UNIT-IV

HIGHWAY CONSTRUCTION MATERIALS AND PRACTICE

1. **Differentiate between "Geo textile and Geo-Membrane" in Highway construction (NOV/DEC 2019), (NOV/DEC 2018),**

   Geo textile:
   Geotextile; material that can pass water from wicker (woven) or non-woven (non-woven) from the threads or synthetic fibers used in ground work, the synthesis of thin sheets, flexible, permeable used for soil stabilization and improvement.

   Geomembrane:
   Geomembrane; material that serves as a waterproof, made of HDPE (Hight Density Polyethylene) or LDPE (Low Density polyethylen). Geomembrane is made of waterproof material, resistant to corrosion, oil, acid and high heat, which are the current trends in the world of civil engineering.

2. **Write short note on Highway Drainage. (NOV/DEC 2019)**
   - 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.
   - 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

3. **How Geo textiles improve safety and stability of highway embankments? (April/May 2019), (Nov/Dec2015),**

   These are flexible textile fabrics of controlled permeability used to provide filtration, separation or reinforcement in soil, rock and waste material. Load on the soil produces expansion. Thus, under load at the interface between the soil and reinforcement (assuming no slippage occurs, i.e. there is sufficient shear strength at the soil/fabric interface).

   These two materials must experience the same extension, producing a tensile load in each of the reinforcing elements that in turn is redistributed in the soil as an internal confining stress. Thus the reinforcement acts to prevent lateral movement because of the lateral shear stress developed. Hence, there is an inbuilt additional lateral confining stress that prevents displacement. This method of reinforcing the soil can be extended to slopes and embankment stabilization

4. **How adding up the waste plastics help in the improvement of bituminous pavements? (April/May 2019), (Nov/Dec2015),**

   Use of plastic waste in the construction of flexible pavement is gaining importance because of the several reasons. The polymer modified bitumen show better properties for road construction & plastics waste, otherwise considered to be a pollution menace, can find its use in this process and this can help solving the problem of pollution because most of the plastic waste is polymers.

5. **Define flakiness index. (Nov/Dec 2017),(April/May 2017), (May/June 2016)**
   The flakiness index is defined as the percentage by weight of aggregate particles whose least dimension is less than 0.6 times their mean size.

6. **Define Elongation index. (April/May 2018), (Nov/Dec 2016)**
   Elongation index (I E) The percentage by weight of particles whose long dimension is greater than 1.8 times the mean dimension measured with a standard gauge. The elongation, n, is length divided by breadth and the elongation ratio is 1/n.

7. **Differentiate between cut-back bitumen and bitumen emulsions (April/May 2018)**

   Cutback Bitumen

   Normal practice is to heat bitumen to reduce its viscosity. In some situations preference is given to use liquid binders such as cutback bitumen. In cutback bitumen suitable solvent is used to lower the viscosity of the bitumen. From the environmental point of view also cutback bitumen is preferred. The solvent from the bituminous material will evaporate and the bitumen will bind the aggregate. Cutback bitumen is used for cold weather bituminous road construction and maintenance. The distillates used for preparation of cutback bitumen are naphtha, kerosene, diesel oil, and furnace oil. There are different types of cutback bitumen like rapid curing (RC), medium curing (MC), and slow curing (SC). RC is recommended for surface dressing and patchwork. MC is recommended for premix with less quantity of fine aggregates. SC is used for premix with appreciable quantity of fine aggregates.

   Bitumen Emulsion :

   Bitumen emulsion is a liquid product in which bitumen is suspended in a finely divided condition in an aqueous medium and stabilized by suitable material. Normally cationic type emulsions are used in India. The bitumen content in the emulsion is around 60% and the remaining is water. When the emulsion is applied on the road it breaks down resulting in release of water and the mix starts to set. The time of setting depends upon the grade of bitumen. The viscosity of bituminous emulsions can be measured as per IS: 8887-1995. Three types of bituminous emulsions are available, which are Rapid setting (RS), Medium setting (MS), and Slow setting (SC). Bitumen emulsions are ideal binders for hill road

construction. Where heating of bitumen or aggregates are difficult. Rapid setting emulsions are used for surface dressing work. Medium setting emulsions are preferred for premix jobs and patch repairs work. Slow setting emulsions are preferred in rainy season.

8. **List out the major construction machineries normally used at present in Highway Construction. (NOV/DEC 2018),**
   i. Dozer
   ii. Grading
   iii. Wheel Loader
   iv. Hydraulic Excavator
   v. Scrapper
   vi. Batching plant
   vii. Paver finisher
   viii. Mixers
   ix. Hot mix plant
   x. Bitumen mixer
   xi. Bitumen sprayer
   xii. Bitumen storage equipment

9. **What is the purpose of conducting abrasion test? (April/May 2017)**

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

10. **What are the desirable properties of soil highway materials?(Nov/Dec 2017)**
    a. Strength
    b. Drainage
    c. Ease of compaction
    d. permanency of compaction

11. **What is the significance of CBR test? (NOV/DEC 2016)**
    The california bearing ratio test is penetration test meant for the evaluation of sub-grade 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.

12. What is the significance of static immersion test? (May/June 2016)

Bitumen and tar adhere well to all normal types of aggregates provided they are dry and are not exceptionally dusty. This problem of stripping is experienced only with bituminous mixtures, which are permeable to water. This test gives the procedure for determination of the stripping value of aggregates by static immersion method, when bitumen and tar binders are used.

13. What is California bearing ratio? (April/May 2015)

CBR test, an empirical test, has been used to determine the material properties for pavement design. Empirical tests measure the strength of the material and are not a true representation of the resilient modulus.

14. Define Softening point (April/May 2015)

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

PART-B

1. **Discuss the following test procedures for testing procedures for the testing the quality of aggregate and Bitumen.(Nov/Dec 2019), (Nov/Dec 2015), (Nov/Dec 2017), (May/June 2016), (April/May 2018)**

Test on Aggregate

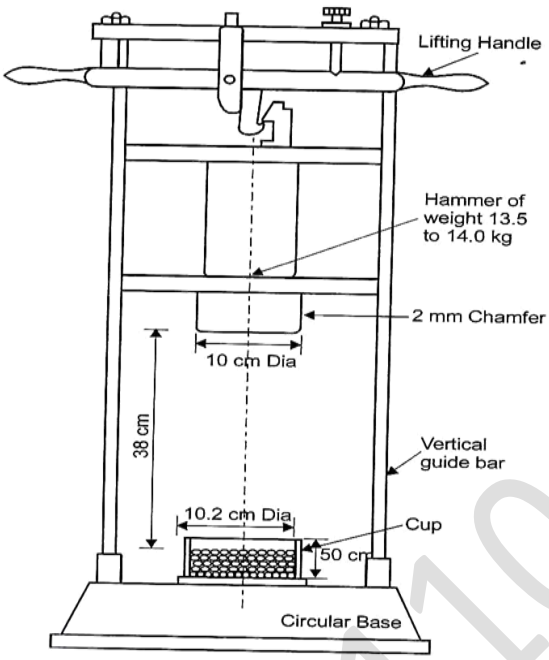
- **i) Aggregate Impact Test**
- **ii) Crushing Test**
- **iii) Los angles abrasion test**
- **iv) Flakiness Index Test**
- **v) Soundness test**

Test on Bitumen

- **i) Softening Point Test on Bitumen**
- **ii) Penetration test on Bitumen**
- **iii) Ductility test on Bitumen**
- **iv) Viscosity test**

(i) Aggregate Impact 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.

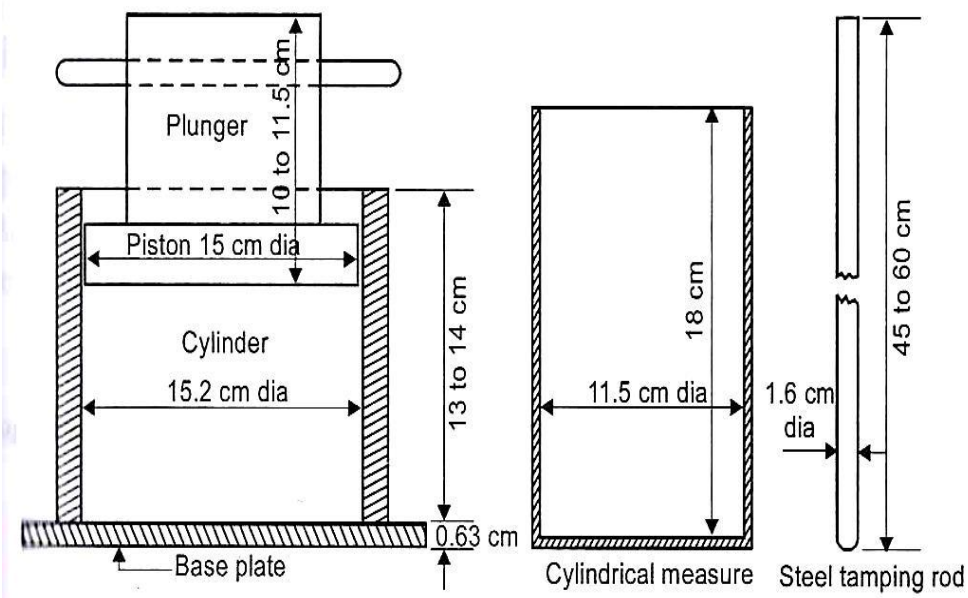
(ii) **Crushing strength test**

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_1g) 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_2g.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=$100w_2/w_1$



Aggregate crushing test apparatus

(iii) **Los angles abrasion test**

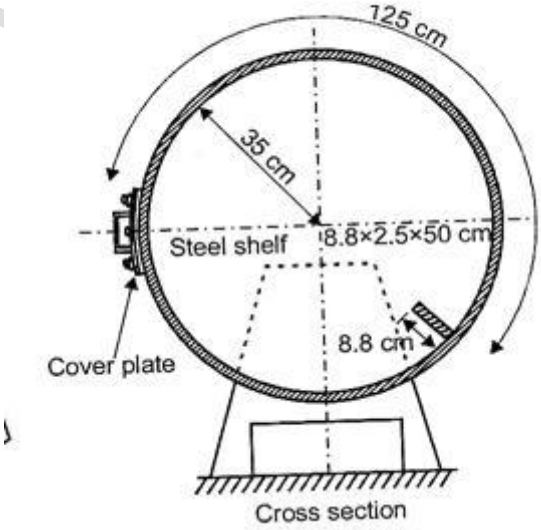
The principle of los angles abrasion test is to find the percentage wear due to the relative rubbing action between the aggregate and steel balls used as abrasive charge. Pounding action of these balls also exists during the test and hence the resistance to wear and impact is evaluated in this test. 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.

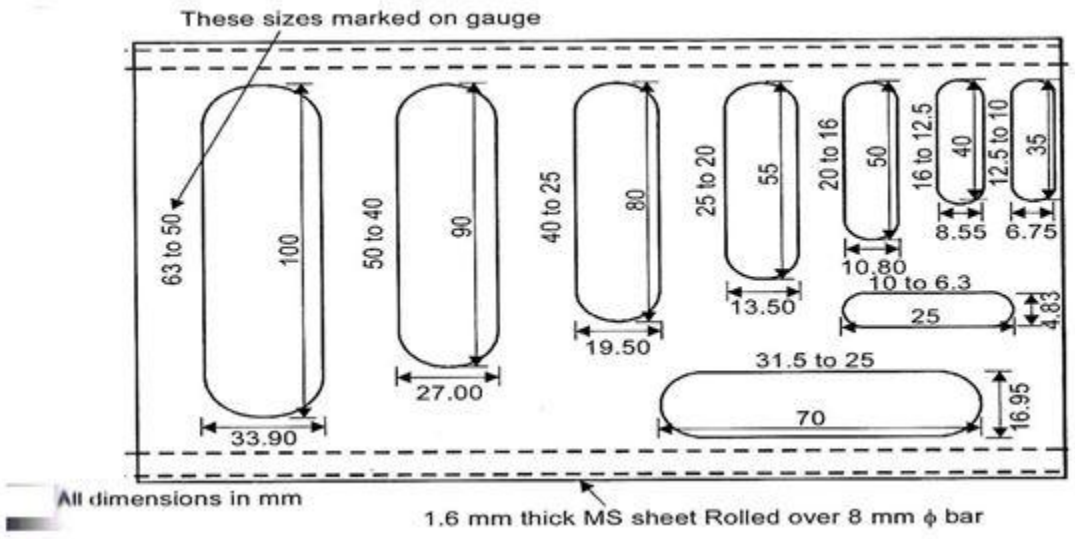


(IV) Flakiness Index Test

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.



(V) 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 are 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

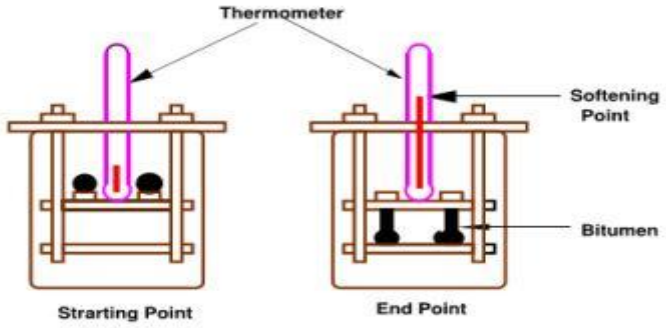
cycles of alternate wetting in a saturated solution of either sodium sulphate or magnesium sulphate for 16 - 18 hours and then dried in oven at 105 110oC to a constant weight. After five cycles, the loss in weight of aggregates is determined by sieving out all undersized particles and weighing. And the loss in weight should not exceed 12 percent when tested with sodium sulphate and 18 percent with magnesium sulphate solution

TEST ON BITUMEN

(i) 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 5^0C 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 70^0C.**

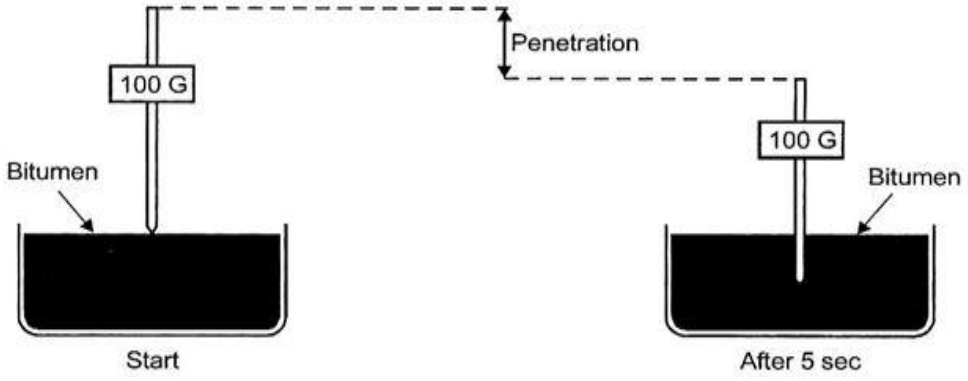
(ii) **Penetration test**

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 25^0C.

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.



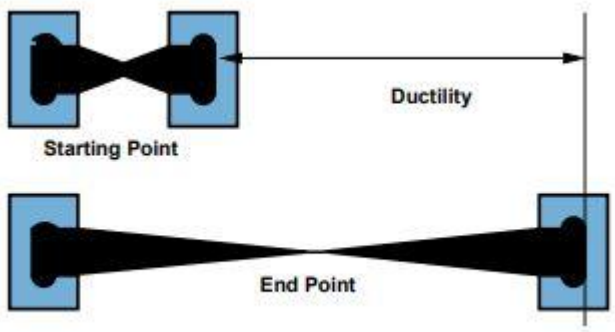
Penetration test concept

(iii) Ductility test on Bitumen

Ductility is the property of bitumen that permits it to undergo great deformation or elongation. Ductility is defined as the distance in cm, to which a standard sample or briquette of the material will be elongated without breaking. Dimension of the briquette thus formed is exactly 1 cm square.

The bitumen sample is heated and poured in the mould assembly placed on a plate. These samples with moulds are cooled in the air and then in water bath at 27o C temperature. The excess bitumen is cut and the surface is leveled using a hot knife.

Then the mould with assembly containing sample is kept in water bath of the ductility machine for about 90 minutes. The sides of the moulds are removed, the clips are hooked on the machine and the machine is operated.



The distance up to the point of breaking of thread is the ductility value which is reported in cm. The ductility value gets affected by factors such as pouring temperature, test temperature, rate of pulling etc.

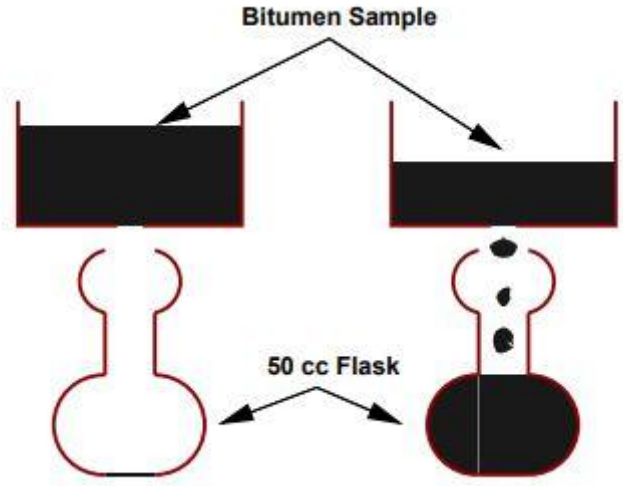
A minimum ductility value of 75 cm has been specified by the BIS. Figure 23.4.2 shows ductility moulds to be filled with bitumen.

(iv) Viscosity test

Viscosity denotes the fluid property of bituminous material and it is a measure of resistance to flow. At the application temperature, this characteristic greatly influences the strength of resulting paving mixes.

Low or high viscosity during compaction or mixing has been observed to result in lower stability values. At high viscosity, it resist the compactive effort and thereby resulting mix is heterogeneous, hence low stability values. And at low viscosity instead of providing a uniform film over aggregates, it will lubricate the aggregate particles.

Orifice type viscometers are used to indirectly find the viscosity of liquid binders like cutbacks and emulsions.



The viscosity expressed in seconds is the time taken by the 50 ml bitumen material to pass through the orifice of a cup, under standard test conditions and specified temperature. Viscosity of a cutback can be measured with either 4.0 mm orifice at 25o C or 10 mm orifice at 25 or 40o C.

2. Explain the method of construction of cement concrete road (April/May 2015)

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

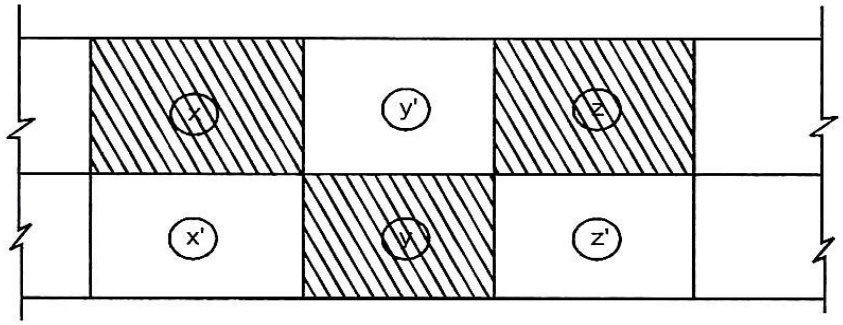
Alternate bay method

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.
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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

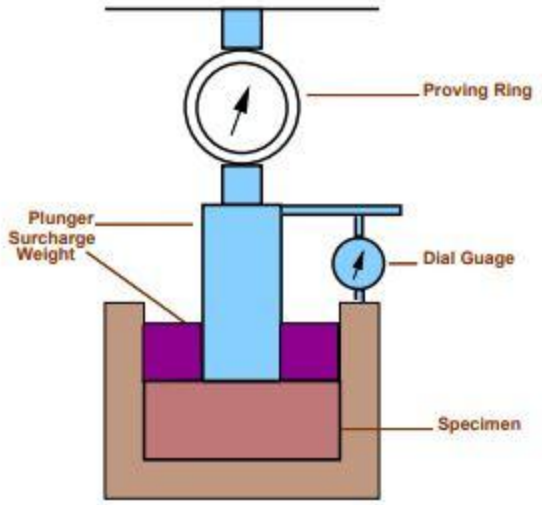
It is very important to ensure proper curing of the finished concrete. Following are the methods usually adopted:

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

3. California Bearing Ratio Test (April/May 2019), (April/May 2017), (Nov/Dec 2016), (Nov/Dec 2015)

California Bearing Ratio (CBR) test was developed by the California Division of Highway as a method of classifying and evaluating soil-sub grade and base course materials for flexible pavements. CBR test, an empirical test, has been used to determine the material properties for pavement design.

Empirical tests measure the strength of the material and are not a true representation of the resilient modulus. It is a penetration test wherein a standard piston, having an area of 3 in2 (or 50 mm diameter), is used to penetrate the soil at a standard rate of 1.25 mm/minute. The pressure up to a penetration of 12.5 mm and it's ratio to the bearing value of a standard crushed rock is termed as the CBR.



In most cases, CBR decreases as the penetration increases. The ratio at 2.5 mm penetration is used as the CBR. In some case, the ratio at 5 mm may be greater than that at 2.5 mm. If this occurs, the ratio at 5 mm should be used.

The CBR is a measure of resistance of a material to penetration of standard plunger under controlled density and moisture conditions. The test procedure should be strictly adhered if high degree of reproducibility is desired.

The CBR test may be conducted in re-moulded or undisturbed specimen in the laboratory. The test is simple and has been extensively investigated for field correlations of flexible pavement thickness requirement.

Test Procedure The laboratory CBR apparatus consists of a mould 150 mm diameter with a base plate and a collar, a loading frame and dial gauges for measuring the penetration values and the expansion on soaking.

The specimen in the mould is soaked in water for four days and the swelling and water absorption values are noted. The surcharge weight is placed on the top of the specimen in the mould and the assembly is placed under the plunger of the loading frame. Load is applied on the sample by a standard plunger with dia of 50 mm at the rate of 1.25 mm/min.

A load penetration curve is drawn. The load values on standard crushed stones are 1370 kg and 2055 kg at 2.5 mm and 5.0 mm penetrations respectively. CBR value is expressed as a percentage of the actual load causing the penetrations of 2.5 mm or 5.0 mm to the standard loads mentioned above. Therefore,

$$CBR = \frac{\text{load carries by specimen}}{\text{load carries by standard specimen}} \times 100$$

Two values of CBR will be obtained. If the value of 2.5 mm is greater than that of 5.0 mm penetration, the former is adopted.

If the CBR value obtained from test at 5.0 mm penetration is higher than that at 2.5 mm, then the test is to be repeated for checking.

If the check test again gives similar results, then higher value obtained at 5.0 mm penetration is reported as the CBR value. The average CBR value of three test specimens is reported as the CBR value of the sample.

The average CBR value of three test specimens is reported as the CBR value of the sample.

4. What is the modern construction materials used for the construction of pavements? Explain their characteristics and usage in detail.(April/May 2019), (April/May 2017),

(i)Polymer Modified Bitumen

(ii) Geo- Textile

Polymer modified bitumen is emerging as one of the important construction materials for flexible pavements. Use of plastic waste in the construction of flexible pavement is gaining importance because of the several reasons.

The polymer modified bitumen show better properties for road construction & plastics waste, otherwise considered to be a pollution menace, can find its use in this process and this can help solving the problem of pollution because most of the plastic waste is polymers.

In the construction of flexible pavements, bitumen plays the role of binding the aggregate together by coating over the aggregate.

It also helps to improve the strength of the road. But its resistance towards water is poor. Antistripping agents are being used. A common method to improve the quality of bitumen is by modifying the rheological properties of bitumen by blending with organic synthetic polymers like rubber and plastics.

Geo- Textile

Geo- textile is any permeable textile material used with foundation, soil, rock, earth, etc. that is an integral part of a constructed project, structure or system.

It may be made of synthetic or natural fibers. In contrast; a geo-membrane is a continuous membrane-type liner or barrier. It must have sufficiently low permeability to control migration of fluid in a constructed project, structure or system.

A geo-textile is designed to be permeable to allow the flow of fluids through it or in it, and a geomembrane is designed to restrict the fluid flow.

Some importance applications of geotextile are described below:

Separation

In this function, the geo-textile serves to separate two dissimilar materials, eg, two different soils, landfill material and the native soil, stone material and sub-grade soil, old and new pavement, foundation soils and various types of walls, or one of many other similar situations. In some instances, it is difficult to distinguish between the separation and stabilization functions because in both situations the geo-textile is serving as a separator. However, in stabilization some additional phenomena occur.

Stabilization

In this application, the natural soil on which the geo-textile is placed is usually a wet, soft, compressible material, exhibiting very little strength. By acting as a separator, the geo-

textile allows water from the soft natural soil to pass from this soil into a free-draining construction soil, which in turn allows consolidation of the natural soil to take place. As a result of the consolidation process, there is a strength gain in the natural soil, which then provides an adequate foundation for construction to take place.

Reinforcement

The key difference between stabilization and reinforcement is that stabilization is accomplished by providing for drainage of water from the unstable soil, while in reinforcement the strength characteristics (stress–strain) of the geo-textile provide added strength to the whole system. Another difference is that in stabilization the geo-textile is placed on or around the area being stabilized and thereby also acts as a separator, whereas in the reinforcement application the geotextile is placed within the material being reinforced. This is in line with reinforcement concepts in concrete and other materials.

Filtration

The prime function is to retain soil or other fine materials, while allowing water to pass through. Again, it is seen that more than one function is being performed. If there were no drainage of water taking place, movement, and therefore retention of the soil, would not be of concern. Part of the mechanism by which filtration occurs is through the development of a soil filter behind the geo-textile. As the water passes through, soil is filtered out and collects behind the geo-textile. As buildup takes place, a natural soil filter is developed.

Drainage

In the previous sections, drainage was discussed as taking place in a direction perpendicular to the plane of the geo-textile. Here, drainage parallel to the plane of the geo-textile is described. The property called transmissivity is defined as flow parallel to the plane of the geotextile. This type of flow can occur to some extent in all geo-textiles, but is best achieved in needle-punched nonwoven materials. This class of geo-textiles can be manufactured in a range of thicknesses such that this characteristic is optimized.

Moisture Barrier

When impregnated with an asphaltic emulsion, geo-textiles become impermeable and can then be used as moisture barriers. The primary application for this type of geo-textile is in pavement rehabilitation.

5. Explain the different forms of bitumen.(Nov/Dec 2016)

The bitumen can be classified into the following grade types:

i) Penetration Grade Bitumen

ii) Oxidized Bitumen Grades

iii) Cut Back Bitumen

iv) Bitumen Emulsion

v) Polymer Modified Bitumen

(i) Penetration Grade Bitumen

The penetration grade bitumen is refinery bitumen that is manufactured at different viscosities. The penetration test is carried out to characterize the bitumen, based on the hardness. Thus, it has the name penetration bitumen. The penetration bitumen grades range from 15 to 450 for road bitumen. But the most commonly used range is 25 to 200. This is acquired by controlling the test carried out i.e. the distillation process. The partial control of fluxing the residual bitumen with the oils can help in bringing the required hardness.

(ii) Oxidized Bitumen

The refinery bitumen is further treated by the introduction of processed air. This will give us oxidized bitumen. By maintaining a controlled temperature, the air is introduced under pressure into soft bitumen. Compounds of higher molecular weight are formed by the reaction of this introduced oxygen and bitumen components. Thus, the Asphaltenes and the Maltenes content increases resulting in a harder mix. This harder mix has a lower ductility and temperature susceptibility. The oxidized bitumen is used in industrial applications such as roofing and coating for pipes. By this method of processing, the bitumen that has a lower penetration can be manufactured, which can be employed for paving roads.

(iii) Cutback Bitumen

These are a grade of bitumen that comes under penetration grade bitumen. This type of bitumen has a temporarily reduced viscosity by the introduction of a volatile oil. Once after the application, the volatile material is evaporated and bitumen gain its original viscosity. The penetration grade bitumen is a thermoplastic material. It shows the different value of viscosity for different temperature.

In areas of road construction, it is necessary for the material to be fluid in nature at the time of laying i.e. during surface dressing. It is also essential for the material to regain back to its original hardness and property after setting. This is ensured by cutback bitumen. The fluidity is obtained for any bitumen by raising the temperature. But when it is necessary to have fluidity at lower temperatures during surface dressing, cutback bitumen is employed. The time for curing and the viscosity of cutback bitumen can be varied and controlled by the

1. Dilution of volatile oil, and
2. The volatility of the oil added.

(iv) Bitumen Emulsion

The type of bitumen forms a two-phase system with two immiscible liquids. One of them is dispersed as fine globules within the other liquid. When discrete globules of bitumen are dispersed in a continuous form of water, bitumen emulsion is formed. This is a form of penetration grade bitumen that is mixed and used for laying purposes. An emulsifier having a long hydrocarbon chain with either a cationic or anionic ending is used for dispersing the bitumen globules. This emulsifier provides an electrochemical environment. The ionic part of the chain has an affinity towards water and the bitumen is attracted by hydrocarbon part.

6. What are the desirable properties of aggregates (May/June 2016), (April/May 2015)

Desirable Properties of Road Aggregates

1. Strength

2. Hardness

3. Toughness

4. Durability

5. Shape of aggregates

6. Adhesion with bitumen

1. Strength

The aggregates to be used in road construction, particularly the aggregates used in the wearing course of the pavement should be sufficiently strong/ resistant to crushing to withstand the high stresses induced due to heavy traffic wheel loads.

2. Hardness

The aggregates used in the surface course are subjected to constant rubbing or abrasion due to moving traffic. Abrasive action may be increased due to the presence of abrasing material like sand between the tyres of vehicle and the aggregates exposed to the top surface. Thus, they should be hard enough to resist the wear due to abrasive action of traffic.

3. Toughness

Aggregates in the pavement are also subjected to impact due to moving wheel loads. The magnitude of impact increase with roughness of road and speed of vehicle. Severe impact is common when heavily loaded steel tyred vehicles move on WBM. The resistance to impact or toughness is thus another desirable property of aggregates.

4. Durability

The aggregates are subjected to physical and chemical actions of rains and ground water, the impurities in them and that of atmosphere. Thus it is desirable that the road stones used in the construction should be sound enough to withstand the weathering action. The property of aggregates to withstand the adverse actions of weather may be called soundness.

7. Discuss the requirements of good drainage system (April/May2018)

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:

1. Collection of surface water
2. 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.

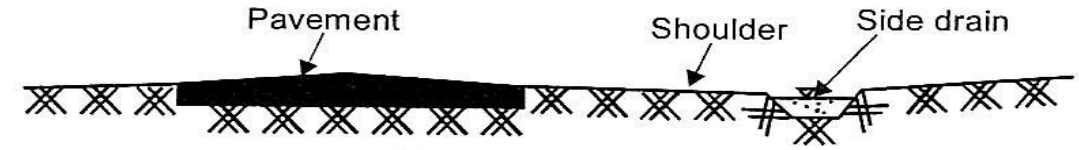
Side drains of suitable size and adequate longitudinal slope are constructed along both the sides of the road at some distance from the foot of embankment. The side drains are trapezoidal in shape.

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.

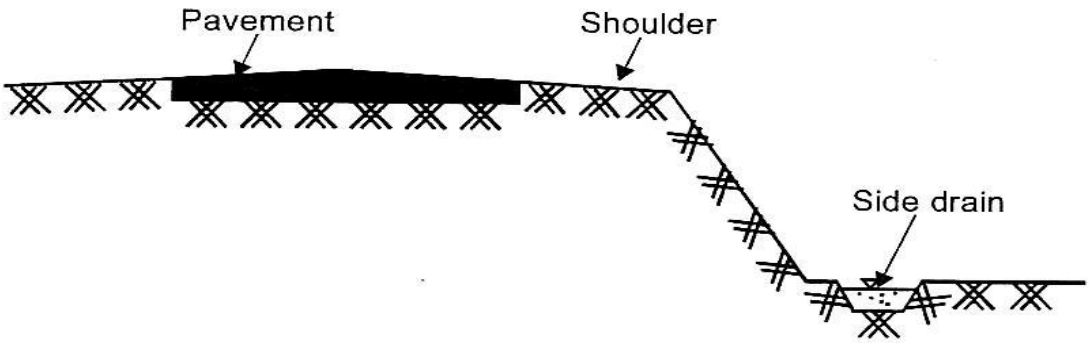
In case of urban roads, underground drainage facilities are provided to drain off surface water. Urban drains are provided because of presence of foot path and other developments. Water drained from the pavement surface can be drained longitudinally and may be collected in catch pits and carried forward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

catch pit with grating to pavement the entry of rubbish into the drainage system is shown in fig.

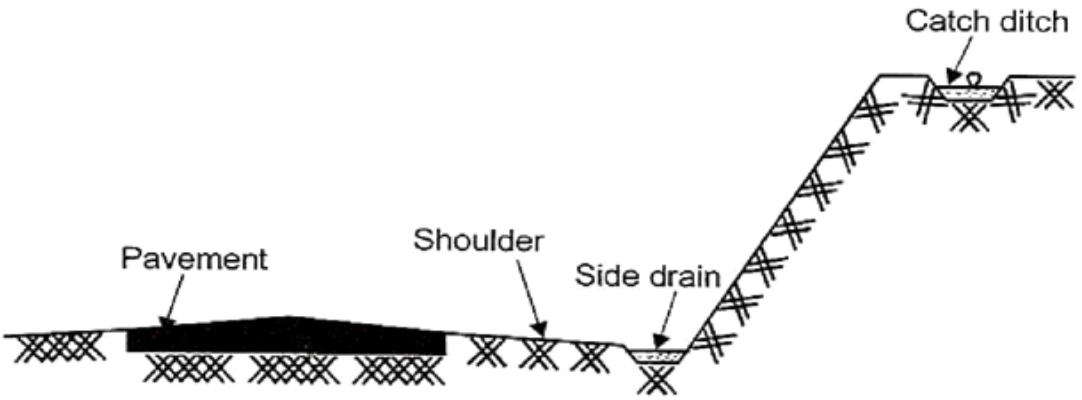
Highway drainage is of much more important in hill road formation, it is essential to divert and dispose off the water flowing down the hill slope across the road and efficient it will result in complex maintenance problems. Hence drainage arrangements in hill road should be made to work efficiently.



(a) Side-drain in ground line

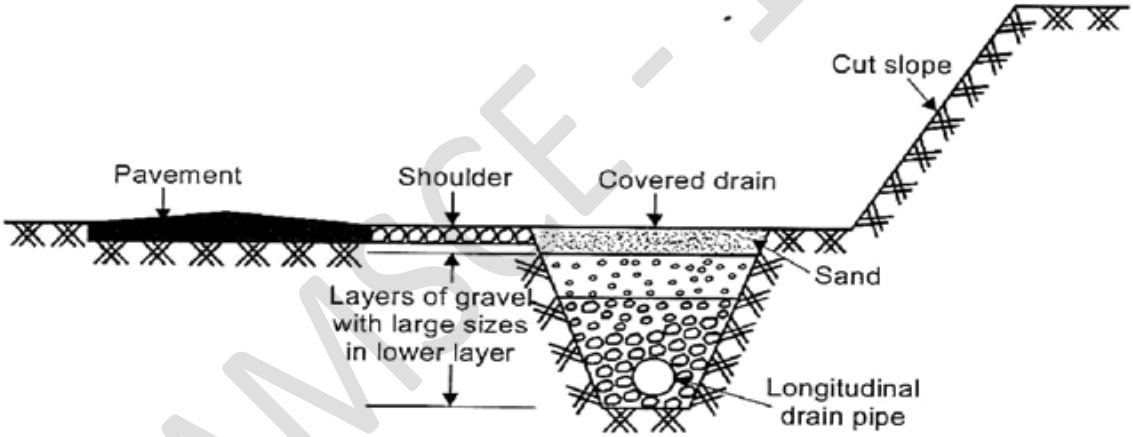


(b) Side-drain in filling ground (embankment)

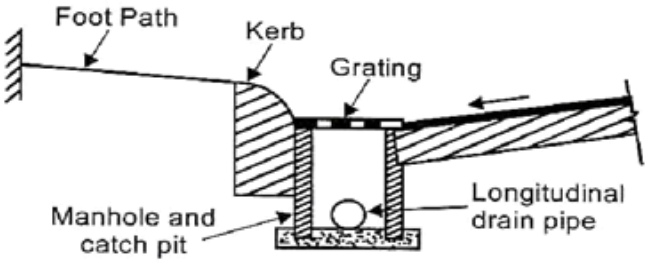


(c) Side-drain in cutting

Arrangement of side-drains



Trench filled with gravel and sand



Surface Drainage system in urban roads

8. What is geo textiles? Describe the functions of geotextiles in road construction (April/May 2018)

Geo textile:

Geotextile; material that can pass water from wicker (woven) or non-woven (non-woven) from the threads or synthetic fibers used in ground work, the synthesis of thin sheets, flexible, permeable used for soil stabilization and improvement.

Woven Geotextiles

i. Load carrying filaments, fibres and yarns in woven geotextiles are aligned in specific directions
ii. This is usually along the longitudinal direction or warp direction and transverse direction or weft direction
iii. They provide separation as well as filtration functions

Non –Woven Geotextiles

i. The filaments are entangles and bonded together
ii. There is no specific direction to the fibres and hence they elongate longer when
iii. compared to woven geotextiles
iv. They are mostly used as separators

Knitted Geotextiles

i. Knitted geotextiles are similar to non-wovens but bundles of load carrying
ii. Filaments can be made to be aligned in a given direction and this type of product is called as directionally structured fabric or DSF
iii. They provide an alternative to woven geotextiles

Geotextiles:

i. One of the two largest groups in geosynthetics
ii. They are textiles in the traditional sense, but they consist of synthetic fibers rather than natural ones such as cotton, wool, or silk
iii. These synthetic fibers are made into flexible, porous fabrics by standard
iv. Weaving machinery or are matted together in a random nonwoven manner or knitted. The major point is that geotextiles are porous to liquid flow across their manufactured plane and also within their thickness, but to a widely varying degree

The fabric always performs at least one of four discrete functions:

- Separation,
- Reinforcement,
- Filtration, and/Or Drainage

Geogrids

They represent a rapidly growing segment in geosynthetics Geogrids are polymers formed into a very open, gridlike configuration, i.e., they have large apertures between individual ribs in the transverse and longitudinal directions They are made by either Stretching in one or two directions On weaving or knitting machinery

(i) By bonding straps or rods
(ii) There are many specific application areas,

Geo-membranes

- They represent the other largest group in geosynthetics
- They are relatively thin, impervious sheets of polymeric material used primarily for linings and covers of liquids or solid-storage facilities
- This includes all types of landfills, reservoirs, canals, and other containment facilities
- Thus the primary function is always containment as a liquid or vapor barrier or both.

Geonets

- Geonets, also called geospacers, constitute another specialized segment within the geosynthetics area
- They are formed by a continuous extrusion of parallel sets of polymeric ribs at acute angles to one another
- When the ribs are opened, relatively large apertures are formed into a netlike configuration
- Two types are most common, either biplanar or triplanar
- Their design function is completely within the drainage area where they are used to convey liquids of all types

Geomats

- A three-dimensional water permeable mat made from extruded and bi-oriented polyethylene grids.
- The underside of the mat is made flat to provide even contact with the prepared soil surface
- The upper surface is made cuspated to provide excellent soil retention
- Geomats are applied to create stable vegetation along river, pond banks and slopes to prevent erosion processes of surfaces.
- Geomats are used in combination with geotextiles to reinforce foundations and increase bearing resistance.

Geosynthetic Clay Liners

They are rolls of factory fabricated thin layers of bentonite clay sandwiched between two geotextiles or bonded to a geo-membrane Structural integrity of the subsequent composite is obtained by needle-punching, stitching or physical bonding GCLs are used as a composite component beneath a geo-membrane or by themselves in geo-environmental and containment applications.

Geofoams

Geofoam is a product created by a polymeric expansion process resulting in a "foam" consisting of many closed, but gas-filled, cells. The resulting product is generally in the form of large, but extremely light, blocks which are stacked side-by-side providing lightweight fill in numerous applications . The primary function is dictated by the application; however separation is always a consideration

Geocells

- Geocells (also known as Cellular Confinement Systems) are three-Dimensional honeycombed Cellular structures that form a confinement system when in-filled with compacted soil.
- The cellular confinement reduces the lateral movement of soil particles, thereby maintaining Compaction and forms a stiffened mattress that distributes loads over a wider area.
- Traditionally used in slope protection and earth retention applications, geocells made from Advanced polymers are being increasingly adopted for long-term road and rail load support Much larger geocells are also made

from stiff geotextiles sewn into similar, but larger, unit cells that are used for protection bunkers and walls

9. Discuss the construction practice adopted for flexible pavement (Nov/Dec 2019)

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 120^0c 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.

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.

10. Discuss in brief the construction practice with modern material and methods to adopted for high type of bituminous pavement as per IRC standards (Nov/Dec 2018).

(Refer Part-B, Question No. 4 & 5)

11. Write in details the different types of test to be conducted to check the suitability of Aggregate Material in highway materials.(Nov/Dec 2018)

(Refer Part-B, Question No. 1 & 6)

12. Describe the construction procedure of a flexible pavement. Explain the equipment required for various layers while constructing the flexible pavement (Nov/Dec 2015).

Preparation of Sub-Grade

Layer Prepare the sub-grade layer, it is done after placing the drainage system, piping and electric cable. The sub-grade surface will be compacted levelled and be cut to make camber as in plan. If the material of the soil did not have a good quality, it will be changed with suitable material.

Base formation covers with 50-75mm sand layer or quarry dust and will be ***compacted with 8-10 tone compactors.***

This job must be done to prevent the clay from absorbing into the stone layer of sub-base and reduce the shear strength of the pavement.

Construction And Compacting The Sub-Base

After the sub-base has been prepared with list materials, it will be placed and constructed into two layers if the thickness is more then150mm. Every layer will be compacted according to the plan.

Sub-baselayer must be compacted carefully with compactor machine.

Compactors with rubber roller can compact 120mm layer in 12 times.

Compacting should start from the side of the road hen slowly towards the middle of the road in horizontal way.

In super-elevated bends compaction machine will start at the lowest part and slowly towards the higher level. The finished part should not be more than 20mm from the plan.

Construction of Road Base

Before road base is constructed, sub-grade surface and sub-base must be formed perfectly and compacted enough.

The lowest layer and sub-base must be prepared ***at least distance of 200m from the base construction.***

This material is place and compacted to on the surface of the road. The road base must be constructed in two layers of same thickness. ***Each layer should not exceed 150mm.***

Construction of Road Surface

The road surface is constructed with bitumen materials, such as concrete asphalt, macadam bitumen and so on. The constructed should be free from dust and waterproof.

To construct the surface layer, the base course must be prepared first. Prime coat is poured onto the road base surface to be a binder between the road bases and the base course.

To pour the prime coat, the temperature must be according to the specifications stipulated.

Base course is built on one layer only with a pavers' machine. After this layer is constructed, it is placed before it is compacted.

The surface is checked and corrected if there are any differences. The compacting must be done immediately. It should be compacted from the side towards the middle of the road. It there is a super elevated bend, then it should be compacted from lower part to higher part. The type of compactors must be according to the specifications.

Finally wearing course is prepared. Like always, base course should be cleaned before tack coat is poured. The compacting job is done the same way as the base course.

PART C

1. Explain in detail about the crushing test, Abrasion test, Impact test and Soundness test on the aggregates used for highway road construction. (April/May 2018)

(Refer Part-B, Question No. 1)

2.Explain the application of Geotextiles and Geomembrance in Road Construction(Nov/Dec 2017)

(Refer Part-B, Question No. 8)

3. Write in detail the present status of highway drainage in Chennai city roads and list out the measures to be taken for effective removal of water from the pavement(April/May 2019), (April/May 2018)

(Refer Part-B, Question No. 7)