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Internal Assessment Test 4 – February 2022

Sub	Pavement Materials and Construction					SubCode:	18CV733	Branch:	CIVIL	
Date:	06/02/2022	Duration:	90 mins	Maxmarks	50	Sem/Sec:	VII		OBE	

Answer all five full questions - Provide neat sketches wherever necessary

		Marks	CO	RBT
1 a)	List the differences between Bitumen and Tar?	[05]	CO1	L2
b)	With a neat sketch, explain the manufacturing process of bitumen.	[05]	CO1	L2
2	Explain the desirable properties of aggregates to be used in pavement construction.	[10]	CO1	L2
3	List the various tests conducted on road aggregates in order to ascertain its suitability and indicate the desirable values of the test results.	[10]	CO1	L2
4 a)	Explain the mechanism of stripping of binder and the methods for improving adhesion.	[05]	CO1	L2
b)	Describe the laboratory procedure to determine hardness property of bitumen.	[05]	CO1	L2
5	Describe the chemical constitution of bitumen and list the desirable requirements of bitumen.	[10]	CO1	L2

Solution

1 a)

S. No	Parameter	Bitumen	Tar
1	Colour	Black to brown in colour	Brown in colour
2	Origin	Fractional distillation of petroleum	Destructive distillation of coal/ wood
3	Solubility	Soluble in carbondisulphide and carbon tetrachloride	Soluble in toluene
4	Carbon content	Less compared to tar	More compared to bitumen
5	Molecular weight	Range from 400-5000	Range from 150-3000
6	Composition	Large molecular weight aromatic compounds	Low molecular weight oily matter
7	Ability to coat aggregate	Has high resistance to coating aggregates and strip off easily in the presence of water	Coats aggregates easily
8	Temperature susceptibility	Less temperature susceptible	More temperature susceptible
9	Resistance to weathering	More	Less

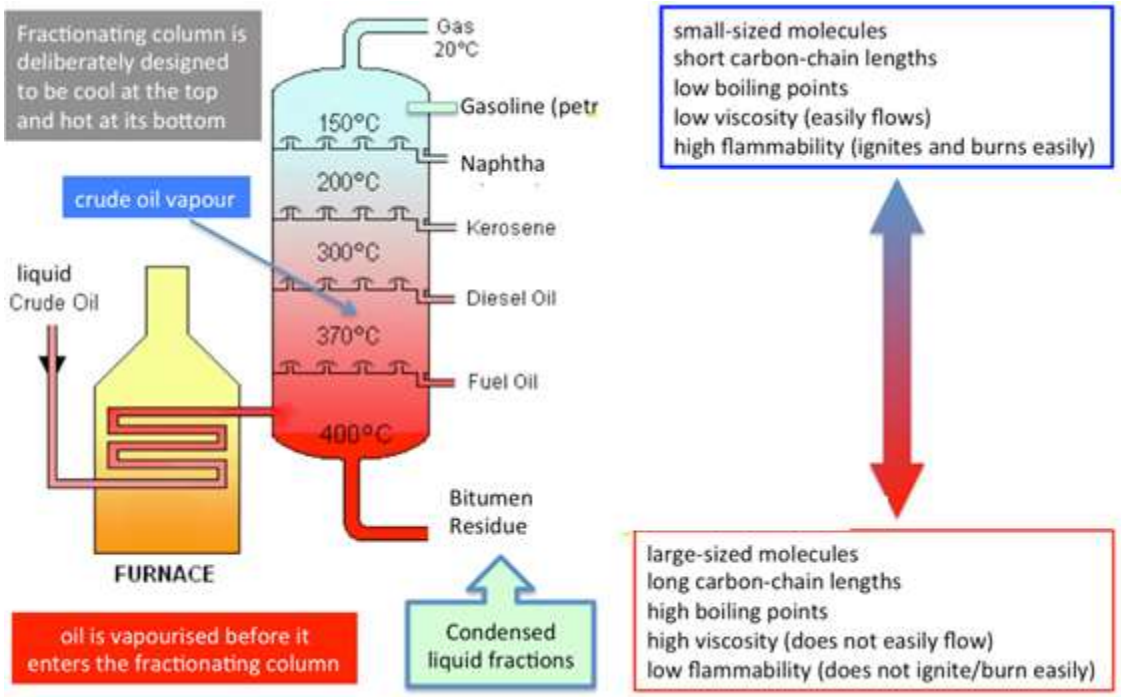
b)

Manufacture of bitumen

- Bitumen is produced by fractional distillation of crude oil.

- *Usually, distillation is done in two steps. First the crude oil is heated up to 300-350°C and introduced into an atmospheric distillation column. Lighter fractions like naphtha, kerosene and gas oil are separated from the crude oil at different heights in the column. The heaviest fractions left at the bottom of the column are called heavy residue.*
- *The long residue is heated up to 350-400°C and introduced into a vacuum distillation column. By using reduced pressure it is possible to further distillate lighter products from the residue because the equivalent temperature (temperature under atmospheric conditions) is much higher.*
- *The residue at the bottom of the column is called short residue and is the feedstock for the manufacture of bitumen.*
- *The viscosity of the short residue depends on the origin of the crude oil, the temperature of the long residue, the temperature and pressure in the vacuum column and the residence time.*

The details are shown in the sketch below.



3)

- *In order to decide the suitability of the aggregate for use in pavement construction, following tests are carried out:*
- *Crushing test- It is used to determine the crushing strength of aggregates. The aggregate crushing value provides a relative measure of resistance to crushing under gradually applied crushing load.*
- *A value less than 10 signifies an exceptionally strong aggregate while above 35 would normally be regarded as weak aggregates.*
- *Abrasion test- Abrasion test is carried out to test the hardness property of aggregates and to decide whether they are suitable for different pavement construction works. The principle of Los Angeles abrasion test is to find the percentage wear due to relative rubbing action between the aggregate and steel balls used as abrasive charge.*

- A maximum value of 40 percent is allowed for WBM base course in Indian conditions. For bituminous concrete, a maximum value of 35 percent is specified.
- Impact test- The aggregate impact test is carried out to evaluate the resistance to impact of aggregates.
- Aggregates to be used for wearing course, the impact value shouldn't exceed 30 percent. For bituminous macadam the maximum permissible value is 35 percent. For Water bound macadam base courses the maximum permissible value defined by IRC is 40 percent.
- Soundness test- Soundness test is intended to study the resistance of aggregates to weathering action, by conducting accelerated weathering test cycles. The Porous aggregates subjected to freezing and thawing is likely to disintegrate prematurely. To ascertain the durability of such aggregates, they are subjected to an accelerated soundness test.
- The loss in weight should not exceed 12 percent when tested with sodium sulphate and 18 percent with magnesium sulphate solution.
- Shape test- The particle shape of the aggregate mass is determined by the percentage of flaky and elongated particles in it. Aggregates which are flaky or elongated are detrimental to higher workability and stability of mixes. 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. Flakiness gauge is used for this test. The elongation index of an aggregate is defined as the percentage by weight of particles whose greatest dimension (length) is 1.8 times their mean dimension. This test is applicable to aggregates larger than 6.3 mm. Elongation gauge is used for this test.
- The sum of flakiness index and elongation index should not be greater than 35.
- Specific gravity and water absorption test- The specific gravity and water absorption of aggregates are important properties that are required for the design of concrete and bituminous mixes. The specific gravity of a solid is the ratio of its mass to that of an equal volume of distilled water at a specified temperature. Because the aggregates may contain water-permeable voids, so two measures of specific gravity of aggregates are used:
- Apparent specific gravity and Bulk specific gravity.
- Apparent Specific Gravity, is computed on the basis of the net volume of aggregates i.e the volume excluding water-permeable voids.
- Bulk Specific Gravity, is computed on the basis of the total volume of aggregates including water permeable voids.
- Water Absorption: The difference between the apparent and bulk specific gravities is nothing but the water permeable voids of the aggregates.
- The specific gravity of aggregates normally used in road construction ranges from about 2.5 to 2.9. Water absorption values ranges from 0.1 to about 2.0 percent for aggregates normally used in road surfacing.
- Bitumen adhesion test- Bitumen adheres well to all normal types of road aggregates provided they are dry and free from dust. In the absence of water there is practically no adhesion problem of bituminous construction. Adhesion problem occurs when the aggregate is wet and cold. This problem can be dealt with by removing moisture from the aggregate by drying and increasing the mixing temperature. Further, the presence

of water causes stripping of binder from the coated aggregates. This problem occurs when bitumen mixture is permeable to water.

- IRC has specified maximum stripping value of aggregates should not exceed 5%.

4 a)

Stripping refers to the condition wherein bitumen fails to coat aggregates. This condition can occur under two conditions.

i.When aggregate is completely saturated (ii) water tries to impregnate a bituminous mix.

Generally aggregates do have a negative charge. Hence, it has a tendency to attract opposite charges. However, the affinity of water towards negatively charged aggregate is more than the bitumen. Hence water always has a tendency to strip bitumen from aggregates.

There are different tests that can be used to determine stripping of aggregates. Most commonly adopted method is static immersion test. Here aggregates are mixed with 5% binder at a temperature of 100°C. The bitumen coated aggregates is immersed in water at a temperature of 40°C for 24 hrs. The extent of stripping is ascertained by comparing the area of stripping. Percentage of uncoated area is noted as stripping value. According to IRC, the maximum stripping value is 25 %.

Adhesion can be improved by using antistripping agents.

b)

Hardness property of bitumen is ascertained using Penetration tests.

Definition: It measures the hardness or softness of bitumen by measuring the depth in tenths of a millimeter to which a standard loaded needle will penetrate vertically in 5 seconds.

Significance:

- Measures hardness/softness of bitumen
- Decides the grade of bitumen to be used based on climatic conditions

Procedure:

- Soften the material to a pouring consistency at a temperature not more than 60°C for tars and pitches and not more than 90°C for bitumen.
- Stir it thoroughly until it is homogeneous and free from air bubbles and water. And pour the melt in to the container to a depth of at least 10 mm in excess of the expected penetration.
- Place it along with the transfer dish in the water bath at 25°C and allow it remain for 1.5 to 2 hours for 45mm deep container and 1 to 1.5 hours for 35mm deep container..
- Remove the dish and put it upon the stand of penetration apparatus.
- Adjust the needle (previously washed, cleaned well with benzene and dried) just to make contact with the surface of the sample.
- The sum of the weights of the needle, carrier and super imposed weights i.e. the total moving weight shall be 100 ±0.25 grams.
- Bring the pointer to zero. Release the needle for five seconds and measure the distance penetrated.
- Make at least three determinations at points on the surface of the sample not less than 10mm apart and not less than 10mm from the side of the dish.

Reporting of results:

- The bitumen grade is specified in terms of penetration value, 80-100 or 80/100 grade bitumen means the penetration value of bitumen is in the range of 8 cm to 10 cm at standard test conditions.
- Grades available range from 20 to 225
- In hot climates a lower penetration grade is preferred.

5)

Chemical Components in bitumen are:
Naphthene aromatics (naphthalene [C10H8]), consisting of partially hydrogenated polycyclic aromatic compounds
Polar aromatics, consisting of high molecular weight phenols (hydroxyl added to benezene cycle) and carboxylic acids produced by partial oxidation of the material
Saturated hydrocarbons; the percentage of saturated compounds in asphalt correlates with its softening point
Asphaltenes, consisting of high molecular weight phenols and heterocyclic compounds
Desirable Properties of Bitumen
Bitumen should be fluid enough at the time of mixing to coat the aggregates evenly by a thin film. This can be achieved better by adding cut-backs or by adding emulsifiers.
The bitumen should not be highly temperature susceptible. It should exhibit little change in viscosity with change in temperature. This is important for different climatic conditions. During the hottest weather the mix should not become too soft or unstable, and during cold weather the mix should not become too brittle causing cracks.
Bitumen should have a good amount of voltailes in it and it should not lose them excessively when subjected to high temperature because this influence the durability of the bitumen.
Bitumen should be ductile and not brittle.
Bitumen should have adequate affinity and adhesion to aggregates used in the mix and should not get stripped off in the presence of water.