PAVEMENT MATERIAL ENGINEERING

Final Assignment/Quiz

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Muhammad Ishaq

ID#155508

Subject: Pavement Material Engineering

Submitted to: Engineer Shabir Ahmad

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Ans#4 part1:

Manufactured bitumen, or bitumen as it is always called, is a product of fractional distillation of crude oil.

Crude oil is derived from organic matter (vegetable matter, marine organisms), which, millions of years ago, deposited in very thick layers together with mud and rocks at the bottom of oceans. Under the action of overlying pressure, waterborne rocks were formed.

The saline environment disintegrated the organic matter, which, under the influence of high pressure, temperature, bacterial activity and probably radiation, transformed into hydrocarbons in the form of crude oil. Further rock deposits in later years forced the

Crude oil to rise towards the earth surface through the pores of the rocks. In places where the rocks were impermeable, the crude oil with gases formed underground reservoirs and remains there until it is extracted.

Depending on the initial composition of the organic matter, as well as the prevailing conditions, crude oil obtained its physical properties and chemical composition. As a consequence, crude oil differs from one oil field to another and varies from a black, viscous to a tawny, low-viscous liquid.

The bitumen from crude oil (petroleum) is produced from fractional distillation of crude oil under high-temperature vacuum conditions. An additional process (separation) is also used in a solvent de asphalting unit, usually placed after the distillation tower.

The solvent de asphalting unit separates aliphatic compounds from asphaltenes also producing high quality de asphalted oil. Further processing may also be carried out by 'blowing' (oxidation)

if harder and more viscous bitumen is to be produced. The products are then called oxidized

Bitumen's. A schematic representation of bitumen production is shown in Figure.

The type of bitumen produced is determined by both the origin of crude oil and the vacuum (10–100 mm Hg) and temperature conditions (350°C–400°C) exist in the distillation column.

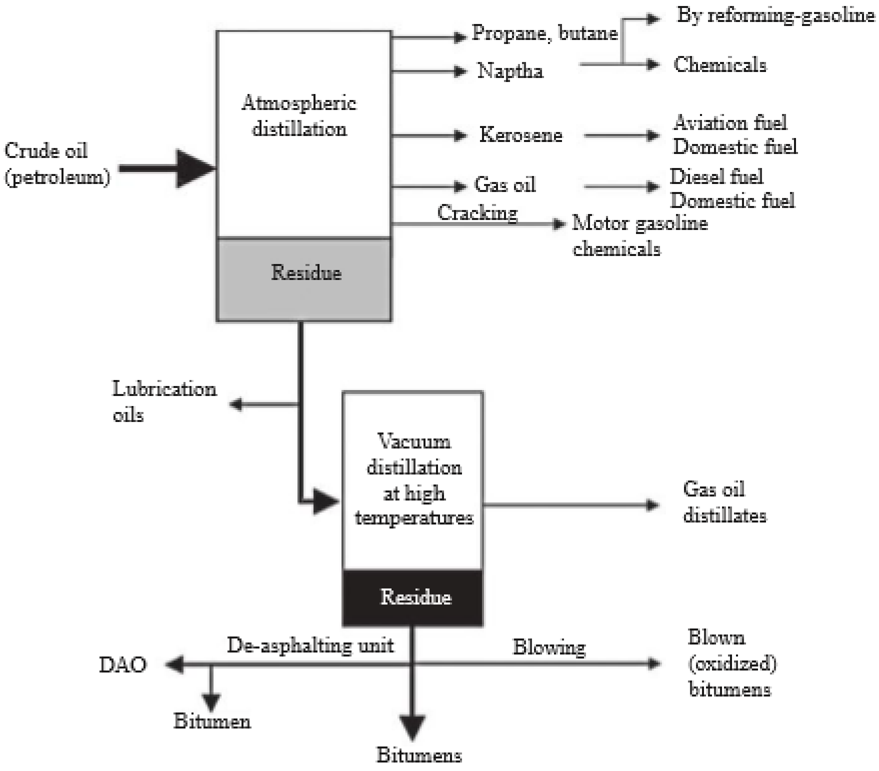
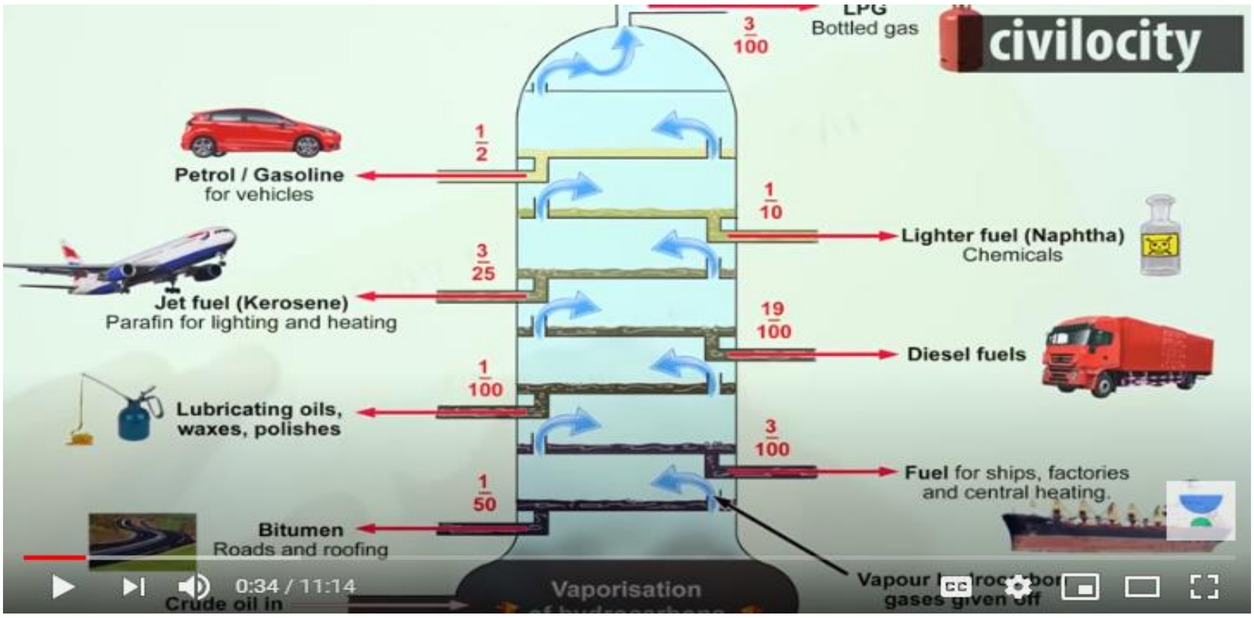


Figure 3.1 Simplifed representation of crude oil distillation process for bitumen production and other materials.



Bitumen can be subject to further processing apart from blowing, such as emulsification or dissolution with solvents. In these cases, bituminous emulsions and cut-back and flashed bitumen's are produced, respectively.

Finally, various chemical additives may be added to the bitumen, producing the modified bitumen's.

Q#4part2:

Chemical composition of bitumen

Bitumen (asphalt) is a complex chemical compound composed predominately of carbon and

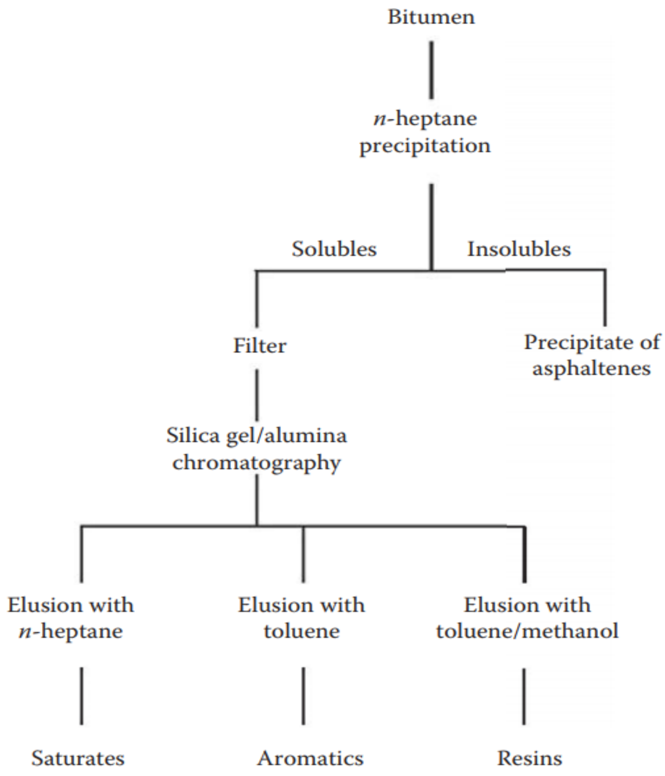
Hydrogen (hydrocarbon), with a small amount of heterocyclic compounds containing sulfur, nitrogen and oxygen

Bitumen also contains traces of metals including nickel, magnesium, iron, vanadium and calcium in the form of inorganic salts and oxides.

Elementary analysis of bitumen's produced from a variety of crude oil showed that most

Bitumen contains carbon, 82%–88%; hydrogen, 8%–11%; oxygen, 0%–1.5%; and nitrogen, 0%–1%. The exact composition of bitumen differs, and it depends on both the source of the crude oil and the modification during its fractional distillation. It also depends on the

On coming ageing in service (Shell Bitumen 2003).



Schematic representation of the analysis for broad chemical composition of bitumen.

Despite the complexity of bitumen’s chemical composition, it is possible to be separated into two broad chemical groups, the asphaltenes and the maltenes.

Maltenes can be further sub divided into saturated hydrocarbons, aromatic hydrocarbons and resins.

This separation of bitumen into the abovementioned fractions can be carried out using

Four methods:

(a) Solvent extraction,

(b) Chromatography,

(c) Adsorption by finely divided solids and removal of unabsorbed solution by filtration and.

(d) Molecular distillation used in conjunction with one of the other techniques.

The first two of the abovementioned methods are mostly used.

The solvent extraction is relatively simple and quick, but the separation is poorer than the one resulting from chromatography. Chromatography is the most widely used method for the detection of asphaltenes.

Asphaltenes are insoluble to an n-heptane solution; thus, they are precipitated as sediment. In

contrast to asphaltenes, maltenes are soluble in n-heptane, as well as to other solvents.

End of question 4 part 1 and 2

Ans#3

1-Macadam Bases:

- 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.

2-Macadam Bases-*Types*:

- Water Bound Macadam (WBM) if the stone materials are held together by the addition of water and filler
- Dry Bound Macadam if the aggregates are held together by mechanical interlock only
- Wet Mix Macadam if graded stones are mixed with water and compacted
- Penetration Macadam if a bituminous material is sprayed over the stones and allowed to penetrate into the course and by "premix" macadam if the bituminous material is mixed with the aggregates prior to laying.

3-Difference between water Bond macdam and Wet Mix Macadam:

3.1-WBM Road (Water Bound Macadam Road):

WBM road means water bound macadam road.the pavement base course made of crushed or broken aggregates mechanically interlocked by rolling and voids filled by screening and binding material.

- Course Aggregate
- Screenings (filler material)
- Binding Material

OR

It is the layer of broken stone aggregates bound together by stone dust or screening and water applied during construction, and compacted by heavy smoothed wheel rollers.

The term macadam means the pavement base course constructed by broken aggregates that are interlocked mechanically by rolling and voids filled with screening and binding materials with the help of water. The WBM is used as a sub-base, base course or surface course. The thickness of each layer ranges from 7.5 cm to 10 cm depending on the size of aggregates used.
To prolong the life of WBM road, a bituminous surfacing is provided. Construction procedure involves preparation of foundation, provision of literal confinement, spreading of coarse aggregates, rolling, application of screening, sprinkling and grouting, application of binding material, and setting and drying.

- Water bound macadam may be defined as a dense and compact course of a road pavement
- *composed of stone aggregates*
- *bound together by a thin film of cementing medium consisting of fine mineral filler (such as stone screenings or gravel) with cementitious properties and*
- *containing a minimum laden moisture to impart to the binder necessary cohesive and adhesive properties to enable it to bind the aggregates together*.

<u>Materials</u>

- <u>Coarse Aggregate</u>
    - Broken Stone Aggregates
        - Hard varieties such as Granite, Basalt, Diorite, Quartzite, etc.
        - Softer varieties such as Sandstone, Limestone, Kankar, Laterite etc.

    - Over-burnt Bricks
- Screening (Choke)
    - Moorum, Other Mixtures
- Binding Material (Soil Binder)
    - Limestone Dust, PI => 6

Size and Grading Requirements of Coarse Aggregates

- The main source of strength of a water-bound macadam surface is due to the mechanical interlock in the aggregates and it is thus apparent that the aggregates should be well graded.
- Well graded aggregates can be obtained only by a crusher whereas hand breaking can yield single size aggregates.
- For soft aggregates such as kankar, laterite or brick ballast which get crushed excessively under roller, the grading is not very important.

Requirements of Screenings and Binding Material

- The screenings, also known as "choke" materials, fill in the voids left in the coarse aggregates after they are consolidated and help to cement the stone aggregates together.
- To effectively perform these functions, the screenings should be properly graded and also should have some plastic material in them to impart cementitious properties.
- Excess of plasticity is harmful since, 'under the influence of moisture, the material may lose its stability.
- Screening materials may be dispensed with in case of soft aggregates such as kankar, laterite, brick ballast etc.

Thickness of courses:

- The water-bound macadam is constructed by spreading loose metal which gives a consolidated thickness of 75 mm-100 mm. A compacted layer less than 75 mm thickness is not desirable and a compacted layer more than 100 mm is equally undesirable.
- If the thickness of the base is more than the above value, the construction is done in multiple layers.
    - Application of Screenings
    - Application of Binding Material

3.2-Wet Mix Macadam: The construction of Wet Mix Macadam(WMM)consist of laying and compacting clean ,crushed and graded aggergates, premixed with water .Wmmis prepeared in a mixing plant ,in which aggregates and water with suitable proportion are mixed together.the optimum moisture content of the mix is determined in the laborator.

After the completion of the construction ,setting time is given ,during which it is desirable that not even construction equipment should pass over the surface:

- Wet-Mix macadam is a specification in which a well-graded aggregate is mixed with water in a mechanical mixer and the resultant mixture is laid by pavers and compacted.
- The aggregate is generally crusher-run, and includes fines also. Because of the close grading, the course will have good interlock with excellent density.

Grading the material should be Well-Graded.

- The optimum moisture content for mixing is determined by conducting suitable density tests. The moisture content during mixing is maintained at this optimum ± 0.5 per cent. The moisture content is usually in the range 2-5% by weight.

Construction:

after laying the GSB layer the WBM layer has to be layed.in this layer dust material is used ie.the size of dust particle is 10mm in size.

For express ways two layers of wmm has to be layed i.e of size 125mm of each layer after compaction .afetre laying the two layers over WMM layer prime coat is done and after that wait for 24 hours to penetrate bitumen of 3mm inside WMM layer

- The mixing can be done in a suitable mechanical mixer. Specially designed mixers can be fabricated for this specification. Otherwise, a bituminous macadam plant can be used.
- Ordinary concrete mixers can also be used. Laying is done by paver-finishers and compaction by 8-10 ton smooth wheel rollers.

Water Bound vs. Wet Mix Macadam:

- The main advantage of wet-mix macadam over water-bound macadam is that it is composed of a well-graded mixture. This ensures good interlock and high stability.

- Addition of water while mixing facilitates the handling of the mixture. The operation of laying is much simpler than that of water-bound macadam, where the screenings and binding material have to be added in stages and forced into voids. If a crusher-run material is used, there is no possibility of plastic fines entering into the mixture.

- The compaction is greatly facilitated by the moisture added which lubricates the individual particles.

- One disadvantage of the wet-mix macadam is that it is slightly costlier than water-bound macadam. This is because the specification involves the use of mixing plant and paver. On the other hand, water-bound macadam has been traditionally a labour-oriented specification.

- The aggregates for wet mix macadam will have to be crusher-run, whereas the aggregates for water-bound macadam are generally hand-broken.

End Of question#3

Ans#1: Part:1: Why to do granular stabilization:

Among many theoretical and and practical possibilities of stabilizing soils , the following have been identified as practical and economical solutions.

Soil stabilization refers to improvement of soil so that it performs a required function. Soil stabilization techniques can be classified into two groups, mechanical and admixture. Mechanical stabilization can be through densification or compaction, addition of granular material and compaction, and the use of reinforcement, such as geotextile. Admixture stabilization (which also includes compaction as part of the process) can be done with the use of additives, such as lime, Portland cement, and asphalt.

Cementing agents such as asphalt help develop bonds between soil particles, and hence increases cohesive strength, and decreases the absorption of water. Water-retaining agents such as calcium chloride ($CaCl_2$) reduce evaporation rates and help in reducing dust in construction sites as well as unpaved roads.
There are three methods of stabilization.

- Mechanical stabilization
- Physical stabilization(grannula stabilzation
- Chemical stabilization

Granular stabilization:is a combination of physical and chemical stabilization methods in which granular bearing skeleton is modified with pore filling and /or cementing natural and extraneous material.

In this technique two or three soils are blended together to improve the physical properties of weak soil.

The soils having particle size greater that 0.075 mm are titles as a medium course grain soil.

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

 Transfer load without Permanent Deformation

 Provide Frictional Resistance

 Bears Volume Stability

They may also contain material with particle sizes less than 0.075mm without violating the requirements given above if:

(1) the volume of the silt-clay size (< 0.075 mm) fraction plus that of the water, normally required to satisfy the capillary and physicochemical sorption capacity, does not exceed the volume of the pore space left by the stable continuous granular skeleton; and

(2) The ratio of the size of the smallest bearing grain to that of the largest silt clay particle is such as to cause no detrimental interference of grain-grain contact of the granular skeleton.

Stabilization of this class of soils is designated **"Granular Stabilization".**

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.

Granular Stabilization involves the mixing of two or more materials to modify the engineering properties such as the Californian Bearing Ratio (CBR), the particle size distribution (PSD) and/or the Plasticity (PI) to "manufacture" materials with properties equal to or better than unbound granular materials used by conventional methods. This type of stabilization is predominantly used in the subgrade improvement and/or embankment works and has applications in all infrastructure types from roads, industrial storage areas, container depots, and railway lines and aircraft pavements.

Some examples of materials that may be deficient in certain engineering properties are:- Poorly graded pavement gravels and engineered fill materials

- Wind and/or river deposited sands
- Silty sands, sandy clays, silty clays
- Crusher run products
- Waste quarry materials
- Industrial by-products
- Highly plastic materials

Ans#1part:2: **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?

1. Granular (Physical) stabilization considering 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 densification effort are best presented by the

Talbot formula: s= (d/dmax)m

where

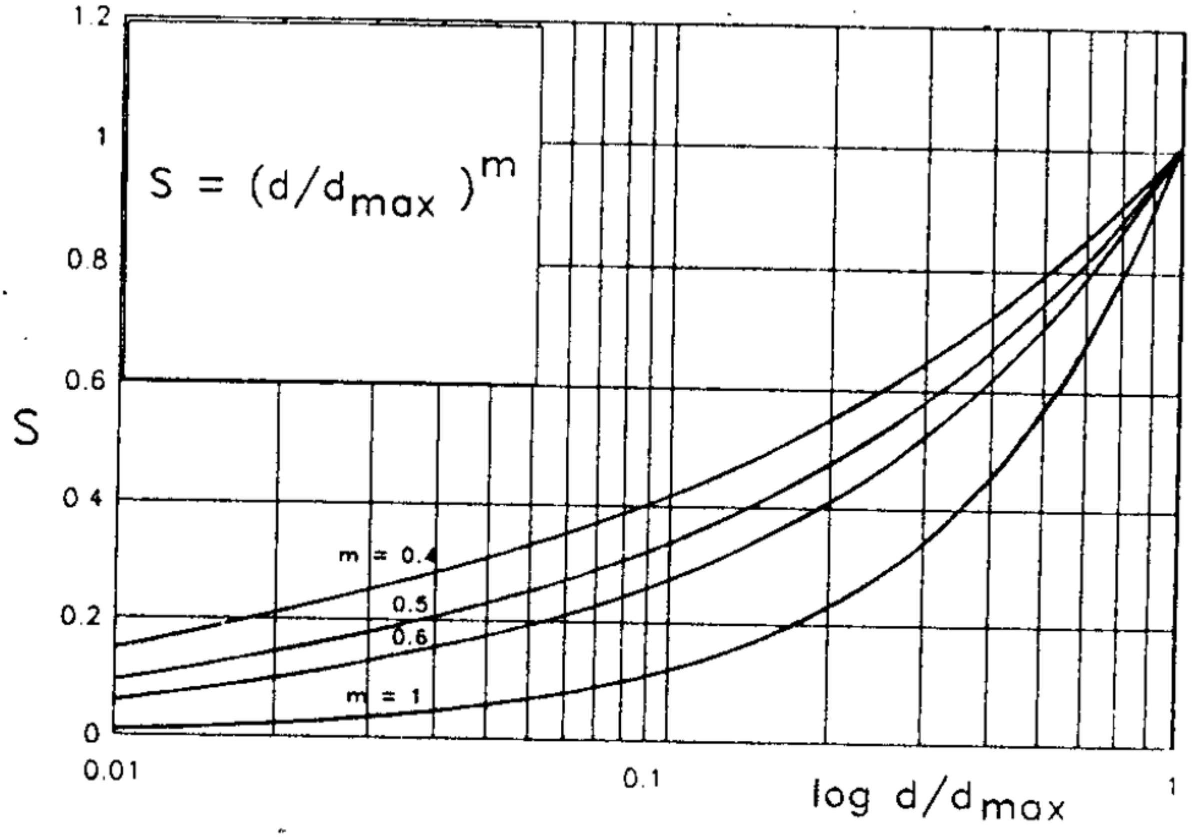
s = weight percent of the particles with diameter less than d.

dmax = maximum particle diameter in the mixture

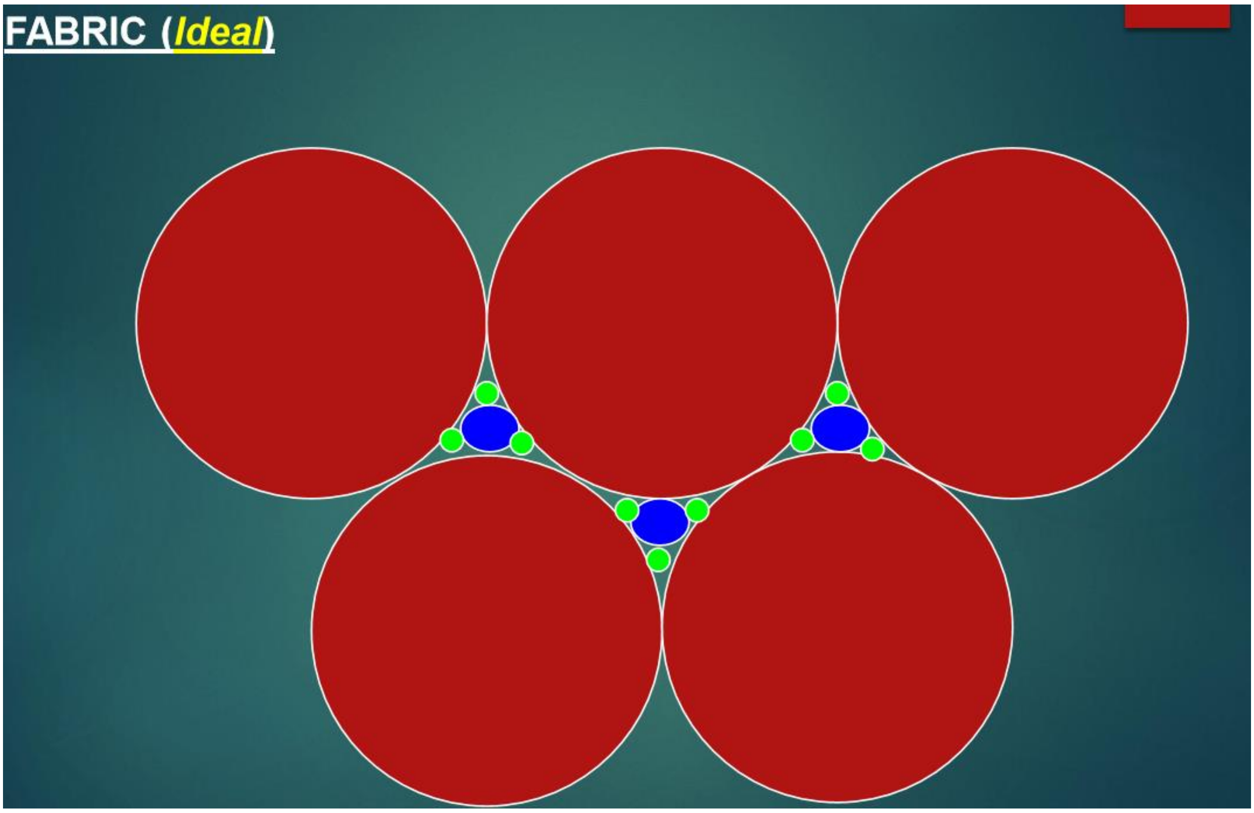
m = exponent determined empirically

The factor m varies between 0.11 and 0.66.

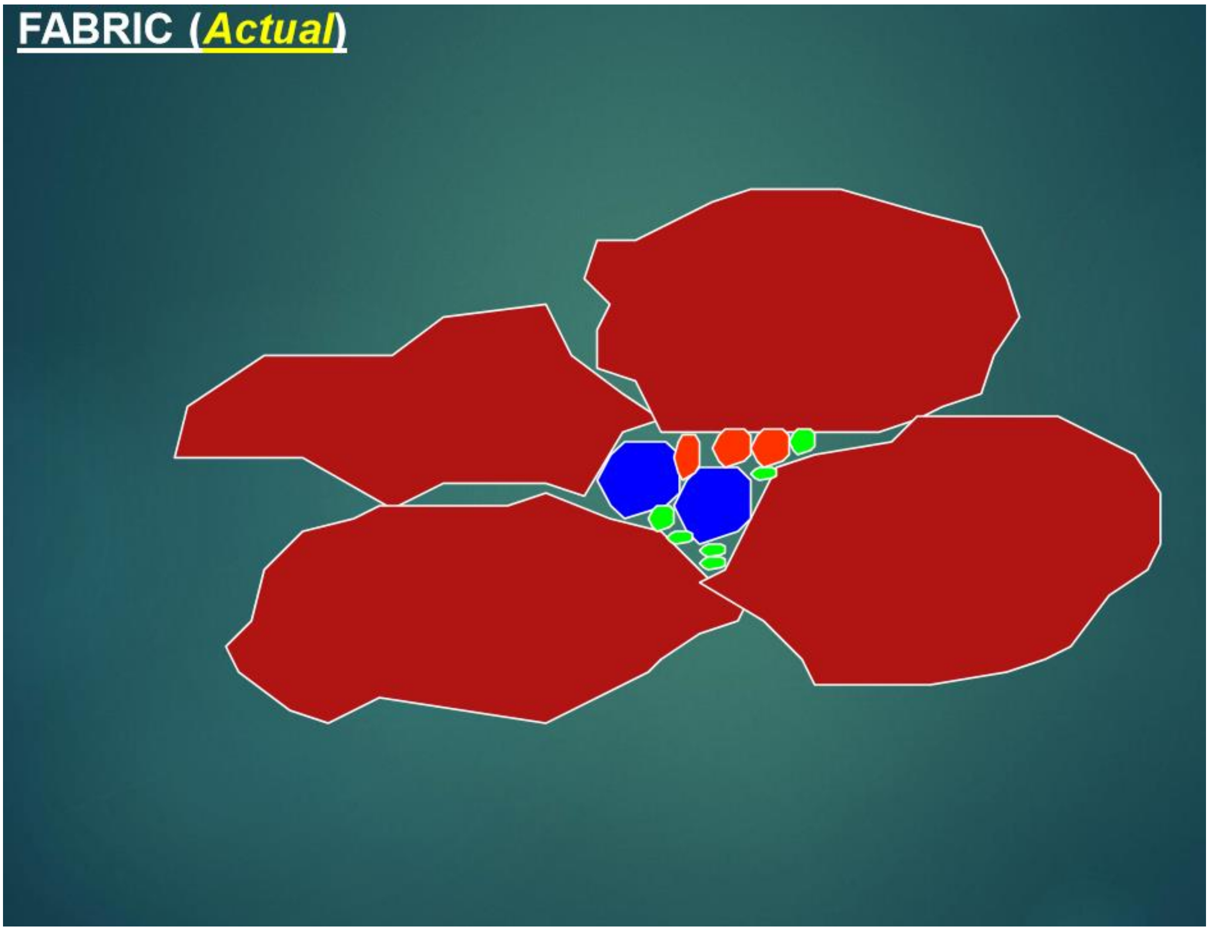
U.S. Bureau of Public Roads recommends 0.45 as the best overall value for m.



2.2-FABRIC(*Ideal*):



FABRIC(*Actual*)



Soil Binder:

Soils with granular bearing skeleton in the densified state possess 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 (4.76 mm), "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.

COLLAMERITICS:

Specifications on Gradation and Selection of Soil Elements

The properties of the final mixture are generally controlled and judged by gradation, the liquid limit, and the plasticity index. A granular bearing skeleton may be established by several different methods. The choice depends on the soil and other materials available intended use and special properties desired in the stabilized system time constraints for planning and construction.

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.

End Of Question#1 part 1 and 2

Ans#2 part1:

As a material expert we can identify aggregate by study of the Types of Aggregates, Their Properties and Tests is of great importance to a highway engineer.

Aggregates can be obtained from two sources,

Naturally Occurring Deposits

- Processed Material
- Blends of Natural or Processed Materials.
- Stabilized Materials

The majority of aggregates used in road construction are obtained from naturally occurring deposits. Natural aggregates for road-making are obtained from rock of the following geological groups :

Igneous Rocks (95% of Earth's Crust)

which are formed by the cooling of molten material sedimentary Rocks (5% of Earth's Crust & 75% of Earth's Surface) which are formed by deposition of granular material

Metamorphic Rocks

which are igneous or sedimentary rocks that have undergone transformations due to heat and pressure.The weathering product may be of two general types:

Residual Materials which may be either weathered or unweathered, generally occur in large deposits and are obtained by quarrying.

Transported Deposits are found, for example, in stream beds, sand and gravel bars, and alluvial fans.

Aggregate Identification: Mineral aggregates may be classified in a number of different ways.

Each classification technique is useful in developing an understanding of the type of material to be used in the pavement.

Pedological:

It is extremely helpful if the rock can be classified with respect to its general geologic type.

It is not necessary that the person involved with highway materials be a geologist to make this classification.

An understanding of geology and mineralogy are, however, extremely helpful, particularly in interpreting and predicting the performance of aggregates produced from the various available deposits.

==Ans#2 part2:== **there are two main parts of aggregate investigation:**

- Field Investigation *(Material Sourcing)*
- Laboratory Evaluations

Aggregate Prospecting:

Rock Quarries

- A grid of boreholes
- large sized holes
- core sampling

Subsurface Profiles:

- **Existing Sources**
- **<u>Shallow Deposits</u>**
- A similar procedure is required

❖ **Shallow Deposits**

- A grid of test pits/trenches
- Representative Sampling
- from different depths
- from bottom and sides
- Typical of the average properties**.**

- **Deep Deposits**

- sampling from stockpiles

❖ **Rock Quarries**

- A grid of boreholes
- large sized holes
- core sampling.

Deep Deposits

- visual inspection through cuts
- sampling from stockpiles

- First and foremost, it needs to be emphasized that the repeatability and reproducibility of test results depend primarily on the SAMPLING.
- A laboratory sample is obtained from a bulk sample collected, either in a number of increments or in one go, from a batch or a stockpile.
- Samples are normally collected using a sampler which is in the form of metallic tube or a scoop whose Opening is 3 times the maximum aggregate size.
- Sampling of aggregates is sometimes done at various production sources in order to avoid the segregation which occurs in stockpiles, Some of the sampling procedures followed are :
- 1. Sampling from stationary conveyor belt
- 2. Sampling at belt and chute discharge points
- 3. Sampling from stockpiles