

## UNIT-IV

### Tests on Soils

#### CBR

- The most widely used test for design of flexible Pavement is the "California Bearing Ratio" test, abbreviated as the CBR test.
- The test was originally developed by the California Division of Highway by O.T. Porter and a design methodology was evolved from survey of pavement conditions carried out in California in 1929.
- For laboratory testing, a Phosphor-bronze mould with internal dimensions 150mm dia x 150mm height is used. The mould has a detachable perforated base which can be fitted at either end. A bronze disc 50mm deep and 152mm dia enables a specimen exactly 127mm high to be obtained.

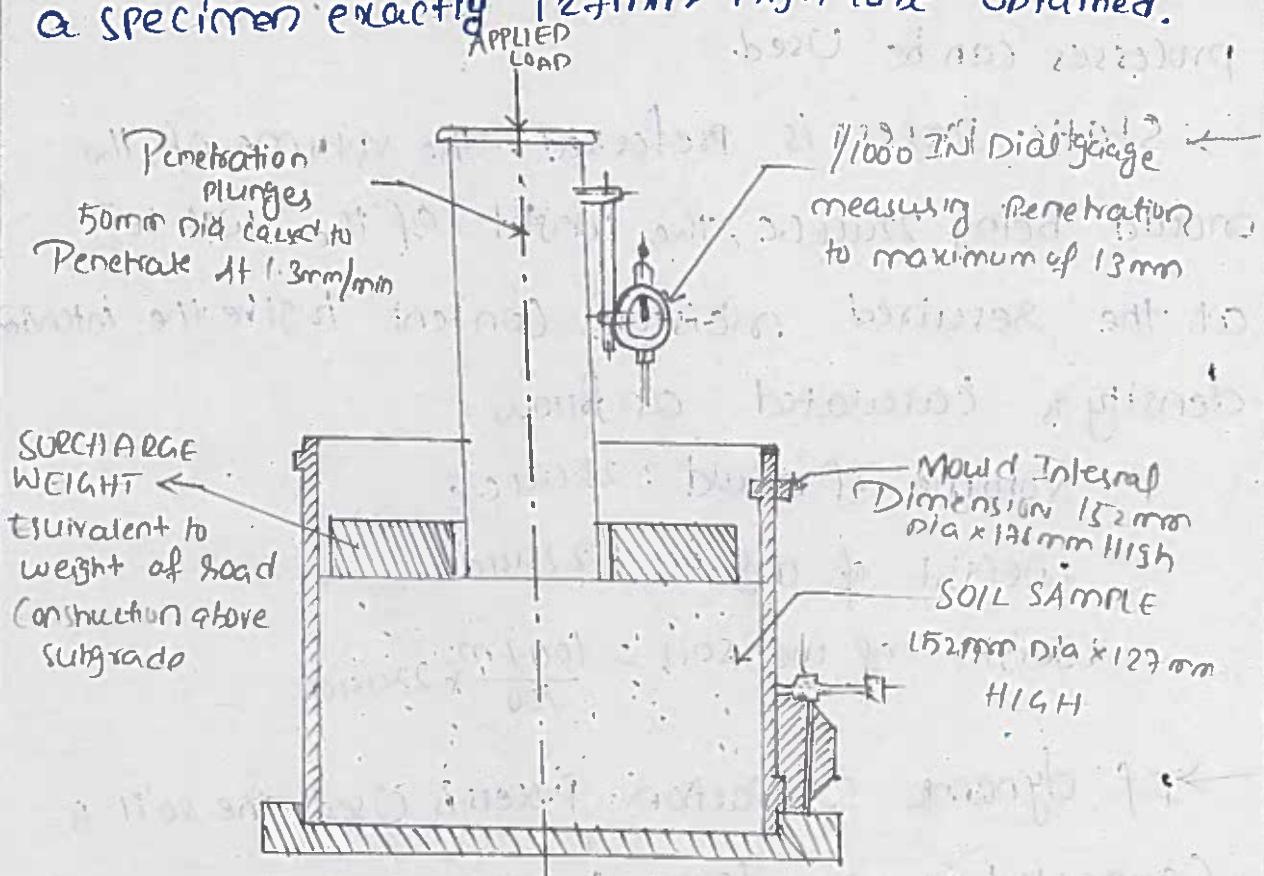


Fig CBR test apparatus

- The loading is done by a machine giving a constant rate of strain. If such a machine is not available, an ordinary hydraulic testing machine is used, providing the rate of penetration is controlled by a stop catch.
- The plunger is standardised with a dia of 50mm and is placed at the centre of mould containing the soil specimen. A dial gauge records the penetration. The vertical load from the testing machine is noted.
- For the in-situ test, a loaded truck is used to provide the reaction and loading is achieved by a screw jack.
- The specimens have to be prepared with great care. Undisturbed specimens can be obtained by fitting a cutting edge to the mould and pushing the same into the ground as gently as possible.
- The sample is then trimmed. For preparing remoulded specimens, static or dynamic compaction processes can be used.
- Static process is preferred. The volume of the mould being 2200 cc, the weight of the wet soil at the required moisture content to give the intended density is calculated as follows:
  - volume of mould : 2200 c.c
  - weight of dry soil : 2200 d
  - weight of wet soil =  $\frac{100+m}{100} \times 2200 d$
- If dynamic compaction process is used, the soil is compacted in three layers by using a standard rammer.

- The loading is done at a rate of 1.25 mm/minute. The loads at 2.5mm and 5mm penetration are recorded.
- The CBR value is expressed as a percentage of the actual load passing the penetration of 2.5mm or 5mm to the standard above mentioned loads, respectively.

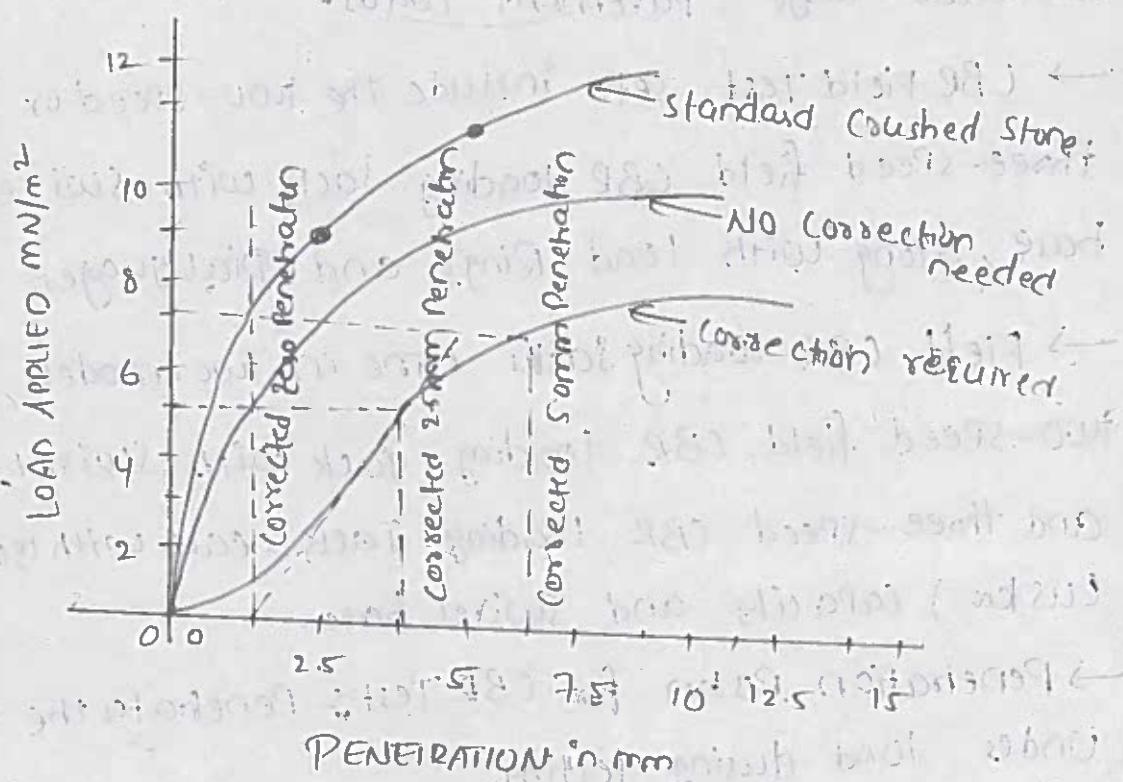


Fig. Load-Penetration Curve (with or without correction)

\* Thus,  $\text{CBR} = \frac{\text{load carried by specimen}}{\text{load carried by standard crushed stone specimen}} \times 100$

- Two values of CBR will be obtained.
- If the value at 2.5mm is greater than that at 5mm penetration, the former is adopted.
- If not, the test is repeated and if the new value of load at 5mm penetration is still greater, this value is used for the calculation of the CBR.

## Field CBR

- Field CBR apparatus are ordered individually for tests performed according to ASTM or Army Corps of Engineers (C.O.E) test methods.
- Additional surcharge masses may be needed to simulate large pavement loads.
- CBR Field Test sets include the two-speed or three-speed field CBR loading jack with swivel base, along with Load Rings and Dial gauges.
- Field CBR loading jacks come in two models, a two-speed field CBR loading jack with swivel, and three-speed CBR loading Jacks, each with 10,000 lb (4536 kg) capacity and swivel base.
- Penetration piston for CBR Test: Penetrates the soil under load during testing.
- Piston extension set for field CBR Test: ensures proper positioning of penetration piston for application of load.
- Connector set for CBR test is required for the connection of multiple Extension Rods and Penetration Piston for application of load.
- Field Surcharge Plate and Masses with Annular or Slotted Openings simulate loads from base coarse or pavement.
- Dial Support Bridge for CBR Test Positions mechanical dial indicator for accurate penetration measurements.

## Modulus of sub-grade reaction

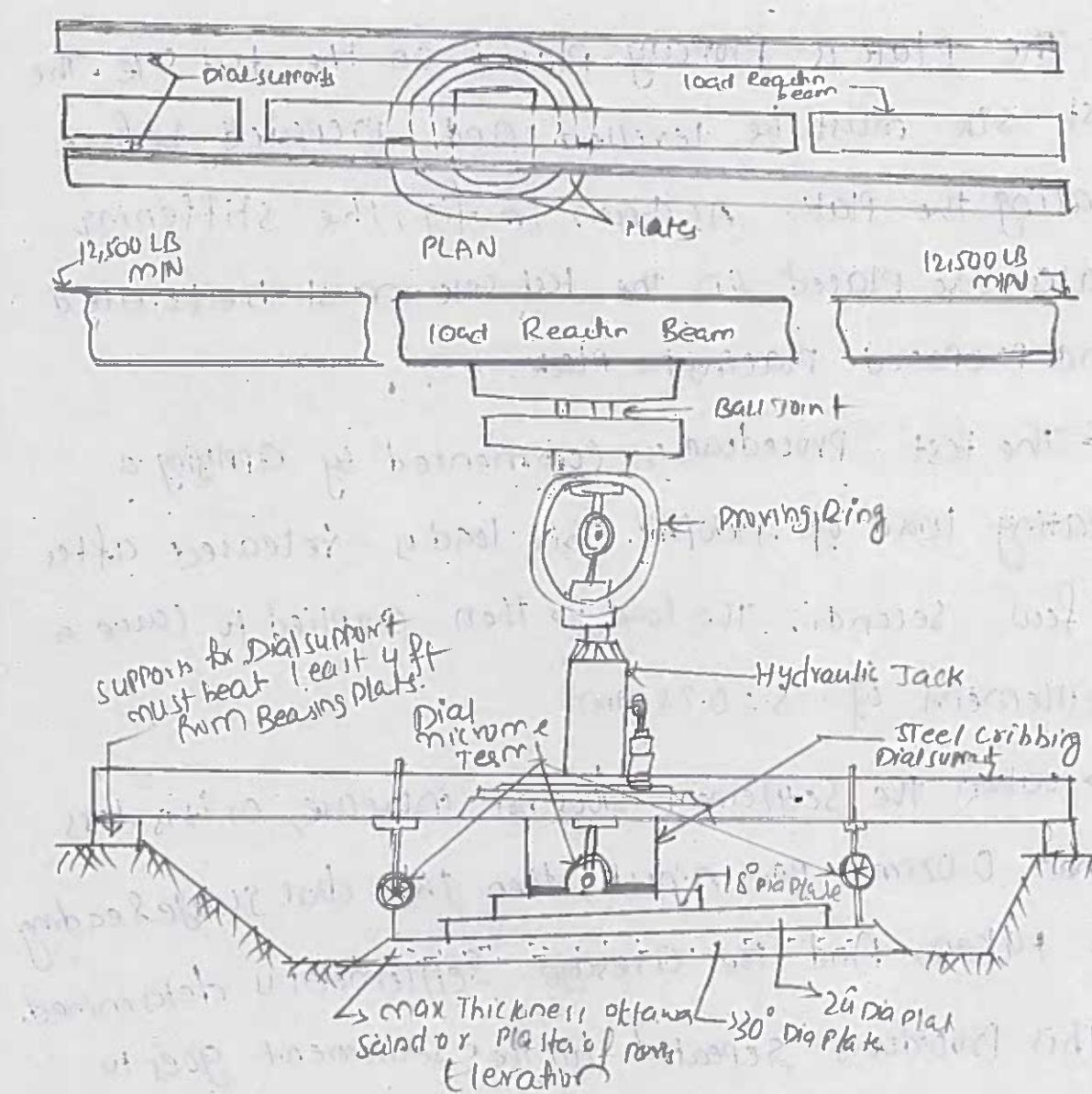
- The modulus of subgrade reaction is determined by the field plate load test. In this test, compressive stress is applied to the soil layers through rigid plates, and the deflections are measured for different values of stress.
- The test set up consists of a loading frame that has a hydraulic jack, a reaction beam, and a proving ring.
- The settlement of the plate is measured using a dial gauge. The dial gauge are attached to a separate datum frame as shown in fig. The standard size of the plate is 750mm in diameter.
- The plate is properly placed on the test site. The test site must be levelled and prepared before placing the plate. As shown in fig., the stiffening plates are placed on the test site must be levelled and prepared placing the plate.
- The test procedure is commenced by applying a seating load of  $7 \text{ kN/m}^2$ . This load is released after a few seconds. The load is then applied to cause a settlement of  $S = 0.25 \text{ mm}$ .
- When the settlement does not increase, or it is less than  $0.025 \text{ mm}$  per minute, then the dial gauge reading is taken, and the average settlement is determined. This procedure is repeated till the settlement goes to  $0.145 \text{ mm}$ .

→ A graph is plotted between the bearing pressure ( $P$ ) and the corresponding settlement caused ( $\Delta$ ) or  $\delta$ .

$$K = \frac{P}{\Delta} = \frac{P}{0.125}$$

→ The pressure corresponding to the settlement  $0.125\text{cm}$  is read from the plot, and the value of ' $K$ ' is determined as:

$$K = P / 0.125$$



## Tests on Aggregate

### Specific gravity

- The test is performed by Immersing in distilled water a sample (2-3)kg of aggregates enclosed in a wire-mesh container for 24 hours.
- The container with the aggregate is weighed when immersed in water, thus giving its buoyant weight ( $w_1$ ).
- The material is then surface dried and weighed in air, giving the saturated weight ( $w_2$ ).
- Thereafter the material is oven dried at a temperature 100 - 110°C and the dry weight determined ( $w_3$ ).
- The Percentage of water absorption

$$= \frac{100 \times (w_2 - w_3)}{w_3}$$

Bulk Specific gravity of aggregate

$$= \frac{\text{Dry weight of aggregate}}{\text{Volume of aggregate}}$$

Volume of aggregate

$$= \frac{w_3}{\text{Volume of displaced water}}$$

=  $\frac{w}{\text{wt of displaced water}}$

S.P. gravity of water

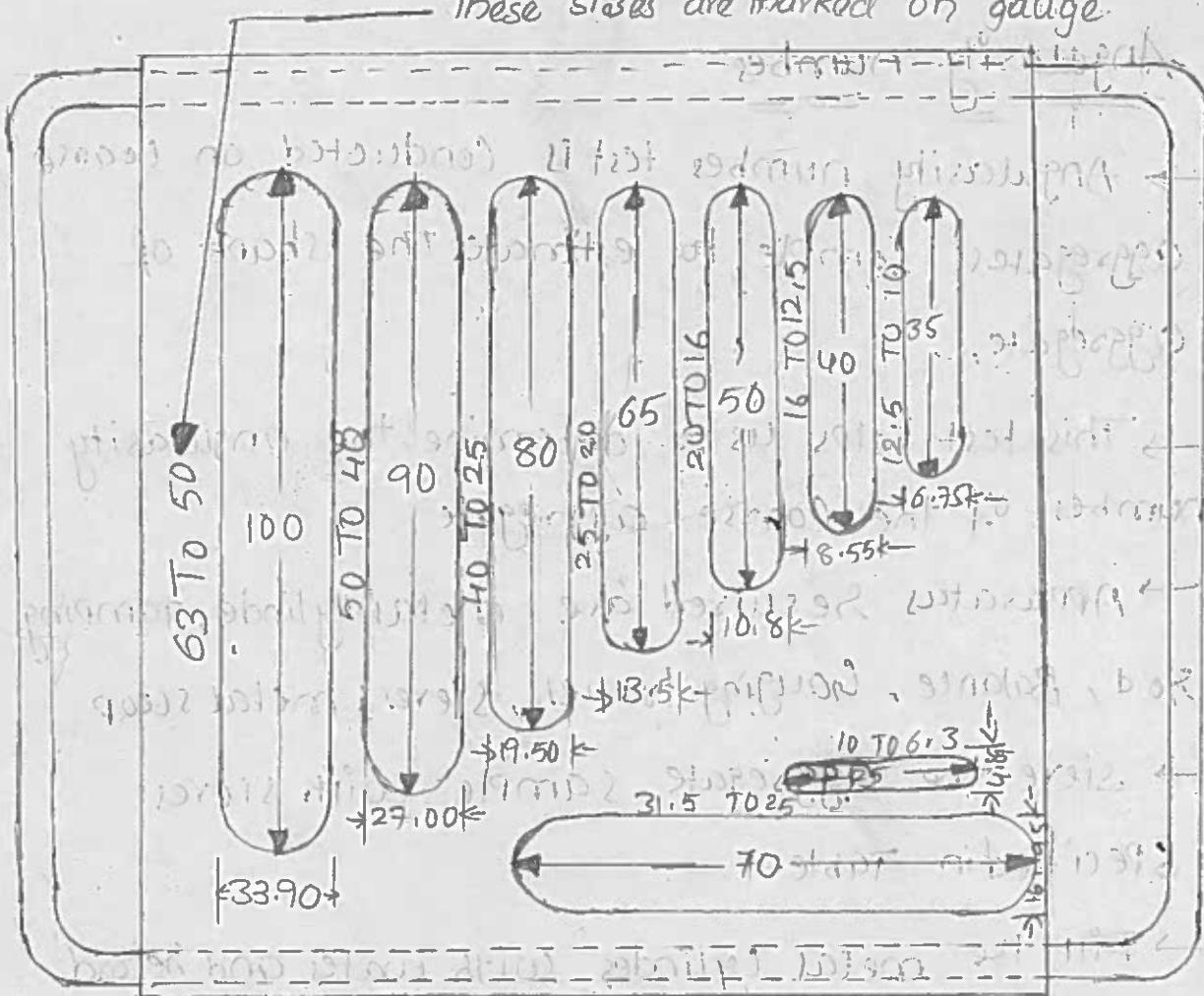
$$= \frac{w_3}{w_2 - w_1}$$

[S.P. gravity of  $H_2O = 1$ ]

- It is seen that the specific gravity of aggregate varies from 1.9 to 3.0

## Shape (flakiness and elongation indexes)

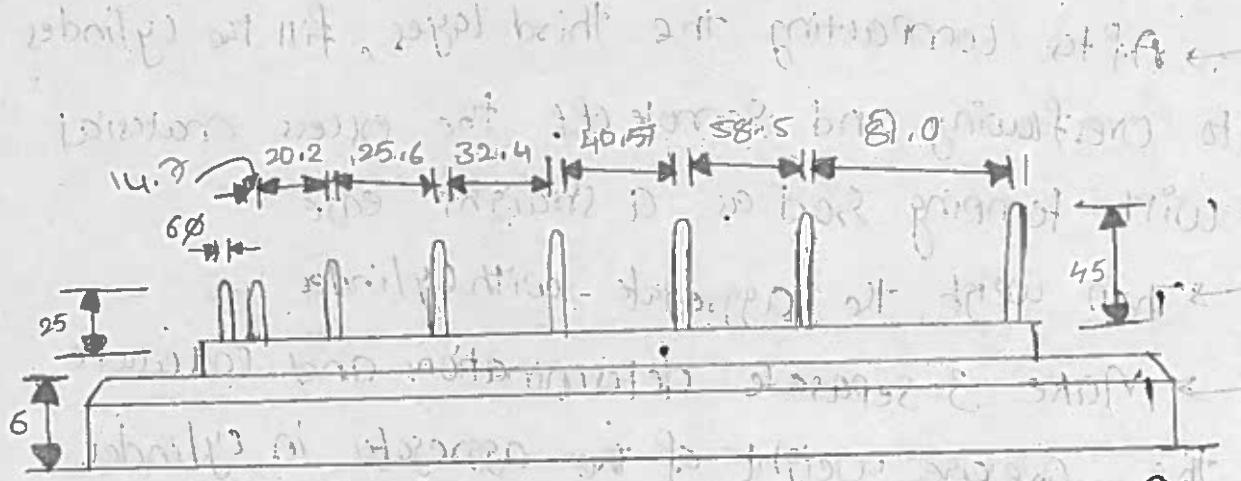
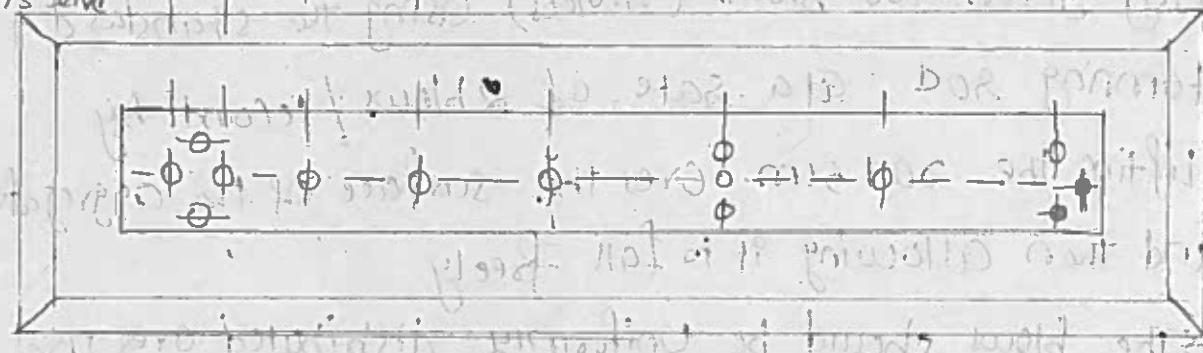
- These tests are conducted on Coarse aggregates to assess the shape of aggregates. Aggregates which are flaky or elongated are detrimental to the higher workability and stability of mixes.
- They are not conductive to good interlocking and hence the mixes with an excess of such particles are difficult to compact to the required degree.
- The flakiness index is defined as the percentage by weight of aggregate particles whose least dimension is less than 0.6 of their mean size. It is determined according to the procedure laid down in IS : 2386 (Part I).
- The elongation index of an aggregate is the percentage by weight of particles whose greatest dimension (length) is greater than one and four-fifths times their mean dimension.
- This test is not applicable to aggregate smaller than 6.3mm.
- The test is covered by IS: 2386 (Part-I)
- The standard flakiness and elongation gauge are shown in figure.
- The combined value of flakiness and elongation indices, recommended by the MORTH specification for aggregates for many of the bituminous materials for road works is 30.



(a) Thickness gauge

Passing is save  $\rightarrow 10 | 2.5 | 16 | 20 | 25 | 40 | 50$

Retained is save  $\rightarrow 6.3 | 10 | 12.5 | 16 | 20 | 25 | 40$

(b) Elongation gauge  
Fig. Flakiness and elongation gauges, Unit-4 pg-9/34

## Angularity number

- Angularity number test is conducted on coarse aggregates sample to estimate the shape of aggregate.
- This test helps us to determine the angularity number of the coarse aggregate.
- Apparatus required are metal cylinder, tamping rod, Balance, Gauging trowel, sieves, metal scoop
- sieve the aggregate sample with sieves specified in TABLE-I
- Fill the metal cylinders with water and record its volume
- Take sufficient quantity of aggregate to perform the test
- Compact the aggregate in 3 layers, each layer being given 100 blows (strokes) using the standard tamping rod at a rate of 2 blows / second by lifting the rod 5cm over the surface of the aggregate and then allowing it to fall freely
- The blows should be uniformly distributed over the surface of the aggregate.
- After compacting the third layer, fill the cylinders to overflowing and remove off the excess material with tamping rod as a straight edge
- Then weigh the aggregate with cylinder
- Make 3 separate determinations and calculate the average weight of the aggregate in cylinder.

Passing through IS sieves	Retained on IS sieves
20mm	16mm
16mm	12.5mm
12.5mm	10mm
10mm	6.3mm
6.3mm	4.25mm

### Water Absorption

→ These test are conducted together, water absorption and specific gravity test. The more water absorption the higher the voidage. Some rocks are adversely affected in their strength when water enters the material and softens it. Laterite is good example.

→ Take 2kg of aggregate sample is taken, washed to remove fines and then placed in the wire basket. The wire basket is then immersed in water, which is at a temperature of  $22^{\circ}\text{C}$  to  $32^{\circ}\text{C}$ .

→ Immediately after immersion the entrapped air is removed from the sample by lifting the basket 25mm above the base of the tank and allowing it to drop, 25 times at a rate of about one drop per sec.

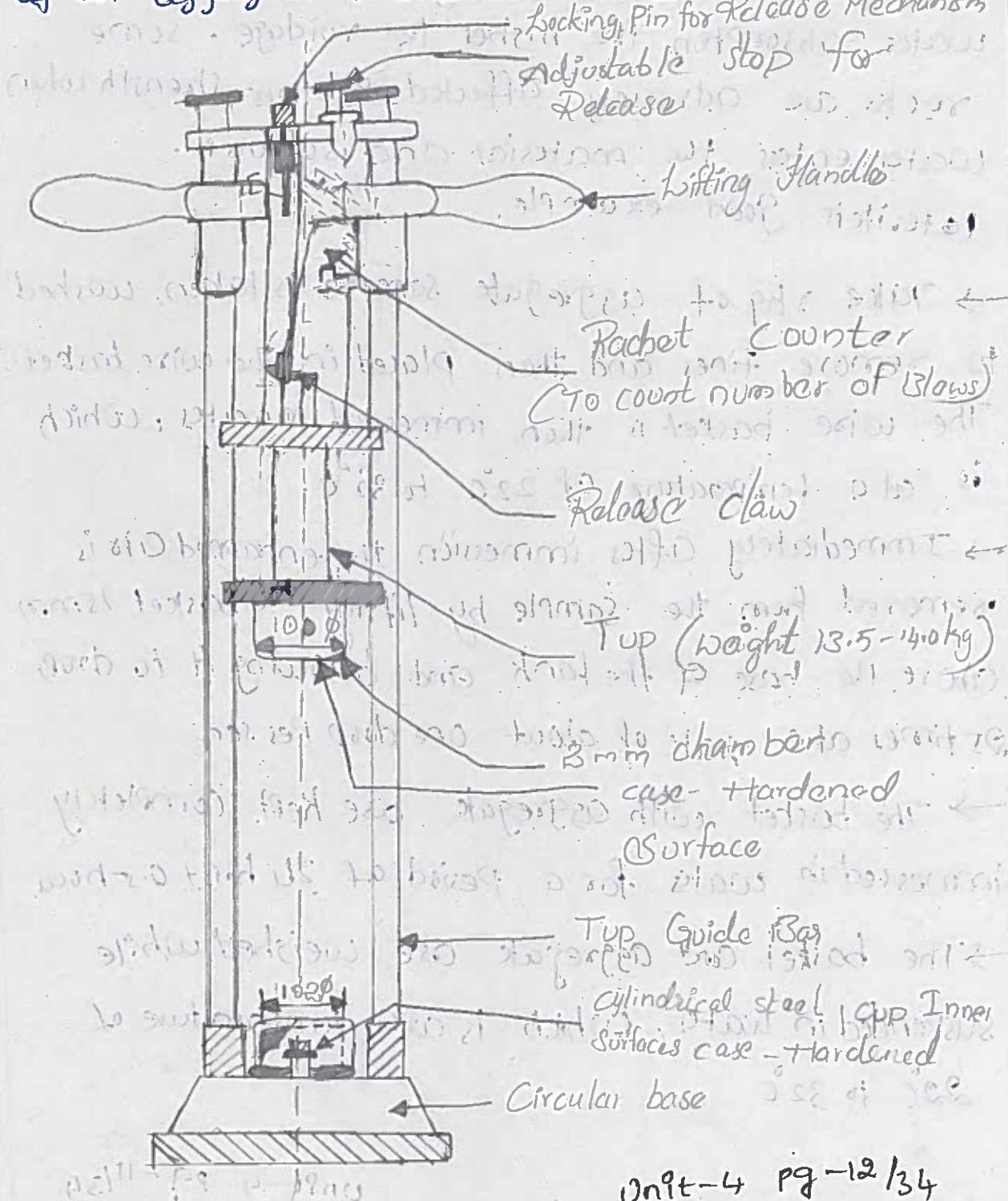
→ The basket with aggregate are kept completely immersed in water for a period of  $24\text{ hrs} \pm 0.5\text{ hour}$ .

→ The basket and aggregate are weighed while suspended in water, which is at a temperature of  $22^{\circ}\text{C}$  to  $32^{\circ}\text{C}$

- The basket and aggregates are removed from water and dried with dry absorbent cloth.
- The surface dried aggregates are also weighed.
- The aggregate is placed in a shallow tray and heated to 100 to 110°C in the oven for 24 ± 0.5 hours, later it is cooled in an airtight container and weighed.

### Impact test

- This is a test designed to evaluate the resistance of an aggregate to sudden impact.



- Since vehicle loads cause impact, this test gives an indication of the performance of aggregates to resist crushing under impact.
- The test has been adopted as an Indian standard (IS:2386 Part IV) (Ref.6). The IRC specification also indicate the minimum acceptable values as per this test.
- The test consists of subjecting a specimen of aggregate filled into a cylindrical mould 10.2cm internal dia and 5cm height.
- The impact is provided by dropping a hammer of weight  $13.5 \pm 0.05$  through a height of 380mm.
- Aggregates passing fully through 12.5mm sieve and retained on 10mm sieve are filled in the cylindrical measure in three layers, each layer being given 25 strokes with a rod.
- The sample is then transferred to the cup of the aggregate impact testing machine and tapped 25 times with the rod.
- After subjecting the specimen to 15 blows through the hammer, the crushed aggregate is sieved on 2.36mm sieve.
- The weight of material passing through this sieve expressed as a Percentage of the total weight of the sample gives the Aggregate Impact value.
- The test is conducted in dry state as well as in wet state.
- For low-grade aggregates, a maximum of 50 percent wet aggregate impact value is allowed when used in sub-base.

Abrasion test :- This is a very popular test for measuring the abrasion resistance of aggregates. The top layers of a pavement get abraded due to the movement of tyres.

→ A material which is highly abrasion resistant has a long life. The test has been standardised in India (IS:2386 - Part IV)

→ The machine consists of a circular drum of internal diameter 700mm and length 500mm mounted on a horizontal axis enabling it to be rotated. An abrasive charge consisting of cast iron spherical ball of 18mm dia and weight 390-445gm is placed in the cylinder along with the aggregates.

→ The weight and numbers of the abrasive spheres varies according to the grading of the sample.

→ The weight of this material expressed as a percentage of the total weight of the sample is known as the Los Angeles Abrasion value.

→ For WBM Base Course in India, a maximum value of 40 Percent is allowed. For bituminous course, a maximum of 30 to 35 Percent is specified.

Attrition test :-

→ For the Attrition test, 5kg of broken angular pieces of stone is placed in both the cylinders of Perai's attrition testing machine.

→ The cylinders are kept in an inclined position such that their axis makes an angle of 30 degrees with the horizontal.

- Now the cylinders are rotated at the rate of 30 r.p.m for 5 hours.
  - Later on these pieces are removed from cylinders and passed through a 1.5mm sieve.
  - The quantity of stones pieces referred on the sieve is weighed. And by this,
  - The loss of weight of the sample can be calculated. The percentage of wear can be calculated as
- $$\text{Percentage of wear} = \frac{\text{Loss in weight}}{\text{Original initial weight}} \times 100$$

→ Stones which should have a greater percentage of wear are unsuitable for road construction.

### Crushing resistance

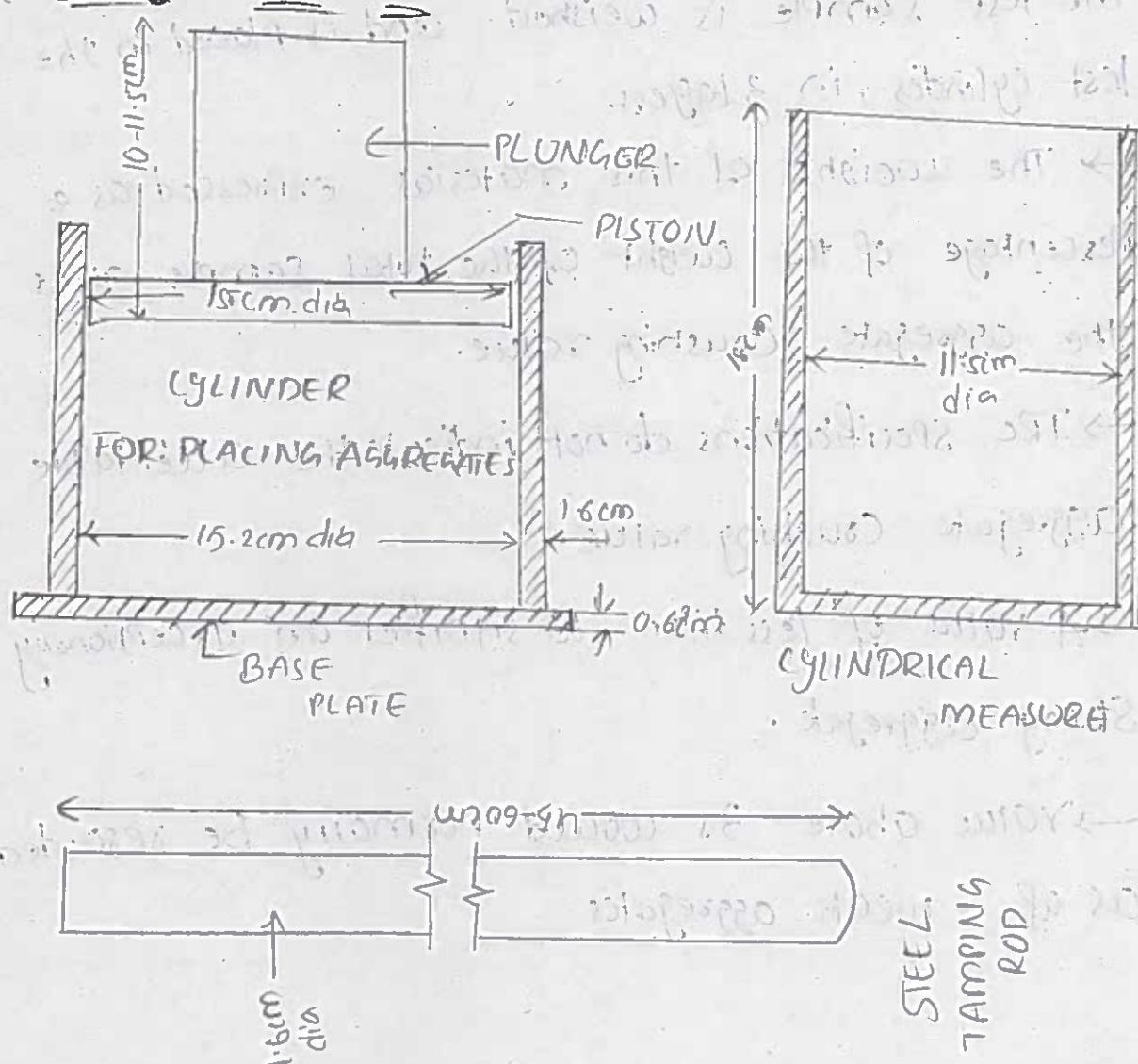


Fig: Aggregate crushing strength apparatus  
Unit-4 pg-15/34

- One of the modes in which a pavement material can fail is by crushing under severe stresses.
- A test devised to express the crushing strength is the aggregate crushing test.
- The test has been standardised by the Indian Standard Institution (IS: 2386 - Part IV) Ref (c).
- The test consists of subjecting the specimen of aggregate in a standard mould to a compression test under standard loading conditions.
- Dry aggregates passing through 12.5 mm sieve and retained on 10 mm sieve are filled in a cylindrical measure 11.5 cm and 18 cm high; in three layers, each layer being tampered with a standard rod 20 times, the test sample is weighed and is placed in the test cylinders, in 3 layers.
- The weight of this material expressed as a percentage of the weight of the total sample gives the aggregate crushing value.
- IRC specifications do not indicate the acceptable aggregate crushing value.
- A value of less than 10 signifies an exceptionally strong aggregate.
- Value above 35 would normally be regarded as of weak aggregates.

## Durability (weathering resistance):-

- This test is used to check the presence of soluble matter in the stone.
- Take three samples, previously dried in an oven at  $105^{\circ}\text{C} + 5^{\circ}\text{C}$  for 24 hours and cooled to room temperature in a desiccators.
- The sides of the samples are smooth finished. The so dried samples shall be weighed. Let their dry weight be  $w_1$ .
- Each test samples shall be freely suspended in water for 24 hours at  $20^{\circ}\text{C} - 30^{\circ}\text{C}$  and then weighed in that condition. Let this weight be  $w_2$ .
- The test sample shall be taken out of water and surface dried and weighed in air. Let this weight be  $w_3$ .
- Each sample is placed separately in a dish made porcelain or glass containing a solution of 2 gm powdered gypsum in 25 ml of water.
- These three dishes prepared with the test samples are placed in a ventilated oven at  $105^{\circ}\text{C} + 5^{\circ}\text{C}$  for 5 hours.
- The dishes containing the samples are now removed from the ovens.
- They are allowed to cool naturally to room temperature. This process completes one cycle of treatment prescribed under the test.
- Each sample is placed in a fresh dish in a

New solution of 2gm of gypsum in 25ml of water and the same process of placing in ventilated oven is repeated. Thirty such cycles are repeated on all the three samples.

→ Each sample is first cleaned by a stiff brush to remove superficially sticking gypsum and then immersed in clean water for 24 hours.

→ Each sample is taken out from water, surface dried and weighed fourth time and fifth time fourth time in air ( $w_4$ )

And fifth time ( $w_5$ ) in a suspended slate in water.

#### Stone Polishing value of Aggregate :-

→ The Resistance of Aggregate to Polishing under traffic determines its skid resistance.

→ The standard method BS812 (Part II) adopted for testing the Polishing Characteristics is to embed the aggregate in a curved mould in cement-sand mortar and subject the sample to accelerated polishing caused by a rotating pneumatic wheel.

→ The specimens are mounted on a circular frame 400mm dia. The size of each specimen is 45mm wide x 90.5mm long.

→ The rubber wheel is 20cm dia and 5cm broad loaded with 40kg load at a tyre pressure of 3.15 ± 0.15 kg/cm<sup>2</sup>.

→ Sand and water are fed to the machine when it is rotated at an R.P.M of 320-325 for 3hrs 15 minutes.

- The specimens are thereafter tested for their Polishing value on a British Portable Tester.
- This machine consists of a rubber sliding shoe which is mounted at the end of a Pendulum.
- The slides, when released, brushes test past the specimen and comes to a halt. The specimen directly measures the Polishing Stone Value (PSV) on a graduated scale.
- Most specifications for wearing courses in flexible pavements require the Polished stone value (PSV) of aggregates to be a minimum of 55.

### Tests on bitumen

#### SPOT test

→ When the degree of cracking is slight, solubility test does not indicate these characteristics. For detection of overheating or cracking, a more sensitive means of detection is employed by means of spot test.

→ This test measures whether bitumen is heterogeneous or homogeneous. Overheated or cracked bitumen will be colloidally unstable.

→ In the standard test, 2g of bitumen is dissolved in 10 ml of standard naphtha solvent.

→ After one hour and again after 24 hours a drop of the solution is placed on a filter paper. If the stain on the paper is of a uniform colour, the test is

negative and the bitumen is considered to be un-cracked and is acceptable. If the spot forms a dark brown or black circle in the centre with a surrounding annular ring of lighter colour, the result is positive and the material is considered to be cracked.

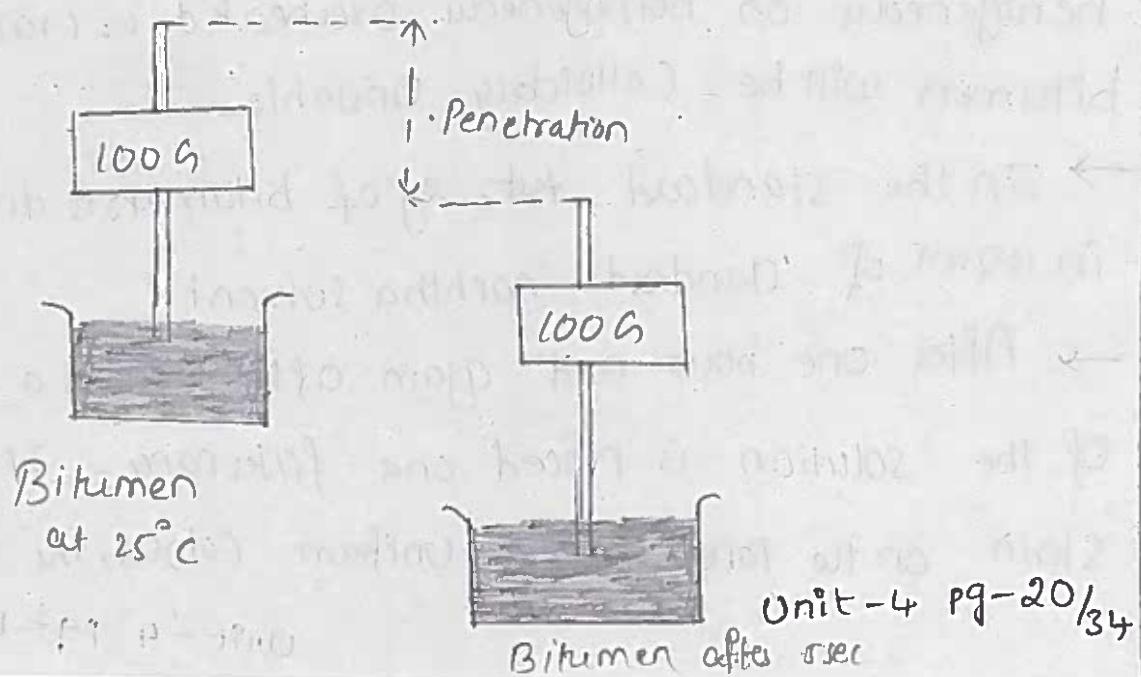
→ This test is controversial as it detects overheating but it does not always detect blend of cracked and normal materials.

→ Moreover, some bitumens due to the nature of Crude Oil show positive result even though they are not cracked.

→ In such cases naphtha is employed which meets the distillation requirements of the standard solvent but which is made from the present Crude Oil.

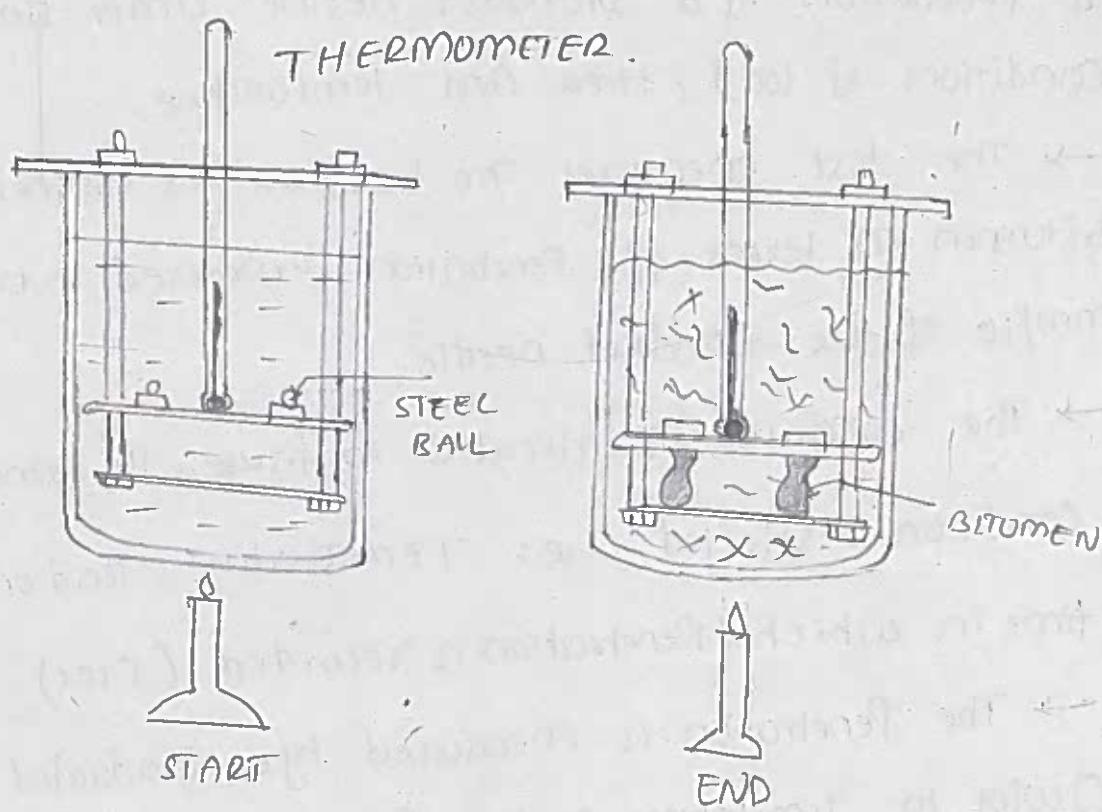
→ Because of these short comings, there is no standard method for this test.

### Penetration test:-



- An indirect measure of viscosity is the amount of penetration of a standard needle under standard conditions of load, time and temperature.
- The test measures the hardness or softness of bitumen in terms of penetration, expressed in units of mm/10 of the standard needle.
- The apparatus is indicated in figure. The standard conditions selected are: Temperature, load on needle, time in which penetration is recorded (5 sec).
- The penetration is measured by a graduated dial. Owing to limitations in the dimensions of the needle and other conditions, penetration less than 2 and greater than 500 cannot be determined satisfactorily.
- IP log is plotted against temperature, practically a straight lines obtained. This enables extrapolation of values.
- Penetration values and absolute viscosity cannot be correlated precisely.
- A Bitumen of Penetration 80/100 signifies that the range of penetration of the bitumen is 80-100 expressed in tenths of a millimeter.
- The lower the penetration value, the harder is the grade of bitumen.

## Softening Point



### Softening Point test

- A viscous material like Bitumen or tars does not have a well defined softening point. However, a standard test determines the temperature at which a standard ball passes through disc of bitumen contained in a ring.
- The test is known as the "Ring and Ball test". A brass ring containing the bitumen sample is suspended in water or glycerine at a given temperature.
- A steel ball is placed on the disc of bitumen. The liquid medium is then heated at the rate of  $5^{\circ}\text{C}$  increase per minute.
- The temperature at which the softened bituminous material touches the bottom metal

Plate placed at a specified distance below the ring is recorded as the softening point.

→ The hardest grade of bitumen in India is 30/40, which has a softening point of 50-65°C. The softest paving bitumen is 18/200 grade, having a softening point of 30-45°C.

### Viscosity

$$\text{For simple liquids } F = \eta \frac{A \cdot v}{d}$$

$$\text{i.e. } \eta = \frac{F \cdot d}{A \cdot v}$$

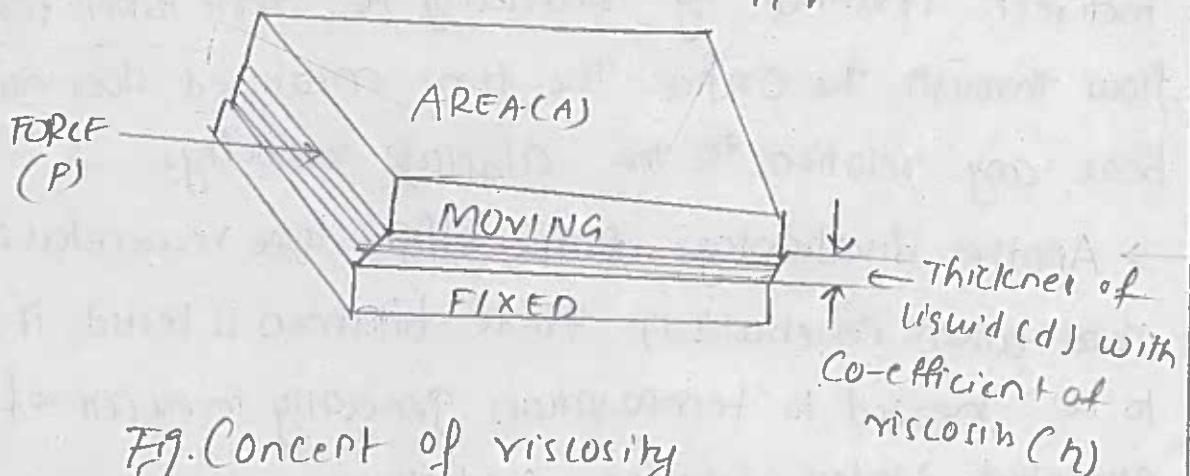


Fig. Concept of viscosity

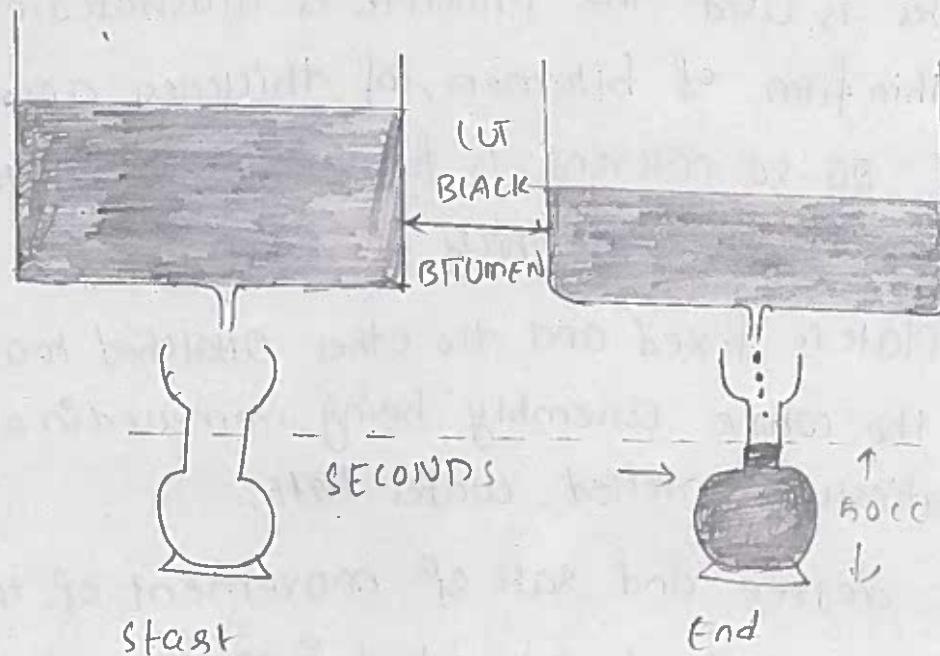


Fig. Viscosity test

- The determination of viscosity is generally done by efflux viscometers. They work on common principles, though they differ in detail.
- The liquid under test is poured to a specified level into a container surrounded by a water or oil bath, providing temperature control.
- At the base of the container is a small orifice with a simple valve control. On opening the valve, the time in seconds is recorded as for stated quantity of liquid to discharge into a measuring liquid.
- These efflux viscometers determine viscosity in an indirect manner by measuring the time taken for flow through the orifice. The time measured does not bear any relation to the absolute velocity.
- Another disadvantage of the efflux type viscometers is that when penetration grade bitumen is tested, it has to be heated to temperatures generally in excess of those expected under service conditions.
- In order to overcome this drawback, a sliding plate viscometer is used. The principle is illustrated in fig
- A thin film of bitumen, of thickness approx. - mately 20-50 microns, is formed between two glass plates  $3 \times 2 \times 0.7$  cm thick.
- One plate is fixed and the other attached to a loading device, the whole assembly being immersed in a thermostatically controlled water bath.
- The degree and rate of movement of the plate to which load is applied is measured electronically.

## Ductility test

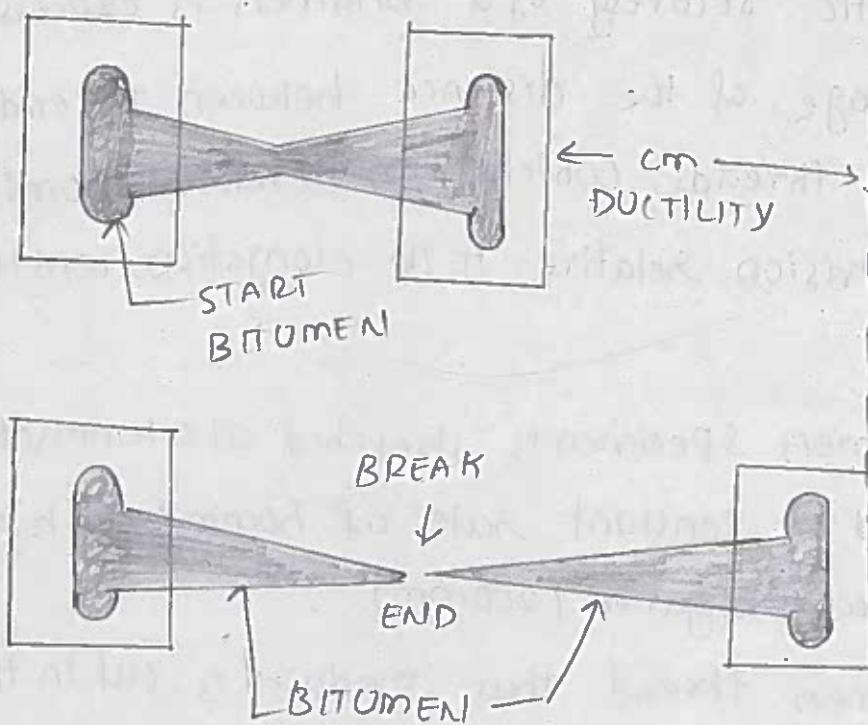


Fig. DUCTILITY TEST

- The ductility of a binder is an indication of its elasticity and ability to deform under load and return to original condition upon removal of load.
- A material which does not possess adequate ductility would crack under a load. This is unsatisfactory since water can penetrate into the surfacing through these cracks.
- The property is determined by measuring the distance that a standard briquette of bitumen, necked to a cross-section of  $\frac{1}{4}$  cm $^2$ , will stretch without breaking when elongated at a rate of 5 cm/min at 27°C.
- The ductility value should be a minimum of 50 as per I.S. Since the conditions of this test are entirely, arbitrary and unrelated to the conditions of actual use in the field.

## Elastic recovery

test. Bitumen

- The elastic recovery of a bitumen is expressed as a percentage of the distance between the ends of the half-threads, which has developed 30min after the division relative to the elongation length of 200mm.
- A Bitumen Specimen is stretched at a temperature of  $25^{\circ}\text{C}$  and a constant rate of  $50\text{mm/min}$  to a predetermined elongation (200mm).
- The bitumen thread thus produced is cut in the middle to obtain two halves of thread.
- After a predetermined time for recovery has elapsed, the shortening of the half thread is measured and expressed as to Percentage of the elongation length.
- This value is especially applicable to bituminous binders modified with thermoplastic elastomers.

## Flash and Fire point test

- Clean all the parts of the cup and its accessories thoroughly and allow them to dry. Ensure all the traces of solvent used for cleaning are removed.
- Take the Bitumen sample in a beaker and heat it to a temperature of  $75-100^{\circ}\text{C}$  - above its approximate softening point. Allow the bitumen to melt until it is converted completely into liquid state.

- Fill the melted bitumen in the cup up to the filling mark indicated on the cup.
- Fix the clip in position on the cup. Ensure that the locating devices of the cup and lid are properly engaged.
- Insert a thermometer and adjust the test flame to a size of a head of about 4mm diameter. Control the rate of the application of heat such that the temperature increases by 5-6°C per minute as recorded from the thermometer.
- Observe the surface of the material carefully during heating.
- Then after the same steps are followed as mentioned in closed up tester except that the stirrer is rotated manually instead of mechanically.
- Note down the temperature when the first distinct flash appears at any point on the surface of the material. Record this temperature as the flash point.
- Continue the heating beyond the flash point and applying the test flame at intervals of 1°C.
- Note down the temperature when the material ignites and continues to burn for at least 5 seconds. Record this temperature as fire point.
- The entire practical is repeated for 2 more times. The corresponding average value of three tests is the flash and fire point of given bitumen specimen.

Introduction to modified bituminous binders like  
Crumb rubber modified

### Binder modification

→ Binder properties may be improved by different process and materials. Binder modification has been driven by the increase in traffic loads, new refining technologies, enhancement in polymers technology, the increasing need to recycle waste material such as plastic bag, plastic bottle, rubber etc.

### Crumb rubber

→ In India waste tyres are termed as solid waste or hazardous waste. It is found that about 60% of waste tyres are disposed in the urban and also in rural areas.

→ The hazards of waste tyres are air pollution, produced due to open burning of tyres aesthetic pollution which are caused by stockpiles of waste tyre and other defects such as changes in hydrological regimes and when gullies and water courses become dumping sites.

→ Crumb rubber is manufactured from two primary feed stocks: tire buffing (shredded rubber), a by product of tire retreading and scrap tire rubber.

→ Higher resistance to deformation under increased road temperature improves smoothness to drive

## Natural rubber modified bitumen

- The bitumen is heated to  $160^{\circ}\text{C}$  prior mixing, and natural rubber is added gradually into the bitumen until the mixture become essentially homogeneous.
- The modified bitumen sample is prepared by means of a high shear laboratory type mixer rotating at  $1100\text{ rpm}$ .
- A commercial modified bitumen PG76 was used as a comparison.

## Polymer modified bitumen binders

- Polymer modified bitumen (PMB) is one of the specially designed and engineered bitumen grades, that are used in making pavement, roads for heavy duty traffic and home roofing solutions to withstand extreme weather conditions.
- PMB is a normal bitumen with the added polymers, which gives it extra strength, high cohesiveness and resistance to fatigue, stripping and deformation, making it a favorable material for infrastructure.
- In recent years a plethora of techniques have been employed in the study of the effect of the addition of polymer on a range of bitumen properties, polymers-bitumen morphology & polymers-bitumen interactions.

# BITUMINOUS CONCRETE

## Critical Parameters Controlling bituminous

Concrete mixture design

→ Marshall mix design

→ The Marshall stability and flow test provides the performance prediction measure for the marshall mix design method.

→ The stability portion of the test measures the maximum load supported by the test specimen at a loading rate of 50.8 mm/minute.

→ The parameters are

- 1) Specific gravity of the mix
- 2) Bulk specific gravity of mix
- 3) Air voids Percent
- 4) Percent volume of bitumen
- 5) Voids in mineral aggregate
- 6) Voids filled with bitumen

→ Marshall stability of a test specimen is the maximum load required to produce failure when the specimen is preheated to a prescribed temperature placed in a special test head and the load is applied at a constant strain.

## Aggregate blending concepts

- The concepts rely on coarse aggregate for the skeleton of the mixture with the proper amount of the aggregate to provide a properly packed aggregate structure.
- Aggregate blending, blending aggregates by graphical method, concrete mix design, grading of aggregate
- A reasonable combination of fine & coarse aggregate must be used.
- Techniques are
  - 1) Trial -and- Error method
  - 2) Triangular -chart- method
  - 3) Modified -triangular -chart method
  - 4) Rectangular -chart or straight line method
  - 5) Routhfuch's Balanced Area method.
  - 6) Japanese method.

→ Projection -Triangular chart or  
Triangle -Rectangular chart method.

  - 8) Mathematical method

### Routhfuch's method

The Method developed by Routhfuch's (11+13) is widely used outside the United States and has been considered in many countries as one of the most useful graphical procedures.

- ① Plot the median or midpoint of the specifications using linear ordinates for the percentage passing, but choose a scale of sieve size such that the grading plots as a straight line.
- ② The grades of aggregate A, B, and C are plotted on this scale (curves A, B and C)
- ③ Straight lines that most clearly approximate the grading curves of the individual aggregates are drawn. This is done by selecting a straight line for each curve such that the areas enclosed between it and the curve area minimum and are enclosed between them.
- ④ The opposite ends of these straight lines are joined together, the proportions for the blend can be read off from the points where these joining lines intersect the straight line representing the specification grading ( $P_1$  &  $P_2$ ).

→ This method yields the following proportions  
Aggregate A = 70.1, B = 24.1, and C = 6.1, totally 100 Percent. The grading for this combination is given.

→ It is to be noted that calculations using the proportions determined graphically are necessary and that the blend may or may not meet the specification.

→ The only case in which the blend determined from the chart yields the exact specification grading (s) is when

- (a) all the aggregate grading curves are linear
- (b) there is neither gap nor overlapping among aggregate.

## Trial and error procedure

- As the name implies, in this method, trial blends are selected and calculated for each sieve for the combined grading.
- The grading that results is compared with the specification.
- Adjustments can be made for the second or the third trial blends and the calculations repeated for the critical sieves until the satisfactory or optimum blends are obtained.
- This method, guided by a certain amount of reasoning, mathematics and graphics, is the easiest procedure to determine a satisfactory blend for two or even three aggregates.

## Introduction to advanced concrete for road

### Applications

- Pavements are the critical element of an efficient highway transportation system for moving people and goods.
- Advanced Concrete is a Computer-aided design (CAD) software application was developed by GRIEC, but is now an Autodesk product, for modelling and detailing reinforced concrete structures.
- Advance Concrete is used in the structural, Civil engineering and drafting fields.

→ Advance concrete was discontinued by Autodesk on January 31, 2014, with Revit as the suggested Replacement.

→ we have long history of providing the best quality block or poured wall foundations for addition and new construction.