## UNIT IV-HIGHWAY MATERIALS AND CONSTRUCTION PRACTICE

### PART - A (2 mark)

**1. Define flaky aggregates. (APRIL/MAY 10)**

Aggregates which pass through the appropriate elongated slot of the thickness gauge are called flaky aggregates. Width of elongated slot would be 0.6 times the average of the size range. For example if the size range is 16to 20mm whose average size is 18mm,the width of the elongated slot is 10.8mm(0.6x18).hence in aggregates of 16to20mm size, the aggregates passing through 10.8mm are called flaky aggregate.

**2. What is the purpose of applying tack coat in bituminous road construction? (APRIL/MAY 10)**

Teak coat is a single initial application of bituminous material on the surfaces which has previously been treated or prepared such as existing bituminous, Portland cement concrete, brick or block surfaces. Teak coat is simply applied to insure adhesion between the existing surface and the new bituminous surface. Since in this case the base is comparatively impervious, the quantity of binder required may be less than the primer.

**3. Define flakiness index. (APRIL/MAY 11)**

The flakiness index of aggregates is the percentage by weight of particles in it whose least dimension (thickness) is less than three fifths (0.60 of their mean dimension.

**4. State any two techniques for protecting the subgrade from moisture due to capillary rise. (APRIL/MAY 11)** If the water reaching the subgrade due to capillary rise is likely to be determintal.it is possible to solve the problem by arresting the capillary rise instead of lowering the water table.

The capillary rise may be arrested either by a capillary cut off of any one of the following two types:

- By providing a granular material of suitable thickness between the subgrade and the highest level of subsurface water table.
- By inserting an impermeable or a bituminous layer instead of a granular material.

**5. Define softening point of bitumen. (MAY/JUNE 12) (NOV/DEC 13)**

Softening point is the temperature at which the substance attains a particular degree of softening under specified condition of test.

**6. State the desirable properties of road aggregate. (MAY/JUNE 12)**

Strength
Hardness
Toughness
Durability

- Shape

**7. Mention the desirable properties of highway materials. (MAY/JUNE 13)**

There are different highway materials, viz, soil, stone, bitumen, concrete. Each material has defined desirable properties for the purpose for which it is used. The desirable properties of soil as a highway material are:

- Short and long term stability of the subgrade and slopes of embankment.
- Compressibility within permissible limits.
- Adequate permeability
- Compaction should be ease and economical
- Minimum volume change at all conditions.

**8. Write the importance of California bearing ratio. (MAY/JUNE 13)**

The CBR test is an empirical test and not based on any theory or mathematical reasoning. however, it is one of the best penetration test to evaluate the sub grade strengths for roads and pavements.CBR values depend very much on moulding water content and density.CBR values are also used to identify the type of aircraft which can land a runway based on thye CBR and load classification number relationship.

**9. Mention the names of tests recommended by Indian standards for testing highway materials. (NOV/DEC 13)**

- Tests for aggregates
- Crushing test
- Abrasion test
- Impact test
- Soundness test
- Water absorption test

Shape test

- Flakiness index
- Elongation index

Test for bitumen

- Penetration test
- Ductility test
- Viscosity test
- Binder content test

- Softening point test
- Flash and fire point test

**10. What are the Index properties available in soil?** The properties are:

i) Grain size analysis
ii) Consistency limits and indices
iii) Plastic limit
iv) Plasticity index
v) Shrinkage limit
vi) Field moisture equivalent

**11. Define Textural classification?**

The textural classification system is based on grain size distribution of the soil and is helpful in classifying a soil which contains different soil component such as sand silt and clay.

**12. Define the three groups of evaluation of soil strength?** The three groups are:

a) Shear test
b) Bearing test
c) Penetration test

**13.How to calculate the CBR value in highway materials?**

The CBR value is calculated using the relation:

$$CBR = \frac{\text{[Load (or) pressure sustained by the specimen at 2.5 or 5.0 min penetration]}}{\text{Load (or) pressure sustained by standard aggregate at the corresponding level}}$$

**14. What is mean by penetration test?**

It may be considered as small scale bearing tests in which the size of the loaded area is relatively much smaller and ratio of the penetration to size of loaded area is much greater than the ratios on bearing test. The California Bearing ratio test and cone penetration tests are commonly known as Penetration test.

**15. What are the problems occur in paving mixes?** The problems are:

i) mixing
ii) Attainment of desired stability of the mix
iii) To maintain the stability under adverse weather conditions
iv) To maintain sufficient flexibility and thus avoid cracking of bituminous surface.
v) To have sufficient adhesion with the aggregates in the mix in presence of water.

**16. What are the types affect the strength test?**

i) Static immersion test
ii) Dynamic immersion test
iii) Chemical immersion test
iv) Immersion mechanical test

v) Immersion trafficking test
vi) Coating test

**17. What are the problems occur in paving mixes?** The problems are:

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**18. What is the equation for group index of soil?**

Group index is function of percentage material passing 200 mesh sieve (0.074mm) liquid limit and plasticity index of soil and is given by the equation.

$G_1 = 0.2\ a + 0.005ac + 0.01\ bd$

**19. What do you understand about flash and fire point of bitumen?**

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

**20. Why joints are provided in cement concrete pavements?**

Joints are provided in cement concrete pavements to reduce temporary stresses, to prevent longitudinal cracks, to prevent shrinkage cracks etc…

Various types of joints are provided in cement concrete pavements,viz, expanction joint, construction joint and warping joint to reduce temperature stresses.other types of joints are longitudinal joint and construction joint.

In order to prevent formation of irregular longitudinal cracks and at the same time to allow for transverse warping and unequal settlement longitudinal joints are provided.

## PART B (16 MARKS)

**1. Discuss the merits and demerits of cement concrete roads. (MAY/JUNE 13)**

**Merits**

- Capable to take unlimited amount of traffic of any type.
- Ease, comfort and safety.
- Smooth, dust free and skid resistance surface High
- degree of visibility during day and night times.
- Economical because of low cost of maintenance and relative performance.
- Standard material highway for urban and expressways.
- Because of rigidity can span or bridge over some minor irregulaties in the sub grade or sub base.
- Wear and tear of tyres and mechanical breakdown is less and hence less operational cost.
- Even failed surface due to some reason forms a very economical base for the new coat.

**Demerits**

- Initial cost of construction is high and needs skilled labour.
- Long construction period because of curing time.
- Providing and maintenance of joint are difficult.
- Because of smooth surface, there will be glare on the eye of driver which is objectionable.
- Repairing of cracks is difficult.

**2. Briefly explain the penetration test and softening point test on bitumen.**

**(APRIL/MAY 11)**

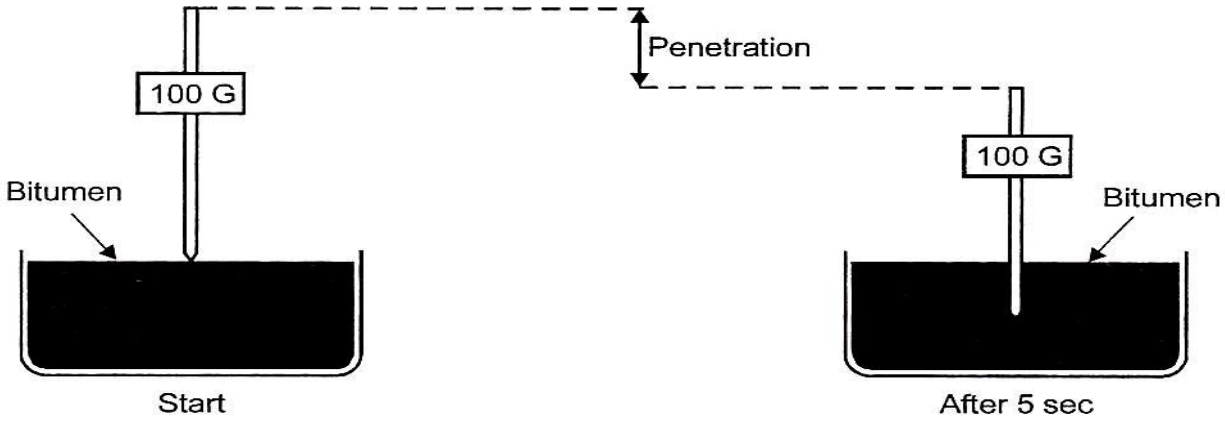
**Penetration test**

The penetration test determines the hardness and softness of bitumen by measuring the depth in tenths of a millimeter to which a standard loaded needle will penetrate vertically in five seconds. The sample is maintained at a temperature of $25^0$C.

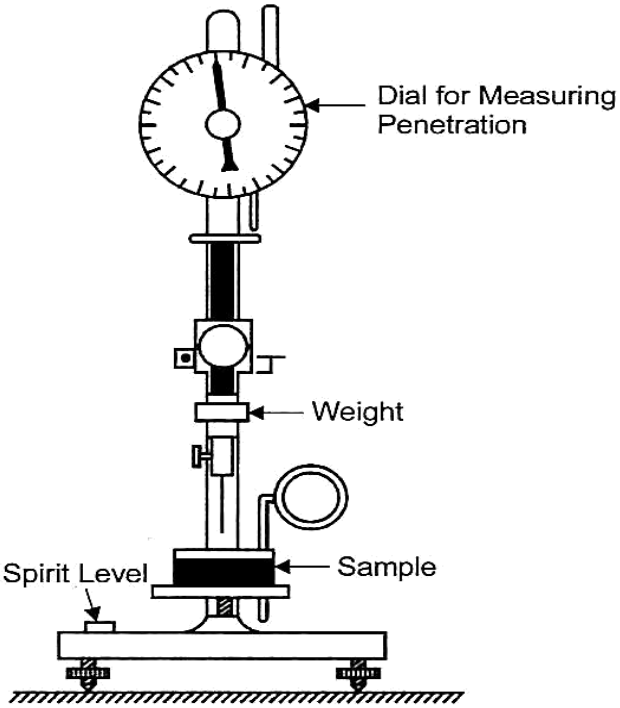
The penetrometer consists of a needle assembly with a total weight OF 100g and device for releasing and locking any position. There is a graduated dial to read penetration values to $1/10^{th}$ of a millimeter.

The bitumen is softened to a pouring consistency, stirred thoroughly and poured into containers to a depth at least 15mm in excess of the expected penetration. The sample containers are then placed in a temperature controlled water bath at temperature of $25^o$C for one hour. The sample with container is taken out and the needle is arranged to contact with the surface of the sample. The dial is set to zero or the initial reading is taken and the needle is released for 54 seconds. The final reading is taken on dial gauge. At least three penetration tests are made on this sample by testing at distances of at least 10mm apart. After each test the needle is disengaged and wiped with benzene and dried. The depth of penetration is reported in one tenth millimeter unit. The mean value of three measurements is reported as a penetration value. It may be noted that the penetration value is largely influenced by any inaccuracy as regards pouring temperature, size of needle weight placed on the needle and the test temperature.

The bitumen grade is specified in terms of penetration value 80-100 or 80/100 grade bitumen mean as that the penetration value of the bitumen is in the range 80 to 100 at standard test conditions.




**Penetration test concept**



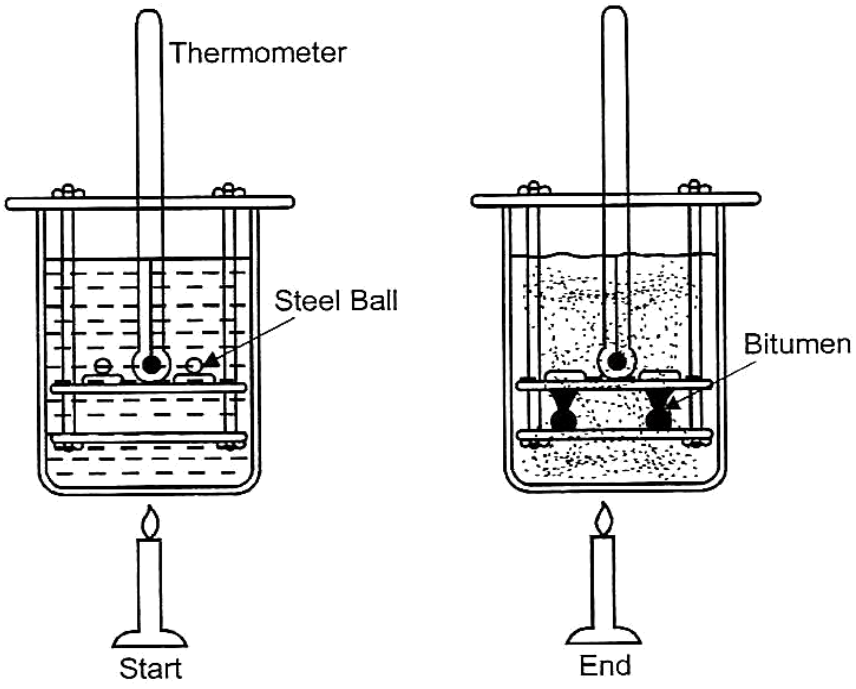

**Penetrometer**

**Softening point test**

The softening point is the temperature at which the substance attains a particular degree of softening under specified condition of test. The softening point of bitumen is usually determined by ring and ball test.

Generally higher softening point indicates lower temperature susceptibility and is preferred in warm climates brass ring containing test sample of bitumen is suspended in liquid like water or glycerin at a given temperature steel ball is placed upon the bitumen sample and the liquid medium is then heated at a rate of $5^0$C per minute. The temperature at which the softened bitumen touches the metal placed at a specified distance below the ring is recorded as the softening point of bitumen. Hard grade bitumen posses higher softening point than soft grade bitumen's.

The softening point of various bitumen grades used in paving jobs very between $35^0$ to $70^0$C.



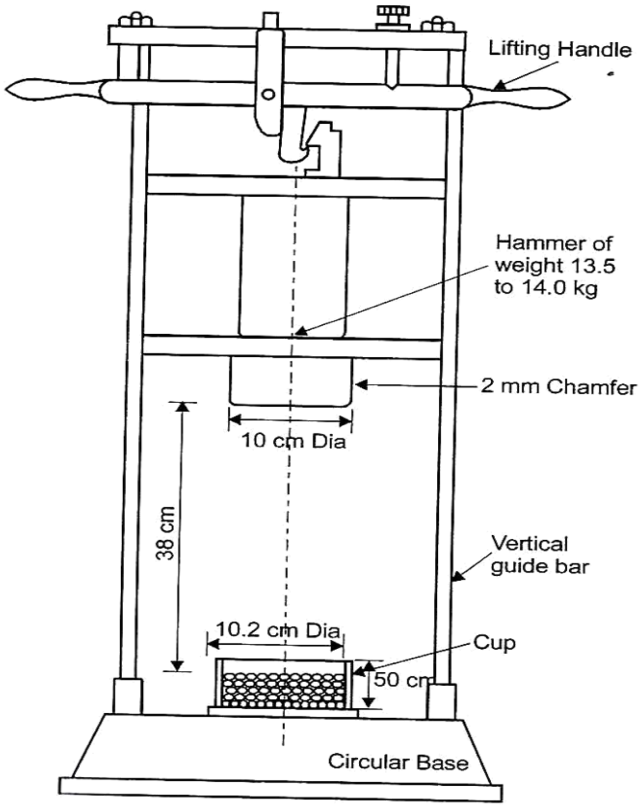

**3. Describe how impact value of aggregate and specific gravity of bitumen is found in laboratory. (APRIL/MAY 11) (APRIL/MAY 10) Impact value test**

A test designed to evaluate the toughness of stone or the resistance of the aggregates to fracture under repeated impacts is called impact test. The aggregate impact test is commonly carried out to evaluate the resistance to impact of aggregate and has been standardized by ISI.

The aggregate impact value indicates a relative measure of resistance of aggregates to impact, which has a different effect then the resistance to gradually increasing compressive stress. The aggregate impact testing machine consists of a metal base and a cylindrical steel cup of internal diameter 10.2cm and depth 5cm in which the aggregate specimen is placed. A metal hammer of weight of 13.5-14.0 kg having a free fall from a height 38cm is arranged to drop through vertical guides.

Aggregate specimen passing 12.5mm sieve and retained on 10mm sieve is filled in cylinder measure in 3 layers by tamping each layer by 25 blows. The sample is transferred from the measure to the cup of the aggregates impact testing machine and compacted by tamping 25 times. The hammer is raised to a height of 38cm above the upper surface of the aggregate in the cup and is allowed to fall freely on the specimen. After subjecting the test specimen to 15 blows, the crushed aggregate is sieved on 2.36mm sieve. The aggregate impact value is expressed as the percentage of the fine formed in terms of the total weight of the sample.

The aggregate impact value should not normally exceed 30percent for the aggregate to be used in wearing course of pavements. The maximum permissible value is 35% for bituminous macadam and 40%for water bound macadam base courses.




**Specific gravity of bitumen**

The density of the bitumen binder is a fundamental property frequently used as aid to classify the binders for use in paving jobs. In most applications, the bitumen is weighted but finally when used with aggregate system; the bitumen content is converted on volume basis using density values. The specific gravity value of bitumen is also useful in bituminous mix design. The density of bitumen is greatly influenced by its chemical composition. Increased amounts of aromatic type compounds or mineral impurities cause an increase in specific gravity.

The specific gravity of bitumen material is the ratio of t6he mass of a given volume of the substance to the same of an equal volume of water, the temperature of both being $27^0$C.the specific gravity is determined either by using a pycnometer or preparing a cube shape specimen in semi solid or solid state and by weighing in water.

Generally the specific gravity of pure bitumen is in the range of 0.97-1.02.the specific gravity of cutback bitumen may be lower depending on the type and proportion of diluents used. Tars have specific gravity ranging from 1.10-1.25.

**4. Explain the importance and procedure of field density test and crushing strength test. (MAY/JUNE 13)**

**Field density tests**

**Theory**

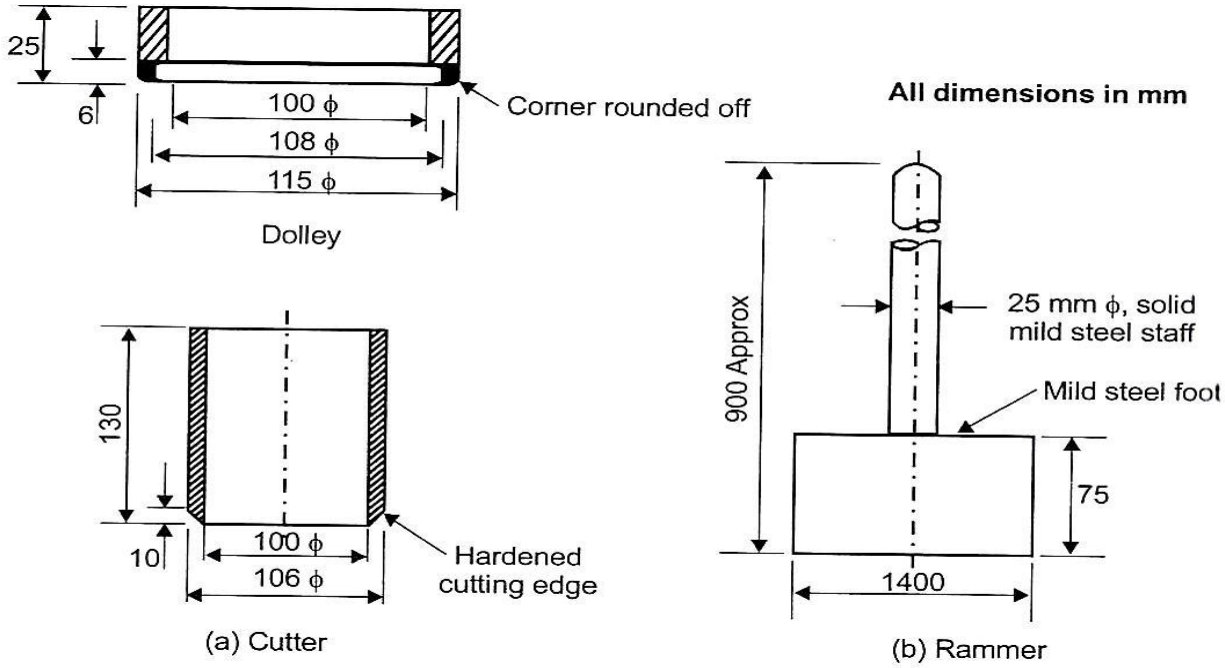
Dry density of a soil in the field is called field density. Field density is found adopting core cutter method or sand replacement method.

**Core cutter method**

**Apparatus required**

- Cylindrical core cutter of steel with steel dolly and steel rammer
- Steel rule, palette knife, straight edge

- Balance of 1 g sensity7vity
- Apparatus for water content determination
- Apparatus for extracting samples from the cutter




**Test procedure**

- The inner dimension of the core cutter is measured and its volume is found ($V_C$).
- The weight of the core cutter is found without the dolly.
- The small area about 300mm$^2$ is cleared and leveled where the in place density is to be determined.
- The cutter is placed on the subsoil by the help of rammer until about 15mm of the dolly protrudes above the surface.
- The soil around the cutter is dug using a spade or pickaxe the cutter bodily removed with soil allowing some soil to project from the lower end of the cutter. The top and bottom of the cutter are trimmed by means of a palette knife and straight edge.
- The cutter with soil and without dolly is weighed ($M_{SC}$).
- The soil is removed from the cutter and the water content determined.

**Computation and result**

Then bulk density, $\rho = (M_{SC}-M_C)/V_C$ g/cc

The field density, $\rho_d = \rho/(1+(w/100))$ g/cc

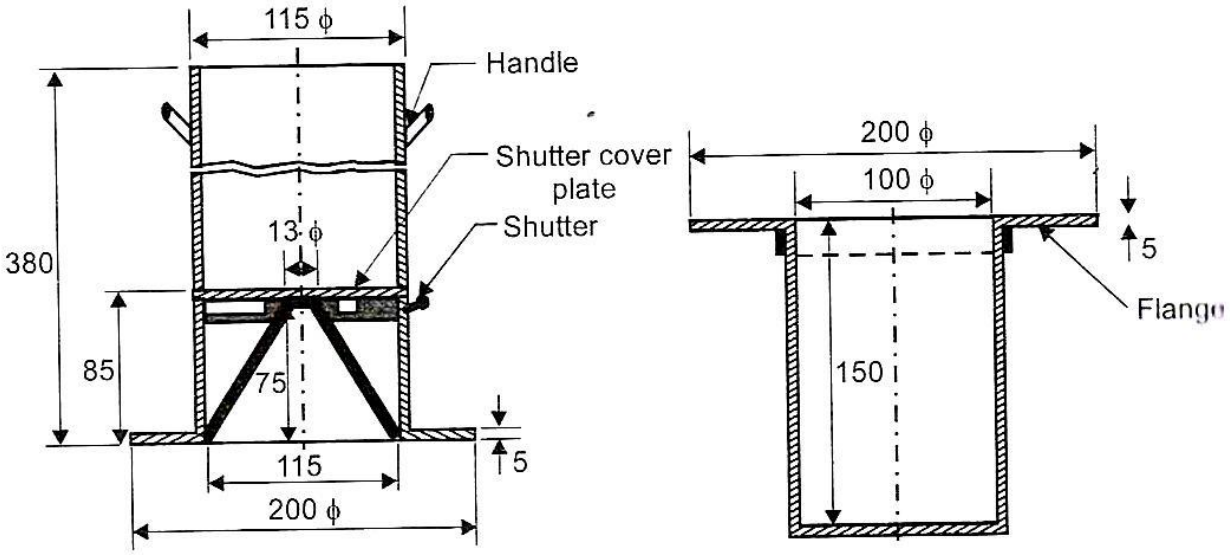
Where the w is the percentage field water content. The dry density and water content of soil are reported to the second decimal place and two significance figures respectively.

**Sand replacement method**

**Apparatus required**

- Sand pouring cylinder
- Closely graded natural sand passing the 1mm IS sieve but retained on the 600µ IS sieve is cleaned.
- Cylindrical calibration can.
- Metal tray with hole.

- Tools for excavating holes.
- Glass –plate-450mm$^2$, 9 mm thick.
- Balance.




(a) Sand pouring cylinder (b) Calibration can

**Test procedure**

- The pouring cylinder is filled with clean sand till the level of sand is about 10mm from the top and weight, $M_1$, is found.
- This mass is maintained constant throughout the test for which the pouring cylinder has to be calibrated.
- Pouring cylinder is placed on a glass plate and the top is closed when the conical portion has been filled.
- Sand on a glass plate is carefully collected and the sand is weighed. Steps first and third are repeated at least three times and the average mass of sand filling the cone is found ($M_2$).
- Internal dimensions of the calibration can be measured and its volume. The can is filled with water up to the brim and find the mass. From the mass the volume is found and checked with the previous one and average volume, V, is determined.
- The pouring cylinder is placed concentrically on top of the calibration can with initial mass, $M_1$.the shutter is opened and the sand is allowed to fill the can. The cylinder is tapped so as to ensure that the can and the conical portion are completely filled with sand. The cylinder is weighed.
- The step four is repeated thrice and the average mass $M_3$ of the cylinder after filling the cone and the can.
- An area of about 450mm$^2$ is cleaned and leveled of the soil to be tested.
- The square tray with a central hole is placed on the prepared surface. A circular hole of 100mm diameter and 150mm depth is roughly dug. All the soil are carefully collected and the mass is found as ($M_s$).in case of a fine grained soil a core cutter is pushed approximately up to a depth of 100mm,the soil is collected and weighed as $M_s$. the core cutter is kept in position till the rest of the procedure.
- Some representative soil for water content determination is taken.

- The t5ray is removed and the pouring cylinder is concentrically placed on the hole with initial mass $m_1$.the shutter is opened and the sand is allowed to fill the core and hole. The cylinder is weighed as ($M_4$).

**Computation and results**

Mass of sand filling calibration can=$M_a$= ($M_1$-$M_3$-$M_2$) g
Bulk density of sand, $\rho_{sd}$ =$M_s$/V g/cc
Mass of sand required to fill the excavated hole, $M_b$= ($M_1$-$M_4$-$M_2$) g
Bulk density of soil, $\rho$= ($M_s$/$M_b$)x $\rho_{sd}$ g/cc
Dry density of soil, $\rho_d$ = $\rho$/(1+(w/100)) g/cc

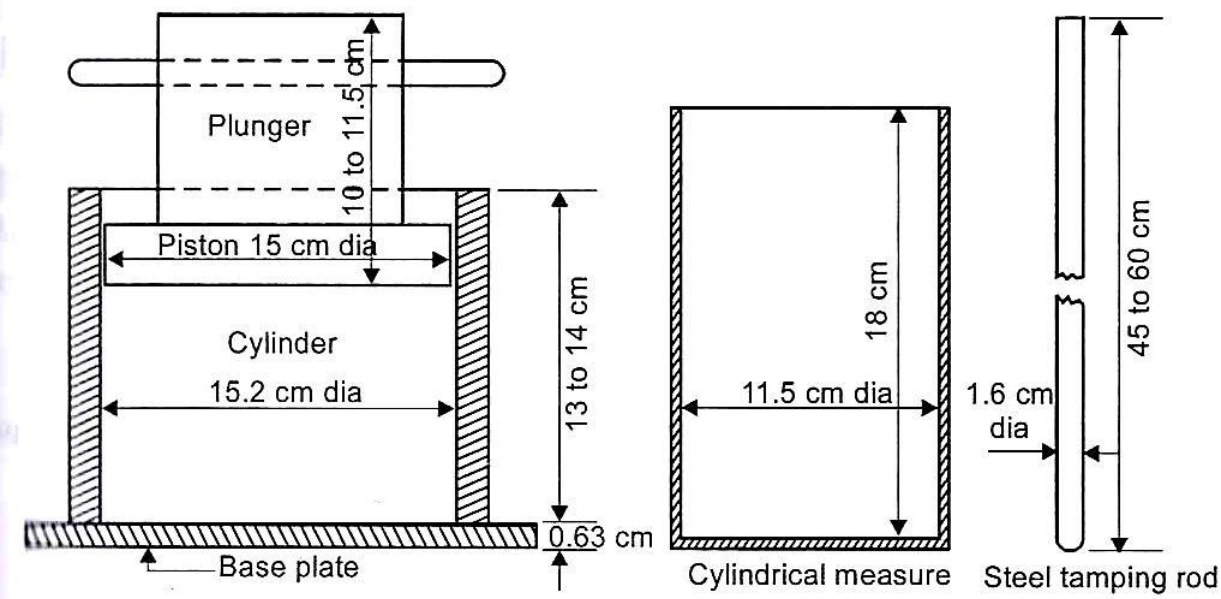
**Crushing strength test**

The strength of course aggregate may be assessed by aggregate crushing strength test. The aggregate crushing value provides a relative measure of resistance to crushing under gradually applied compressive load. To achieve a high quality of pavement aggregates possessing high resistance to crushing or low aggregate crushing value are preferred.

The apparatus for standard test consists of a steel cylinder 15.2cm diameter with a base plate and plunger, compression testing machine, cylindrical measure of diameter 11.5cm and height 18cm, tamping rod and sieves.

Dry aggregates passing 12.5mm IS sieve and retained on 10mm sieve is filled in the cylinder measure in three equal layers, each layer being ramped 25 times by the tamper. The test sample is weighed (equal to $w_1$g) and placed in the test cylinder in compression machine. The plunger is placed on the top of specimen and a load of 40 tones is applied at a rate of 4 tones per minute by the compression machine. The crushed aggregate is removed and sieved on 2.36mm IS sieve. The crushed material which passes this sieve is weighed equal to $w_2$g.the aggregate crushing value is the percentage of the crushed material passing 2.36mm sieve in terms of original weight of the specimen.

Aggregate crushing value=100$w_2$/$w_1$




**Aggregate crushing test apparatus**

Strong aggregates give low aggregate crushing value. The aggregate crushing value for good quality aggregate to be used in base course shall not exceed 45 percent and the value for surface course shall be less than 30 percent.

**5. Describe the procedure recommended by bureau of Indian standards for carrying out the following tests. (MAY/JUNE 12)**

**i) Abrasion test**

Due to the movements of traffic the road stones used in the surface course are subjected to wearing action at the top. Hence road stones should be hard enough to resist the abrasion due to the traffic. Abrasion tests are carried out to test the hardness property of stones and to decide whether they are suitable for the different road construction works. The abrasion test on aggregate may be carried out using any one of the following three tests.

- Los angles abrasion test
- Deval abrasion test
- Dorry abrasion test

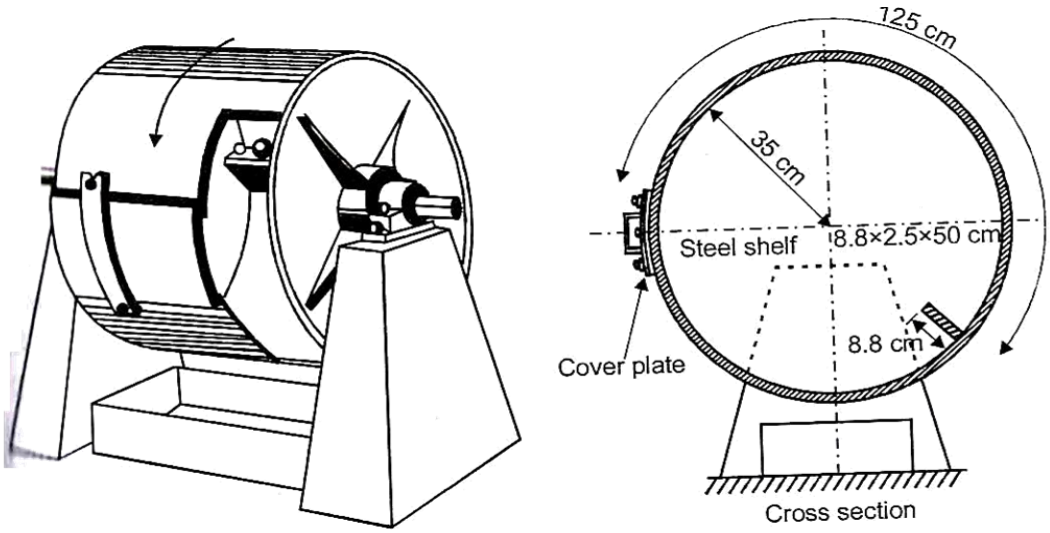
However los angles abrasion test is preferred as the result have been correlated with pavement performance.

**Los angles abrasion test**

The principle of los angles abrasion test is to find the percentage wear due to the relative rubbing action between the aggregate and steel balls used as abrasive charge. Pounding action of these balls also exists during the test and hence the resistance to wear and impact is evaluated in this test. The los angles consists of a hollow cylinder closed at both ends, having inside diameter 70cm and length 50cm and mounted so as to rotate about its horizontal axis.

The abrasive charge consists of cast iron spheres of approximately diameter 4.8cm and each of weight 390-445 g. the number of spheres to be used as abrasive charge and their total weight have been specified based on grading of the aggregate sample.

The specified weight of aggregate specimen, (5 to 10 kg) is placed in the machine along with the abrasive charge. The machine is rotated at a speed of 30-33rpm for the specified number of revolutions(500-1000).the abraded aggregate is then sieved on 1.7mm IS sieve and the weight of powdered aggregate passing this sieve is found. The result of the abrasion test expressed as the percentage wear or the percentage of passing 1.7mm sieve expressed in terms of the original weight of the sample. The los angles abrasion value of good aggregate acceceptable for cement concrete bituminous concrete and other high quality pavement materials should be less than 30 percent. Values up to 50 percent are allowed in base course like water bound and bituminous macadam road. This test is more dependable than other abrasion tests as rubbing and pounding action in the test simulate the field conditions better. Also correlation of los angles abrasion value with field performance and specifications of the test values have been established.

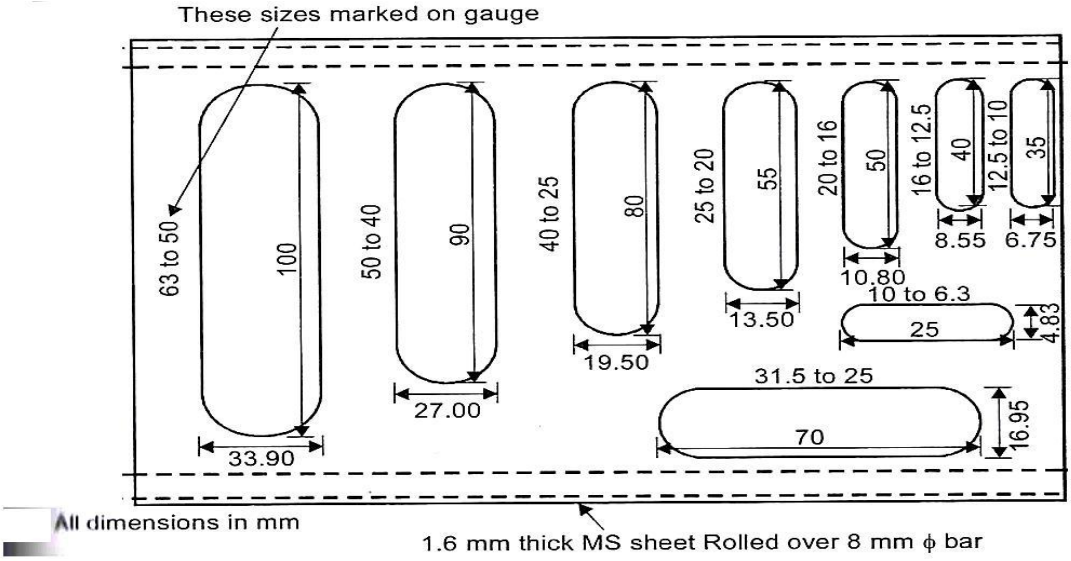



**ii) Flakiness index test**

The flakiness index of aggregate is the percentage by weight of aggregate particles whose least dimensions /thickness is less than three fifths or 0.6 of their mean dimension. The test applicable to sizes larger than 6.3mm.standard thickness gauge is used to cause the thickness of the sample.

The sample of aggregates to be tested is sieved through a set of sieves and separated into specified size ranges. Now to separate the flaky material the aggregate which passes through the appropriate slot would be 0.6 of the average of the size range. If the size range of aggregate in a group is 16-20mm,the width of the slot too be selected in thickness gauge would be 18x0.6=10.8mm.

The flaky material passing the appropriate slot from each size r5ange of test aggregates are added up and let this weigh be w. If the total weight of sample taken from the different sizes ranges is W. flaky index is given by 100w/W percent, or in other words it is the percentage of flaky materials the width of which are less than 0.6 of the mean dimentions.it is desirable that the flakiness index of aggregates used in road construction is less than the 15 percent and normally does not exceed 25 percent.



**6. Specify the design approach for the surface drainage system of highways.**

**(MAY/JUNE 12**)

Surface drainage deals with arrangements for quickly and effectively leading away the water that collects on the surface of pavements, shoulders, and other adjoining areas.

Surface drainage consists of two operations:

- Collection of surface water
- Disposal of collected surface water

Rain water from road surface is left off to the sides by cross slope or camber. Based on the rainfall of the area the rate of cross slope is provided.

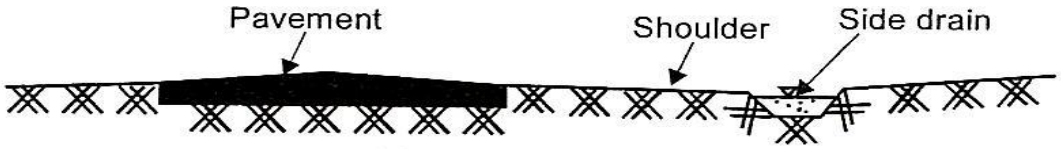
In rural plain area, the disposal of water depends on whether the road is in embankment or in cutting or on ground line.

Side drains of suitable size and adequate longitudinal slope are constructed along both the sides of the road at some distance from the foot of embankment. The side drains are trapezoidal in shape.

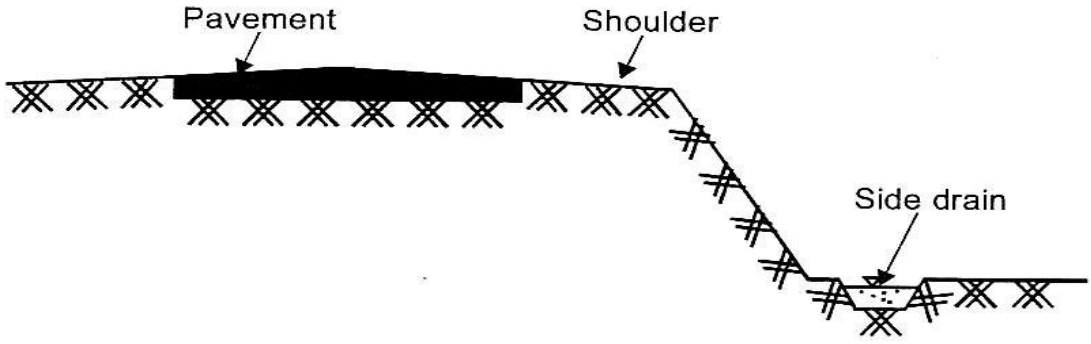
In cuttings, drains are provided along both the sides of the road just next to the shoulders. If there is a restriction of space covered drains or drainage trenches are provided with layers of coarse sand and gravel.

In case of urban roads, underground drainage facilities are provided to drain off surface water. Urban drains are provided because of presence of foot path and other developments. Water drained from the pavement surface can be drained longitudinally and may be collected in catch pits and carried forward through underground drainage pipes. A typical catch pit with grating to pavement the entry of rubbish into the drainage system is shown in fig.

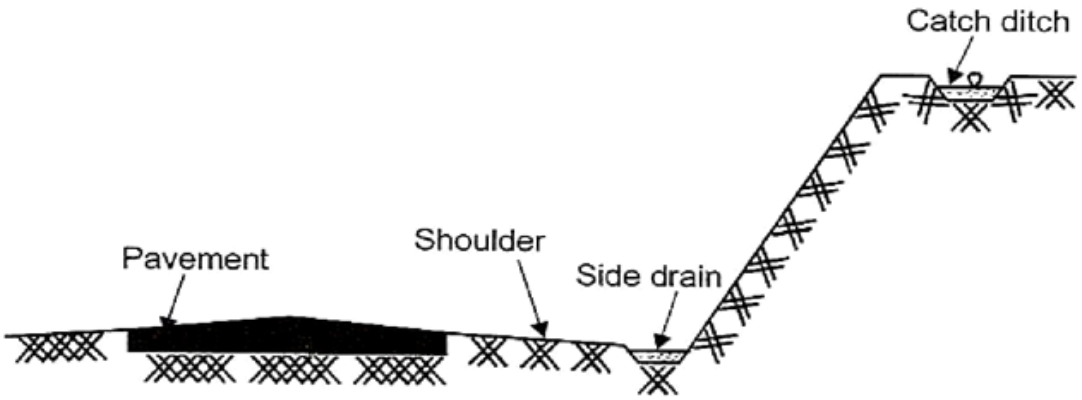
Highway drainage is of much more important in hill road formation, it is essential to divert and dispose off the water flowing down the hill slope across the road and efficient it will result in complex maintenance problems. Hence drainage arrangements in hill road should be made to work efficiently.



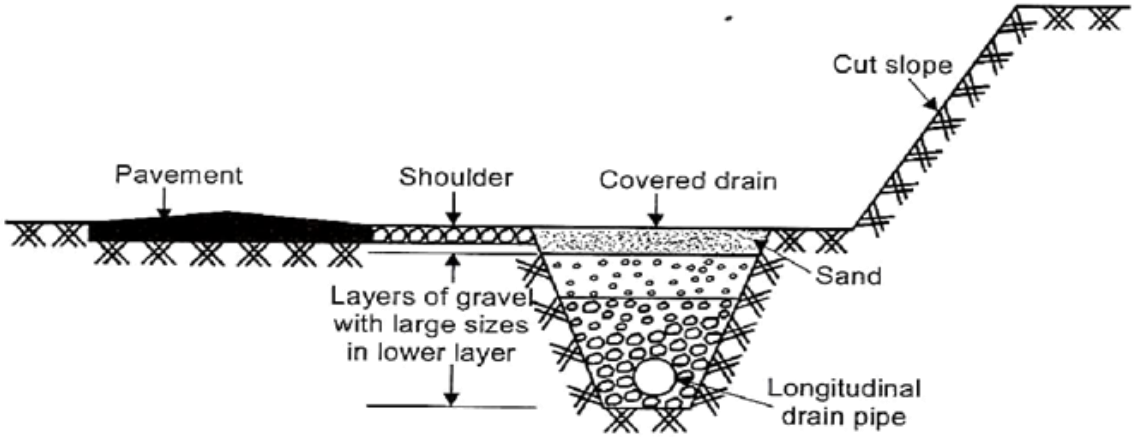

(a) Side-drain in ground line



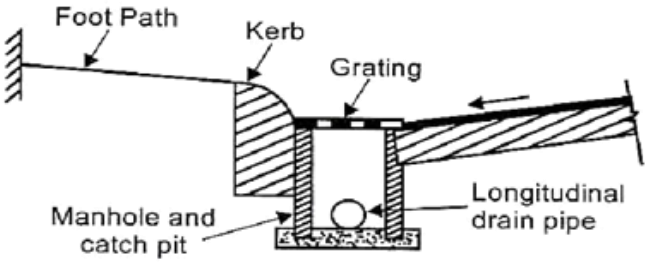

(b) Side-drain in filling ground (embankment)




**Arrangement of side-drains**




**Trench filled with gravel and sand**




**Surface Drainage system in urban roads**

**7. Explain the construction procedure for bituminous concrete. (MAY/JUNE 12)**

- The existing base course is reconditioned as explained in earlier cases at least one week before laying the binder course.
- Then the bitumen course layer will be laid.
- This is also a hot mix process. The hot mix is collected and spread over the prepared surface. The camber and thickness of bitumen layer is checked.
- The placed concrete is rolled by a roller at a speed not more than 5km/hour.
- The number of passes required to attain the final desired thickness depends on the thickness.
- The initial rolling is done using a 8 to 12 tonne roller followed by fixed wheel pneumatic roller of 15 to 30 tonnes. The wheels are kept damp with water or wet gunny.

**8. Explain the test procedure for assessing polishing value of aggregate. (APRIL/MAY 11) (NOV/DEC 13)**

The resistance of stones to polishing under traffic determines its skid resistance. Specimens of stones which are subjected by standard procedure to attain certain shining surface. Such specimens are thereafter tested for their polishing value on a British portable tester. The tester directly measures the amount of polishing by a value called polishing stone value.

**Equipment**

- Curved mould
- Rotating pneumatic wheel
- Portable tester for getting the degree of polishing .this machine consists of a rubber sliding shoe which is mounted at the end of a pendulum. The slider,
  When released, brushes past the specimen and comes to a halt directly showing the polishing value.

**Test procedure**

- The standard procedure adopted for testing the polishing characteristic is to embed the stones in a curved mould in cement –sand mortar and subject the sample to accelerated polishing brought by a rotating pneumatic wheel.
- The size of each specimen is 45mm widex90.5mm 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$^2$.
- The specimen is then fixed and rotated at a speed of 320 to 325 rpm for 3 hours and 15 minutes.
- Sand and water are fed to the machine.
- Specimens are thereafter tested for their polishing value on a portable tester.
- The slider of the machine is released which brushes past the specimen and comes to a halt.
- The degree of polishing of the stone is directly measured on a graduated scale comes to a halt.
- The degree of polishing of the stone is directly measured on a graduated scale as polishing stone value which varies from 250to 80.

**Applications and limitations**

| Stone type | polishing value | quality |
|---|---|---|
| Limestone | 35 to 40 | poor |
| Granite | 40 to 48 | fair |
| Sandstone | >55 | good |

**9. Explain the construction of dense bituminous macadam road. (APRIL/MAY 11)**

The existing surface is reconditioned to proper cross section and the surface is cleaned. On the prepared and cleaned surface a thin layer of binder (prime and teak coat) is applied on a 10 sq.m surface and 4.0 to 7.5 kg of binder is to be used for black top surface or 7.5 to 10 kg for untreated WBM surfaces.

Aggregates of proper gradation and binder are separately heated at about $120^0$c and then mixed in a mixture. This mixture so prepared is placed on the already prepared surface and uniformly spread for the required thickness with rakes. The cross section is again checked. Rolling is done as early as possible after placing premixed material with a 8 to 10 tonne roller.

The rolling is started from the edges and processed towards the centre with uniform overlapping. The wheels of the roller should be kept wet while rolling so as to avoid sticking of mixed material on the wheels.

**10. Explain the construction procedure of the following types of roads. (APRIL/MAY 10) i) Dense bituminous macadam road**

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**ii) Bituminous concrete**

- The existing base course is reconditioned as explained in earlier cases at least one week before laying the binder course.
- Then the bitumen course layer will be laid.
- This is also a hot mix process. The hot mix is collected and spread over the prepared surface. The camber and thickness of bitumen layer is checked.
- The placed concrete is rolled by a roller at a speed not more than 5km/hour.
- The number of passes required to attain the final desired thickness depends on the thickness.
- The initial rolling is done using a 8 to 12 tonne roller followed by fixed wheel pneumatic roller of 15 to 30 tonnes. The wheels are kept damp with water or wet gunny.

**11. Explain the method of construction of cement concrete road. (NOV/DEC 13)**

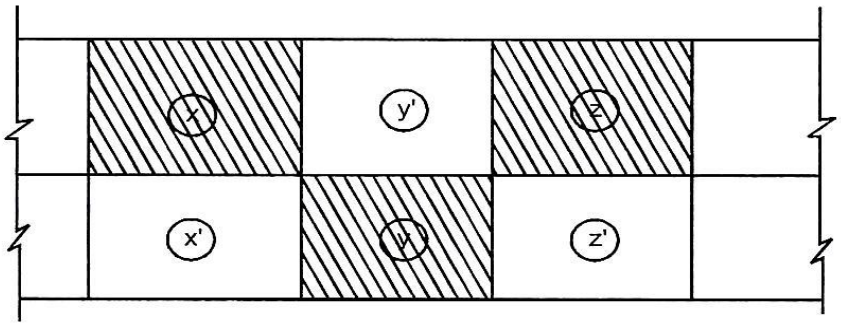
There are two methods of construction of cement concrete road slabs:

- Alternate bay method
- Continuous bay method

**Alternate bay method**

In this method, constructing a bay or one slab in alternate succession leaving the next or intermediate bay. The next construction is done after time gap of one week or so.

For example the alternate bays X, Y and Z are constructed at one stretch. Others, viz., $X^1$, $Y^1$ and $Z^1$ are constructed after one week. This technique provides additional working convenience during the laying of slabs. Provision of construction joints is easier.




**Modes of construction of cement concrete road**

**This mode of construction has the following setbacks:**

- More number of transverse joints have to be provided and thereby increasing the cost.
- Possibility of collection of surface water on the base or sub grade and thereby disturbing the base or sub grade.
- Diversion of traffic is needed as the construction is done on alternate bays covering the entire width.

**Continuous bay method**

In the continuous bay method X, Y, Z, etc are done at a stretch in sequence. Construction joints are however provided at the end of the day's job.

In general the second method is preferred as constructed while the other half is being used by traffic.

**Construction procedure of pavement slab**

- Preparation of sub grade and base
- Placing of forms
- Installation of joints
- Batching of aggregates and cement
- Mixing and placing concrete
- Consolidation and finishing concrete
- Curing of concrete

**Preparation of sub grade and base**

- The sub grade and base should be prepared complying with the following conditions:
- No soft spots are present in the sub grade or base
-

Sub grade or base should be uniformly compacted and extended about 30 cm on either side of the width of pavement to be concreted.

- Sub grade or base should be adequately drained
- Plate load test conducted on the sub grade should yield a minimum modulus of sub grade reaction of 5.5 kg/cm$^3$.

**Placing of forms**

- Wooden or steel forms are used.
- Wooden forms have minimum base width 10 cm for 20 cm slab thickness and of 15 cm for slabs over 20 cm thicknesses.
- Forms are jointed nearly and are set with exact grade and alignment.
- Forms are rigidly fixed such that during the entire operation of concreting they should not deviate more than 3mm from straight edge of 3m length.
- Steel forms commonly used are straight 3m sections.
- They are aligned vertically and horizontally by slip joints and held in position by three or more steel stakes.

**Installation of joints**

- Extreme care should be taken in all operations connected with joints.
- Face of transverse joints should be straight, perpendicular to the centre line of pavement and also perpendicular to the surface of the finished slab.
- Load transfer devices like dowel bars used in expansion joint should be aligned and placed accurately.
- There should be free movement of slab ends in longitudinal direction.

**Batching of aggregate and cement**

- Based on the design concrete mix, the proportion of ingredients like course aggregate and fine aggregate are proportioned by weight in a weigh batching plant. These are placed in the hopper of the mixer along with the necessary quantity of cement.
- Cement is measured by the bag which measures 50kg.thus all batching of material is done on the basis of one or more whole bags of cement taking the unit weight of cement is taken as 1440kg/m$^2$.
- Mixing and placing concrete
- The ingredients are mixed in required quantity for immediate use and are deposited on the sub grade or base.
- Deposited concrete should be to the correct depth and width of pavement section within the formwork.
- The operation of placing concrete should be continuous.

**Consolidation and finishing**

- Concrete is spread uniformly by shovels with redistribution wherever needed. Needle vibrator is used for compaction.
- Surface of the pavement is compacted either using a power driven finishing machine or using a vibrating hard screed.

**Curing of concrete**

It is very important to ensure proper curing of the finished concrete. Following are the methods usually adopted:

- Bonding or each cover kept wet.

- Hay or straw cover kept wet.
- Cover of wet felt mats cotton mats.
- Saw dust kept wet.