Q1.

A) Why do we carry out Granular (Physical) stabilization?

The primary objective is to obtain a well-proportioned mixture of particles with continuous gradation (well graded) and the desired plasticity.

Granular Stabilization: Soils can behave quite differently depending on their geotechnical characteristics. In coarse grained soils, where the grains are larger than 0.075 mm (or 75 µm), the engineering behavior is influenced mainly by the relative proportions of the different sizes present, the shapes of the soil grains, and the density of packing. They may also contain material with particle sizes less than 0.075mm. Stabilization of this class of soils is designated "**Granular Stabilization**" The borderline between coarse and fine grained soils is 0.075 mm, which is the smallest grain size one can distinguish with naked eye.

These soils, when compacted, form a granular bearing skeleton through a network of grain-to-grain contact points that is able to

1. Transfer load without Permanent Deformation
2. Provide Frictional Resistance
3. Bears Volume Stability

It involves preparation of Mixture of Soil-Aggregate consisting of Stone, Gravel, and Sand and containing Silt-Clay and compacted to maximum density to obtain high strength, stability, and durability in all weather conditions.

Granular stabilization is used in construction of Base, Sub-base, and Surface Courses of paved facilities. The requirements for composition of mixtures intended for use as bases generally differ from those for use as wearing surfaces. For example, the compositions for base and sub-base courses are required to have high stability to transfer load and low capillarity, to resist softening with accumulation of moisture. The compositions for wearing surfaces, on the other hand, need to satisfy the conditions of resisting abrasion and penetration of water, and of capillarity to replace moisture lost by surface evaporation. Therefore, the composition of base and subbase soil-aggregate requires less fine-soil fraction than the composition for wearing surface.

Q1.

B) How do we carry out Granular (Physical) stabilization considering Granulometry and Collametry, Fabric, Soil Binder, collameritics and Specifications of gradation and selection of soil elements?

Granulometry is the measurement of the size distribution in a collection of grains.
Granulometry and Collametry: The pore volume and the size of the pores formed by the granular skeleton determine the transition of a particular soil to one with or without a bearing skeleton.Fundamentals of Granulometry are applied to establish quantitative definitions of granular skeleton with effective compactness. Grain-size distributions that yield minimal porosity values with small densificationeffort are best presented by the **Talbot formula**:

s=(d/dmax)m

where

s = weight percent of the particles with diameter less than d.

dmax = maximum particle diameter in the mixture

m = exponent determined empirically

The factor m varies between 0.11 and 0.66.

U.S. Bureau of Public Roads recommends 0.45 as the best overall value for m.

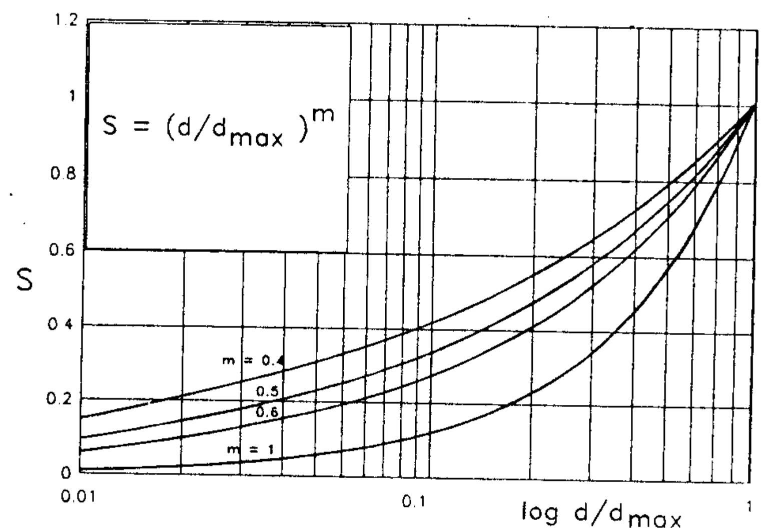


Fig. 9.1 Curve satisfying the Talbot formula

Fabrics:

A Classification of natural soil fabric structures as revealed by the pedlogic microscope in the field and by the petrologic microscope in the laboratory is given in below table which shows their relationship to the great petrologic soil groups. The microstructure of a soil, just as that of any other construction material has a significant influence on its engineering properties and behavior.

TABLE 3.28 KUBIENA CLASSIFICATION OF SOIL FABRIC.

Coating of Mineral Grains	*Arrangement of Fabric*	*Occurrence*
Grains not coated	Grains embedded loosely in a dense ground mass	Lateritic soils
	Grains united by intergranular braces	Chernozems, brown earths, lateritic soils
	Intergranular spaces containing loose deposits of flocculent material	Sandy prairie soils
Grains coated	Grains cemented in a dense ground mass	Desert crusts, podsol B-horizons
	Grains united by intergranular braces	B-horizons of podsolized brown forest soils
	Intergranular spaces empty	B-horizons of iron and humus podsols

Sedimentary soils often show structural characteristics acquired at the time of deposition especially if they have been protected from the effect of normal climatic factors by sufficiently thick superimposed soil layers.

Macroscopic soil structure in the form of secondary aggregates presupposes the properties of cohesion and swelling on the part of the soil material. Structure of this type is caused are associated with soil cultivation, boring and digging by land animals, root activity of plants, Metrologic cycles that result osmosis. Natural formation of macroscopic soil structure is always related to water loss and concomitant shrinkage of swelling cohesive soils. The basic phenomenon can be observed easily on drying mud flats. As water is lost from the surface, tension forces are established in the drying surface layer. Which, because of the water loss, loses its ability to relieve these tension forces by plastic flow? These stresses are finally relieved by the formation of shrinkage cracks that break up the surface layer into pieces of more or less distinct geometric shapes. If the soil material is homogeneous, the ideal pattern of the shrinkage cracks is hexagonal in accordance with the law of least energy. This cracking pattern produces the greatest stress relief with the least amount of work involved. If the soil system is

Into pieces of more or less distinct geometric shape. If the soil material iis homogenous, the ideal pattern of the shrinkage cracks is hexagonal in accordance with the law of least energy. This cracking pattern produces the greatest stress relief with the least amount of work involved.

If the soil system is nonhomogeneous as in the presence of organic matter of different water affinity and greater round the mobility than the mineral soil components, the hexgonse tend to become rounded as the organic matter becomes concentrated at the surfaces of the fissures. The drying of a film made with a solution by addiction of a small amount of water will tend to round the corners of the polygons.

The actual size and shaper of shrinkage structures formed in the soils depends on a number of factors of soil composition and condition as well as on the rate of drying surfaces. However, the basic principle remains that soil sturction formation is caused by water loss and shrinkage.

Soil Binder

Soils with granular bearing skeleton in the densified state possesses volume stability and frictional resistance. They may require

Bonding or Cementation
Increase in Cohesion
Decrease in Permeability or Water Storage Capacity *(if deficient in fines)*

Such stabilized granular soils belong to the class of **Collameritic** (colla = glue, meros = particle) systems. In the terminology of materials science, such bonded soils belong to the class of

“CONCRETES” if the maximum particle size is larger than the openings of No. 4 sieve (4.76mm),

“MORTARS” if the largest particles are of fine sand size or the size of the openings of No. 40 sieve (0.425 mm).

The latter types of materials are also called **"soil binder."** Complete replacement of natural soil binder in a clay-bonded stabilized gravel (clay concrete) by Portland cement produces Portland Cement Concrete.

Partial replacement leads to systems that possess properties intermediate between those of Clay Concrete and a Portland Cement Concrete.

Similarly, partial replacement of the soil binder by asphalt leads to waterproofed granular soil stabilization, and complete replacement by bitumen and filler leads to Bituminous Concrete.

The soil binder or the cementing materials tend to surround the coarse-grain particles and/or form bonding bridges between particles such that the granular system attains rigidity and stability. The strength of such a system is dependent on the strength of the cement and on the shear resistance at the cement-particle interface, as well as on the strength of the granular network.

Specifications on Gradation and Selection of Soil Elements

Soil Binder and Water: are the two elements that create the adhesion and bonding between the coarse grains and provide the continuity of the structure by filling in the voids of the bearing skeleton. The continuous granular skeleton is strengthened and stabilized by the added cohesion.

During dry weather: Shrinkage of soil binder develops tensile forces on the surfaces of the coarse grains, which has the desirable effect of increased compression on the granular skeleton.

During wet weather Swelling of the soil binder might be desirable, as it would reduce the permeability and retard penetration of water. However, introduction of excessive volume change to the system might be detrimental to functioning of the bearing skeleton. Therefore the amount and the properties of the soil binder should be controlled for optimum results.

ASTM and AASHTO Specifications

TABLE 9.3 GRADATION REQUIREMENTS FOR SOIL AGGREGATE MATERIALS [ASTM D1241 (AASHTO M147)].

	Weight Percent Passing Square Mesh Sieves					
	Type I				*Type II*	
Sieve Size (Square Openings)	*Gradation A*	*Gradation B*	*Gradation C*	*Gradation D*	*Gradation E*	*Gradation F*
2 in (50 mm)	100	100	—	—	—	—
1 in (25 mm)	—	75 to 95	100	100	100	100
$\frac{3}{8}$ in (9.5 mm)	30 to 65	40 to 75	50 to 85	60 to 100	—	—
No. 4 (4.75 mm)	25 to 55	30 to 60	35 to 65	50 to 85	55 to 100	70 to 100
No. 10 (2.00 mm)	15 to 40	20 to 45	25 to 50	40 to 70	40 to 100	55 to 100
No. 40 (425 μm)	8 to 20	15 to 30	15 to 30	25 to 45	20 to 50	30 to 70
No. 200 (75 μm)	2 to 8	5 to 15	5 to 15	8 to 15	6 to 15	8 to 15

TABLE 9.4 GRADING REQUIREMENTS FOR FINAL MIXTURES FOR BASES OR SUBBASES (ASTM D2940).

Sieve Size (Square Openings)	*Design Range[a] (Weight Percentages Passing)*		*Job Mix Tolerances (Weight Percentages Passing)*	
	Bases	*Sub-bases*	*Bases*	*Sub-bases*
2 in (50 mm)	100	100	−2	−3
1½ in (37.5 mm)	95 to 100	90 to 100	±5	+5
¾ in (19.0 mm)	70 to 92	—	±8	—
⅜ in (9.5 mm)	50 to 70	—	±8	—
No. 4 (4.75 mm)	35 to 55	30 to 60	±8	±10
No. 30 (600 μm)	12 to 25	—	±5	—
No. 200 (75 μm)	0 to 8[b]	0 to 12[b]	±3	±5

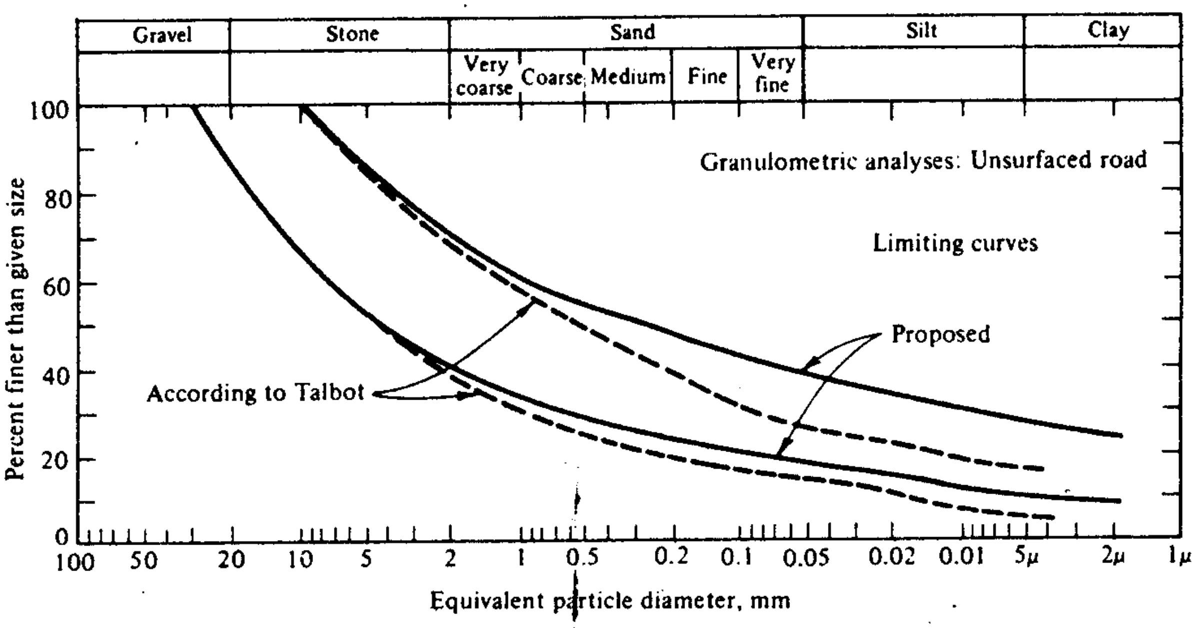


Fig. 9.3 Clay–concrete for laterite soil binder.

Exceptions to Gradation Requirements

Cases may occur in which certain natural materials that do not meet gradation requirements may develop satisfactory CBR values in the prototype.

Exceptions to the gradation requirements are permissible when supported by adequate in-place CBR tests on similar construction that has been in service for several years.

Q2.
A) How would you (being a material expert) identify aggregate referring to Naturally occurring materials, Igneous Rocks, Sedimentary Rock, Metamorphic and Residual material and transported deposits?

Aggregate" is a collective term for the mineral materials such as sand, gravel and crushed stone that are used with a binding medium (such as water, bitumen, portland cement, lime, etc.) to form compound materials (such as asphalt concrete and portland cement concrete). Aggregates can either be natural or manufactured. Natural aggregates are generally extracted from larger rock formations through an open excavation (quarry).

Aggregate Sources

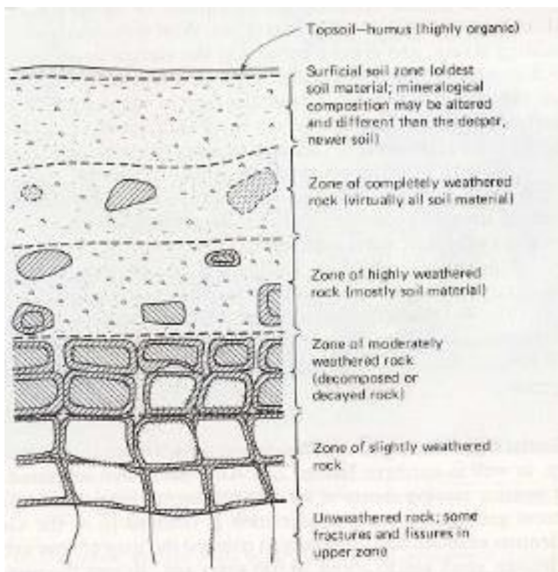
Aggregates can come from either natural or manufactured sources. Natural aggregates come from rock, of which there are three broad geological classifications (Roberts, et al., 1996):

Igneous rock: These rocks are primarily crystalline and are formed by the cooling of molten rock material beneath the earth's crust (magma). Identification of Igneous rocks: such as granite or lava are tough, frozen melts with little texture or layering. Rocks like these contain mostly black, white and/or gray minerals

Sedimentary rocks: These rocks are formed from deposited insoluble material (e.g., the remains of existing rock deposited on the bottom of an ocean or lake). This material is transformed to rock by heat and pressure. Sedimentary rocks are layered in appearance and are further classified based on their predominant mineral as calcareous (limestone, chalk, etc.), siliceous (chert, sandstone, etc.) or argillaceous (shale, etc.).
Identification of Sedimentary rocks: such as limestone or shale are hardened sediment with sandy or clay-like layers (strata). They are usually brown to gray in color and may have fossils and water or wind marks

Metamorphic rock: These are igneous or sedimentary rocks that have been subjected to heat and/or pressure great enough to change their mineral structure so as to be different from the original rock. Identification of Metamorphic rocks: such as marble are tough, with straight or curved layers (foliation) of light and dark minerals. They come in various colors and often contain glittery mica.

<u>Residual soils</u>: Have formed from mostly the weathering of rock and remain at the location of their origin. Weathering process may be attributed to mechanical weathering, chemical weathering and biological weathering. Residual soils can include particles having a wide range of sizes,shapes, and composition depending upon the amount and type of weathering and the minerals in the parent rock. The rate of weathering is generally greater in warm, humid regions than in cool, dry regions. A profile of residual material lying above the unweathered rock

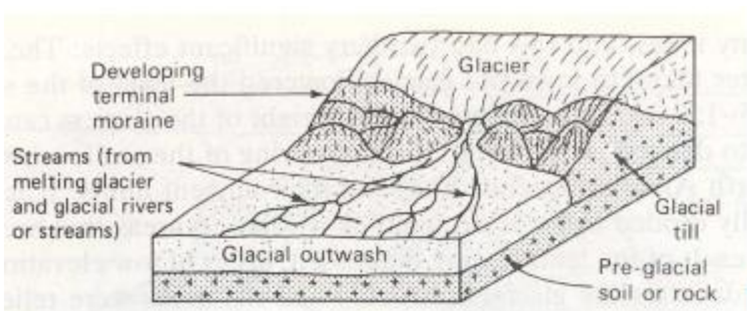


. Profile for residual soil area, indicating stages of transition from rock to soil

Index properties of weathered residual soils

i. % finer than #200 sieve : mostly 5 – 20 %
ii. Soil classification(USCS) : SM, SP

Transported soils: Transported soils are those materials that have been moved from their place of origin, by gravity, wind, water, glaciers, or human activity – either singularly or in combination. The method of transportation and deposition has great effect on the properties of the resulting soil mass.



. The development of a terminal moraine and outwash plain in front of a glacier

Next, check the rock's grain size and hardness

Q2.
B) In aggregate investigation Material sourcing is referred to Filed investigation. Discuss Material sourcing in detail.

Material Sourcing: A sourcing or tender process is used to select the best product or service for a certain category of expenditure.

Unfortunately, lots of these processes are not run well, resulting in loss of large saving opportunities, delivery of poor quality products, or less favorable terms.

When selecting suppliers through a tender or sourcing process, the buyer works in collaboration with internal customers or budget holders. Internal customers are buyer's colleagues working in other departments, such as finance or manufacturing. They are the ones who originally raised the need for the purchase and who will be actually transacting with the selected supplier. Internal customer involvement is usually highest (around 70%) at the specification stage and then drops to around 30% in subsequent stages.

1. Specification development

What are the needs of your internal customer i.e. the person who requires the product or service to be purchased? As a buyer, you challenge and "translate" these needs in specifications that suppliers can understand.

The objective of buyers at the specification stage is two fold**:**

- Reduce total costs
- Safeguard a competitive market at the upcoming negotiation stage

Developing specifications in its turn is a 4 step process**:**

- Assess Customer needs
- Assess what the market has to offer
- Develop specifications
- Define winning criteria

2. Market Assessment

Once you have a clear picture of the business requirements, your next step is to formally invite suppliers to quote for your business.
You formally approach the market via:

Request for Information

- This is used to pre-qualify suppliers to whom you would send the RFQ.

- An RFI is usually a simple and short questionnaire for the supplier, which enables the buyer to judge if the supplier is promising and has a good chance to win the business.
- An RFI is optional. If you know the market relatively well, there is no need for an RFI.

A Request for Quotation

- This is a formal request to the supply market to quote for your business.
- The RFQ is a more complex document with a company presentation, bidding instructions for suppliers and detailed information about the project and requirements.

3. Negotiation

At the negotiation stage, you analyze the offers and select the most promising suppliers to negotiate with. Only then you prepare for negotiation.

During the meeting, your goal is to clarify the terms of the offer and get additional value beyond what has been offered, this might range from a lower price, a better quality product, improved payment terms etc. At the end of this process, you conclude the deal with the best supplier.

Most suppliers build in a price concession in their first offer. In order to obtain this concession, you must:

- Build competition – To get the best results at the negotiation stage, you should have two or more credible alternatives.
- Carefully analyze all quotations to get a feel for a stretching but credible target.

4. Contract discussion

You prepare a formal contract with the supplier and you limit your companies' exposure.

Q3. Mc-Adam was a Scottish engineer who introduced, in the early nineteenth century, the idea of constructing roads composed of small size stones held together by means of a binding material? What are the Macadam bases types and discuss the Water bound Macadam and Wet Mixing Macadam in detail Bound, also elaborate the difference between Water bound Macadam and Wet Mixing Macadam?

McAdam's method

McAdam's method was simpler, yet more effective at protecting roadways: he discovered that massive foundations of rock upon rock were unnecessary, and asserted that native soil alone would support the road and traffic upon it, as long as it was covered by a road crust that would protect the soil underneath from water and wear

Unlike Telford and other road builders of the time, McAdam laid his roads as level as possible. His 30-foot-wide (9.1 m) road required only a rise of 3 inches (7.6 cm) from the edges to the center. Cambering and elevation of the road above the water table enabled rain water to run off into ditches on either side

Size of stones was central to the McAdam's road building theory. The lower 20-centimetre (7.9 in) road thickness was restricted to stones no larger than 7.5 centimetres (3.0 in). The upper 5-centimetre (2.0 in) layer of stones was limited to 2 centimetres (0.79 in) size and stones were checked by supervisors who carried scales. A workman could check the stone size himself by seeing if the stone would fit into his mouth. The importance of the 2 cm stone size was that the stones needed to be much smaller than the 4 in width of the iron carriage tyres that travelled on the road.

McAdam believed that the "proper method" of breaking stones for utility and rapidity was accomplished by people sitting down and using small hammers, breaking the stones so that none of them was larger than six ounces in weight. He also wrote that the quality of the road would depend on how carefully the stones were spread on the surface over a sizeable space, one shovelful at a time.

McAdam directed that no substance that would absorb water and affect the road by frost should be incorporated into the road. Neither was anything to be laid on the clean stone to bind the road. The action of the road traffic would cause the broken stone to combine with its own angles, merging into a level, solid surface that would withstand weather or traffic

Through his road-building experience, McAdam had learned that a layer of broken angular stones would act as a solid mass and would not require the large stone layer previously used to build roads. Keeping the surface stones smaller than the tyre width made a good running surface for traffic. The small surface stones also provided low stress on the road, so long as it could be kept reasonably dry.

TYPES OF MACADAM

Macadam roads can be classified into following types:

1) Water bound macadam

2) Traffic bound macadam

3) Bituminous macadam

4) Cement macadam

5) Wet Mix Macadam

WBM (Water Bound macadam):

The water bound macadam road construction technique was given by the John Macadam. This technique in present day is used as given below.
For WBM construction we use three materials:

1. Aggregates
2. Screeners
3. Binders.

Aggregates:
We use the aggregates of different grades. IRC(Indian Roads Congress) has classified the coarse aggregates into 9 grades, according to their size.

For the construction of the WBM roads aggregates are used in the sub-base, base and surface course and so the aggregates are divided into 3 grades according to their size.
Grade 1 - particles of size 90 mm to 40 mm.
Grade 2 - particles of size 63 to 40 mm.
Grade 3 - particles of size 50 to 20 mm.

The grade 1 aggregates having size of 90 mm to 40 mm are preferred for the sub-base material and grade 2 for the base and grade 1 for the surface course. However, if we only use the WBM as the surface course, it gets deteriorated fast due to abrasion with the traffic so, bituminous surfacing over the WBM is general practice.

Screeners are the aggregates of the smaller sizes, generally 12.5 mm or 10 mm, for grade A and grade B. They are of the same chemical composition as of the coarse aggregates.

For economic considerations IRC has suggested non plastic materials such as, crushed over burnt bricks, moorum, gravels, etc. provided the liquid limit of the material is less than 20%, plasticity index is less than 6.0% and the portion of fines passing 0.075 mm sieve is less than 10%.
However if crush-able type of aggregates are used, use of the screeners may be disposed off.

Binders: Binders, are the layers of materials which are laid after the compaction of the aggregates and the screening materials one after the another. Kankar dust or lime stone dust may be utilized if locally available.

The binding material with plasticity index value of 4% to 9% is used in surface course construction; the plasticity index of binding course material should be less than 6% in the case of the WBM layers used as base course or sub-base course, with bituminous surfacing.

However if the screening used are of crushable material like moorum or soft gravel, there is no need to apply binding material, unless the plasticity index value is low.

WMM (Wet mix macadam);

Aggregates used are of the smaller sizes, varies between the 4.75 mm to 20 mm sizes and the binders(*stone dust or quarry dust having PI(Plasticity Index) not less than 6%*) are premixed in a batching plant or in a mixing machine. Then they are brought to the site for overlaying and compaction.

The PI (plasticity Index) of the binding material is kept low because it should be a sound and non plastic material. If the plasticity index is more then there are the chances of the swelling and more water retention properties. So this value should be kept in mind.

Difference Between WBM And WMM :

Although the cost of construction of the WMM is said to be more than that of the WBM sub-base and bases but the advantages given below will compensate for that. Here are the points of difference:

- The WMM roads are said to be more durable.
- The WMM roads gets dry sooner and can be opened for traffic withing less time as compare to the WBM roads which take about one month for getting dry.
- WMM roads are soon ready to be black topped with the Bituminous layers.
- WMM roads are constructed at the faster rate.
- The consumption of the water is less in case of the WMM roads.
- Stone aggregates used in WBM is larger in size which varies from 90 mm to 20 mm depending upon the grade but in case of the WMM size varies from 4.75 mm to 20 mm.
- In case of WBM, stone aggregates, screenings and binders are laid one after another in layers while in WMM, aggregates and binders are premixed in the batching plants and then brought to the site for overlaying and compacting.
- Materials used in the WBM are the stone aggregates, screenings and binder material(Stone dust with water) while in WMM material used are only stone aggregates and binders.
- Quantity of the WBM is generally measured in cubic meters while that of the WMM in square meters.

Q4.

A) Discuss in detail the Bituminous Materials-Manufacturing.

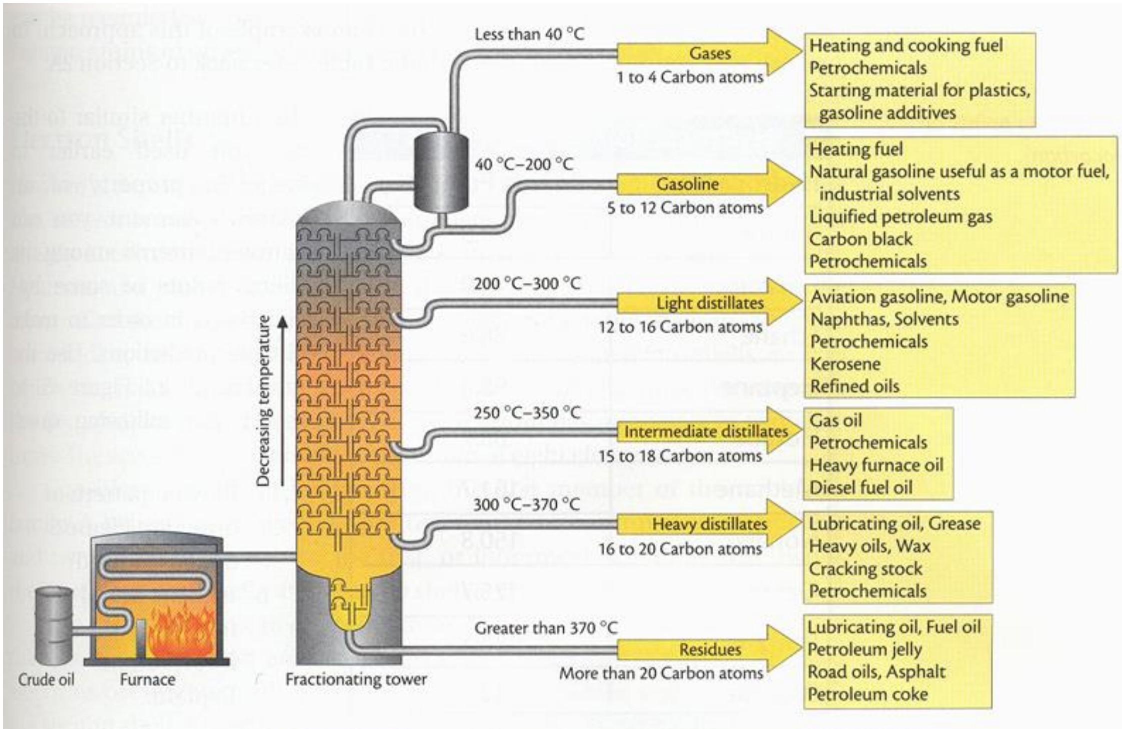
Bituminous material are widely used in a road construction and maintance
Bitumen: It is hydrocarbon / complex organic material of either natural or artificially obtained during fractional distillation of petroleum.
Tar: various liquid obtained from when natural material (wood /coal) are destructing distilled in absence of air Asphalt bitumen with inert natural material of minerals.
Cut Back: If viscosity of bitumen is reduced by volatile diluents like kerosene or oil is said to be cut back
Emulsion: It is bitumen which is suspended in a finely divided condition in water and stabilized with emulsifier

Method Of Manufacturing

Distillation: 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. If second distillation were carried out under atmospheric conditions and by increasing the temperature above 400°C, thermal decomposition/cracking of the heavy residue would occur. 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. Usually, the conditions are such that short residue is produced with a Penetration between 100 and 300 dmm. The amount of short residue decreases and the relative amount of asphaltenes increases with increasing viscosity of the short residue.



Bitumen manufactured from the short residue is called Vacuum Bottom. The differences in properties between high and low penetration grade bitumen are mainly caused by different amounts of molecule structures with strong interactions. Low penetration grade bitumen contains more of these molecule structures.

A second distillation, at reduced pressure, may be used to remove additional amounts of the more volatile products and create vacuum residues of the desired consistency. These one-stage and two-stage distilled asphalt fractions are referred to as straight-run bitumen, because the bitumen is separated from the crude oil while preserving its chemical properties. Different crude oils contain different quantities of vacuum bottom and require specific refining techniques to produce the desired straight-run bitumen. Oxidized bitumen from the bottom of the reactor is sent to the separator, where bitumen vapors are separated which are returned to reactor and then to storage Straight-run bitumen, constitutes oxidized bitumen, the basic material that may be tailored for specific paving or industrial demands. Because oxidized bitumen is a viscous, semisolid material, it is difficult to mix with other substances at ambient temperatures. By heating it, the oxidized bitumen may be made more liquid and can coat aggregates to produce hot-mix paving materials. Other methods to reduce oxidized bitumen's viscosity are to disperse particles of it in water (emulsified bitumen) or to dissolve it in petroleum solvents (cutbacks bitumen). The volatility of the petroleum solvent determines the speed with which the cutback bitumen cures. Bitumen may be modified by exposure to air while the bitumen is at an elevated temperature. The resulting dehydrogenation and polymerization yield a material known as blown or oxidized bitumen. Blown bitumen display greater flexibility, less brittleness, and less susceptibility to changes in weather. They are commonly used in roofing applications, as the process raises the softening temperature of the asphalt and decreases the penetration rate.

Propane Deasphalting: Bitumen is also produced by propane deasphalting and there are differences in the properties of bitumen prepared by propane deasphalting and those prepared by vacuum distillation from the same feed stock. Propane deasphalting also has the ability to reduce a residuum even further and to produce a bituminous product with lower viscosity, higher ductility, and higher temperature susceptibility than other bitumen, although such properties might be anticipated to be very much crude oil dependent. Propane deasphalting is conventionally applied to low-bitumen-content crude oils, which are generally different in type and source from those processed by distillation of higher-yield crude oils.

Air Blowing: The properties of bitumen can be modified by air blowing in batch and continuous processes. On the other hand, the preparation of bitumen in liquid form by blending (cutting back) bitumen with a petroleum distillate fraction is customary and is generally accomplished in tanks equipped with coils for air agitation or with a mechanical stirrer or a vortex mixer. Air is heated up to 150–250°C and introduced at the bottom of a blowing column. It then migrates through the bitumen to the top of the column. The chemical reactions result in bitumen with a different mixture of molecular structures. Catalysts can influence this process.

Blown bitumen has more and stronger molecular interactions than the original bitumen and is therefore more cohesive. Blowing causes the softening point to increase and the penetration to decrease. However, the increase in softening point is usually more than the decrease in penetration. This means that blowing reduces the temperature susceptibility of bitumen. The effectiveness of blowing depends largely on the original bitumen (i.e. the original mixture of molecular structures). With respect to the composition, generally the amount of saturates do not change, the amount of aromates decreases because some oxidized aromates behave like resins, the amount of asphaltenes increases due to trans-formation of some resins and the total amount of resins stays the same.

When bitumen is strongly blown it becomes so cohesive that the adhesive properties become so poor that it is not suited for asphalt applications anymore. Therefore, only semi-blown bitumen is suited for asphalt applications. Semi-blown bitumen can have both improved cohesion and improved adhesion.

Bituminous Materials referred to chemical composition of bitumen

Bitumen is a product of oil refining and is a long chain complex hydrocarbon. It typically contains 82–88% carbon and 8–11% hydrogen, the rest being sulfur, oxygen and nitrogen. There are four fractional components making up the chemical composition of bitumen

Q4.

B) Bituminous Materials-Chemistry is referred to chemical composition of bitumen. Elaborate in detail.

The chemical bitumen components are generally similar, but with some variation depending upon the original crude oil and on the processes used during refining and blending. Bitumens can generally be described as complex mixtures of hydrocarbons containing a large number of different chemical compounds of relatively high molecular weight. There is considerable uncertainty as to the molecular weight distribution of bitumen. The smallest size, approximately 300 Dalton, is determined by the distillation 'cut point' during the manufacture of the bitumen. The largest size has not been finally concluded; earlier research suggested that molecular weights up to 10000 Dalton are present, while some research indicates that there are probably very few if any, molecules larger than 1500 in bitumen.

The molecules present in bitumens are combinations of alkanes, cycloalkanes, aromatics and hetero molecules containing sulfur, oxygen, nitrogen, and metals.

Bitumen functionality relates to how molecules interact with each other and/or with other materials, e.g. aggregate surfaces and water. The content of sulfur, nitrogen, oxygen, and metals in some molecules makes them slightly polar. The significance of molecules containing heteroatoms in bitumen chemistry is the ability to form molecular associations, which strongly influence the physical properties and performance of bitumen. The components containing the heteroatomic compounds can vary in content and characteristics in bitumen obtained from different crude sources.

The sulfur content may be 1-7% by mass in bitumen and can consist of many different sulfur compounds such as thiophenes and sulfides. Studies have shown that the hetero-atoms, sulfur, and nitrogen, occur largely in stable ring configurations. Although nitrogen compounds are not as common, pyrrole, in dole and carbazole groups are found in some bitumens. Oxygen is mainly present in functional groups as carboxylic acids and esters. The metals appear mainly in porphyrin-like structures.

Chemical Components in bitumen are:

1. Asphaltenes
2. Resinous components (polar aromatics)
3. Non-polar aromatics (naphtene aromatics) and
4. Saturates