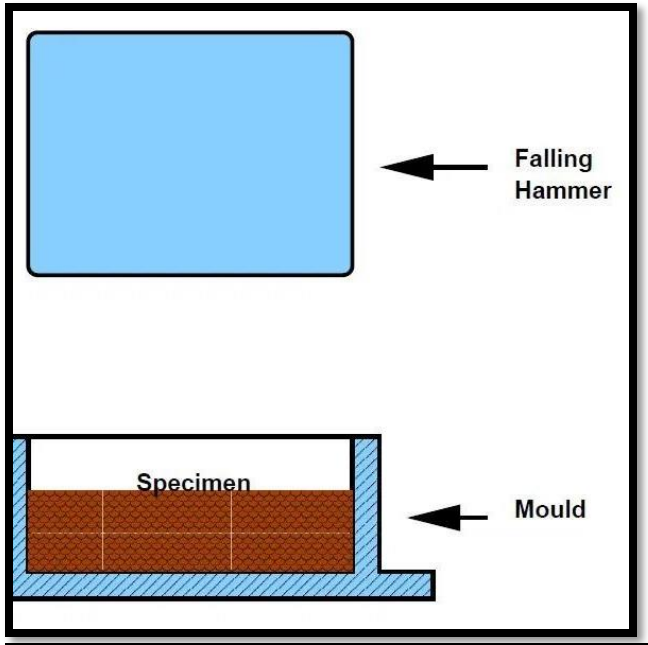


Los Angeles machine



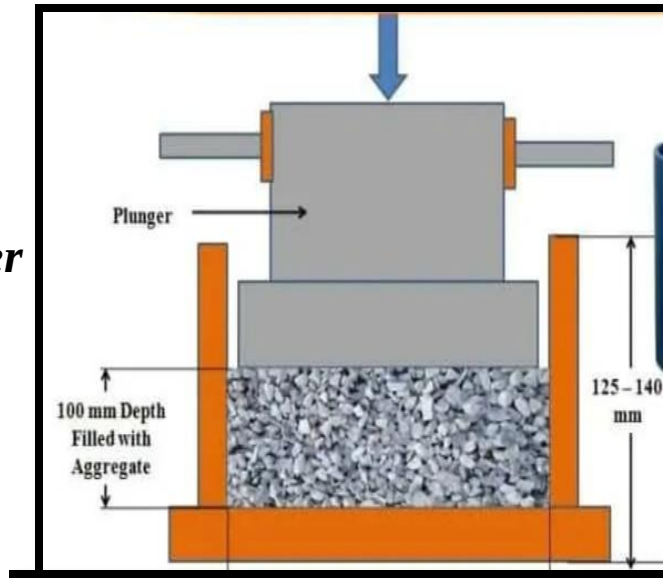
IMPACT TEST

- The aggregate impact test is carried out to evaluate the ***resistance to impact of aggregates.***
- Aggregates passing 12.5 mm sieve and retained on 10 mm sieve is filled in a cylindrical steel cup of internal dia 10.2 mm and depth 5 cm which is attached to a metal base of impact testing machine.
- The material is filled in 3 layers where each layer is tamped for 25 numbers of blows (see Fig-3).
- Metal hammer of weight 13.5 to 14 Kg is arranged to drop with a free fall of 38.0 cm by vertical guides and the test specimen is subjected to 15 numbers of blows. The crushed aggregate is allowed to pass through 2.36 mm IS sieve. And the impact value is measured as percentage of aggregates passing sieve (**W2**) to the total weight of the sample (**W1**).
- **Aggregate impact value = (W1/W2)*100**
- Aggregates to be used **for wearing course**, the impact value **shouldn't exceed 30 percent**. For **bituminous macadam** the **maximum** permissible value is **35 percent**. For **Water bound macadam** base courses the maximum permissible value defined by IRC is **40 percent.**



CRUSHING TEST

- One of the model in which pavement material can fail is by crushing under compressive stress. A test is standardized by **IS: 2386 part-IV** and used to determine the crushing strength of aggregates.
- ***The aggregate crushing value provides a relative measure of resistance to crushing under gradually applied crushing load.***
- The test consists of subjecting the specimen of aggregate in standard mould to a compression test under standard load conditions. Dry aggregates passing through 12.5 mm sieves and retained 10 mm sieves are filled in a cylindrical measure of 11.5 mm diameter and 18 cm height in three layers.
- Each layer is tamped 25 times with at standard tamping rod. The test sample is weighed and placed in the test cylinder in three layers each layer being tamped again.
- The specimen is subjected to a compressive load of 40 tonnes gradually applied at the rate of 4 tonnes per minute.
- Then crushed aggregates are then sieved through 2.36 mm sieve and weight of passing material (**W2**) is expressed as percentage of the weight of the total sample (**W1**) which is the aggregate crushing value.
  - **Aggregate crushing value = (W1/W2)*100**
- A value **less than 10** signifies an exceptionally **strong aggregate** while **above 35** would normally be regarded as **weak aggregates**.



Water Absorption:

- The difference between the apparent and bulk specific gravities is nothing but the water permeable voids of the aggregates.
- We can measure the volume of such voids by weighing the aggregates dry and in a **saturated surface dry condition**, with all permeable voids filled with water. The difference of the above two is M_W.
- M_W is the weight of dry aggregates minus weight of aggregates saturated surface dry condition. Thus,
- **Water Absorption = $(M_W/M_D)*100$**
- The specific gravity of aggregates normally used in road construction ranges from about 2.5 to 2.9. Water absorption values ranges from 0.1 to about 2.0 percent for aggregates normally used in road surfacing.

SOUNDNESS TEST

- Soundness test is intended to study the resistance of aggregates to weathering action, by conducting accelerated weathering test cycles.
- The Porous aggregates subjected to freezing and thawing is likely to disintegrate prematurely.
- To ascertain the durability of such aggregates, they are subjected to an accelerated soundness test as specified in **IS: 2386 part-V**.
- Aggregates of specified size are subjected to cycles of alternate wetting in a saturated solution of either sodium sulphate or magnesium sulphate for 16 – 18 hours and then dried in oven at 105 to 110^0C to a constant weight.
- After **five cycles**, the loss in weight of aggregates is determined by sieving out all undersized particles and weighing.
- The loss in weight should **not exceed 12 percent** when tested with **sodium sulphate** and **18 percent** with **magnesium sulphate** solution