Department of Civil Engineering
Final Assignment / Quiz (Spring 2020)

Subject: Pavement Material Engineering
Instructor: Engr. Shabir Ahmed
Semester: M.S (Civil Engineering)

Name: Hafiz fawadullah
I.D: 15523

Qno. 1.

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

Ans. Granular (Physical) Stabilization:

- Soils with particle sizes greater than 0.075 mm are designated as medium to coarse-grained soils.
- These soils, when compacted, from 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 if:
- (1) the volume of the silt clay size (<0.075mm) fraction plus that of the water, normally required to satisfy the capilary and physicochemical sorption capacity, does not exceed the volumn 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.

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Gradation Requirements for
Aggregate materials (ASTM D1241)
(AASHTO M147)

Sieve size Square openings	Gradation A	Gradation B	Gradation C	Gradation D	Gradation E	Gradation F
2 in (50mm)	100	100				
1 in (25mm)	—	75 to 95	100	100	100	100
3 in (9.5mm)	30 to 65	40 to 75	50 to 85	60 to 100		
No. 4 (4.75mm)	25 to 55	30 to 60	35 to 65	50 to 85	55 to 100	70 to 100
No. 10 (2.00mm)	15 to 40	20 to 45	25 to 50	40 to 70	40 to 100	55 to 100
No. 40 (425μm)	8 to 20	15 to 30	15 to 30	25 to 45	20 to 50	30 to 75
No. 200 (75μm)	2 to 8	5 to 15	5 to 15	8 to 15	6 to 15	8 to 15

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 seve years.

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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 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 detorimental to functiong of the bearing skeleton

Therefore the amount and the prope of the soil binder should controlled for optimum results.

ASTM and AASHTO Specification.

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Particle interface, as well as on the strength of the granular network

Collamerities

Properties of Particles

A) Physical

Granulometry

Laws of arrangement and Packing as functions of size gradation and shape factors.

ii) Mechanical

Strength, toughness abrassion resistance

Properties of Cementing Agents

A) Inorganic

i) Simple Gypsum and lime plasters

ii) Complex Sol hydraulic and other cements

iii) Clay and binder so

Specification 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.

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- 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 internal intermediate between those of clay Concrete and a portland Cement Concrete.
- Similarly, Partial replacement of the soil binder by asphalt leads to water proofed 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

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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 banded 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 (0.425mm)

Soil Binder

- The latter type of materials are also called "soil binder".

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$S = (d/d_{max})^m$

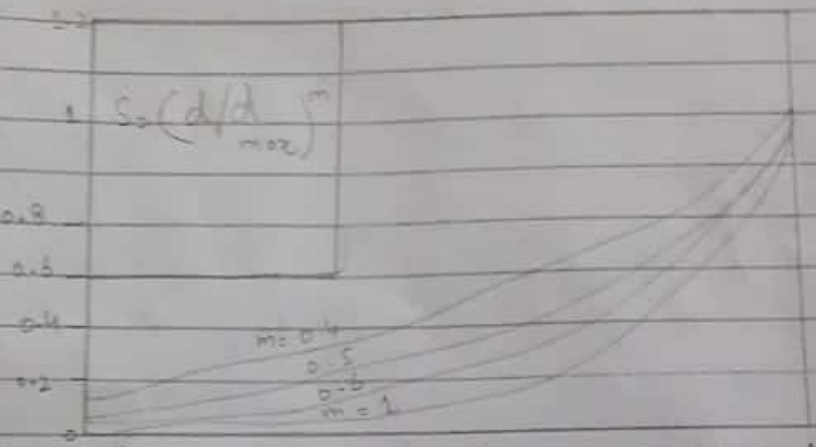
where

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

d_{max} = maximum particle diameter in mixture

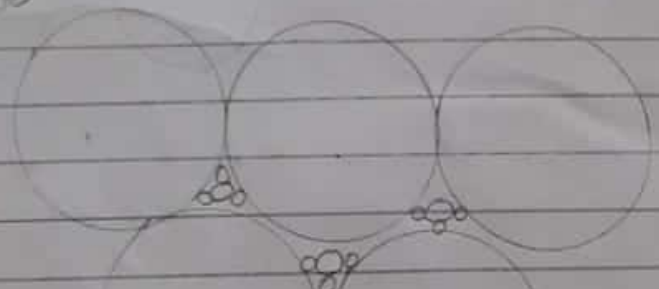
m = exponent determined empirically.

The factor m varies between 0.4 and 0.66. U.S Bureau of Public roads recommends 0.45 as the best over all value for m.

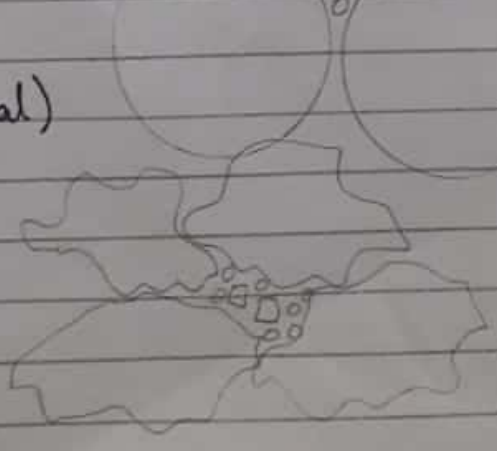


Fabric Curve satisfying the Talbot formula

Fabric (Ideal)



Fabric (Actual)



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- Stabilization of this class of soils is designated "Granular Stabilization".
- 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 primary objective is to obtain a well-proportioned mixture of particles with continuous gradation (well graded) and the desired plasticity.

(ii) How do we carry out Granular (Physical) Stabilization Considering Granulometry and Collametry, Fabric, Soil Binder, Collamerities and Specifications of gradation and selection of Soil elements?

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:

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properties to enable it to bind the aggregates together
- The strength of a water-bound macadam course is thus.
- Primarily due to the through mechanical interlock in the aggregates particles.
- Cohesion between the aggregates particles due to the cementitious film of soil-moisture binder.

WATER BOUND MACADAM.

- Materials
- Coarse Aggregates
  - Broken Stone Aggregates
  - Hard varieties such as Granite, Basalt, Diorite, Quartzite etc.
  - Softer varities such as sand stone, Limestone, Kankar Laterite etc.
  - Over-Burnt Bricks
  - Screening (Choke)
  - Moorum, Other Mixture
- Binding Material (Soil Binder)
  - Limestone Dust, PI => 6

WATER BOUND MACADAM

- 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 where as hand breaking can yield single

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(iii) Oils:-

are the lightes molecules weight material. in the asphalts & generally have a large number of chains in proportion to the number or rings. A numbers of the material in this ray are napthenic. type closed chain.

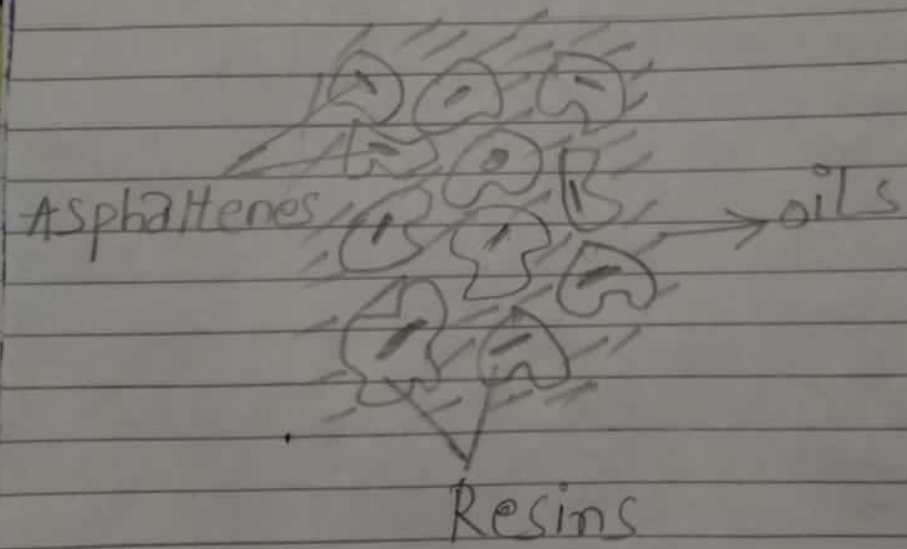
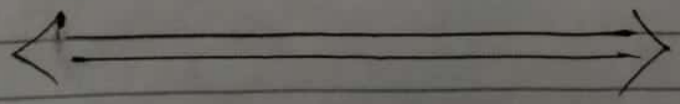


Figure shows: Asphaltenes, oils and Resins.



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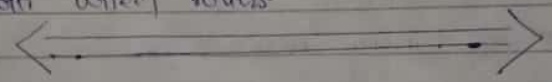
plant can be used.

- Ordinary concrete mixers can be also used, laying is done by paver-finishers and compactions by 8-10 ton smooth wheel rollers.



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Ans

(1) Bituminous Materials - Manufacturing

▲ Manufacturing Process:-

▲ The major method used for the production of asphalts.

- Atmospheric Distillation
- Distillation at reduced Pressure
- Air Blowing
- Solvent refining
- Early refinery methods consisted of a simple distillation process in a retort with attached condenser. The procedure was to pump a quantity of crude oil into the vessel and apply heat to the bottom causing the lower boiling point fraction to boil off leaving a residue which, depending on the type of crude, could be crude grease, bunker fuel oil, or asphalt. Only certain types of crude containing relative high asphalt contents could be used for the productions of asphalt by this method

▲ Distillation remains by far the most common process.

Bituminous Material - Manufacturing

▲ The consistency of the material is controlled by

▲ Temperature

▲ Quantity of steam

▲ Pressure

- Amount of Reflux
- Type of Crude

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Q.No:3

MACADAM BASES - HISTORY

- 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.

- This concept had revolutionized the road building science then, aided as it was by the invention of the stone crusher in 1858 by Blake, the steam road roller by Aveling in 1867 and by the use of bitminous materials early in the twentieth century.

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 gradded stones are mixed with water or comparted

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size aggregate.

- 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 Materials
  - The screening also known as "choke" materials, fill in the voids left in the coarse aggregates after they are consolidated and help to the cement the stone aggregates together.
  - To effectively perform these function the screening should be properly graded and also should have some plastic material in them to impart cementitious properties

WATER BOUND MACADAM.

- Thickness of courses
  - The water bound macadam is constructed by spreading loose metal which gives 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 above value the construction is done in multiple layers.

WATER BOUND Macadam

- CONSTRUCTION
- Spreading metal
  - Manual Method
  - Mechanical Method.

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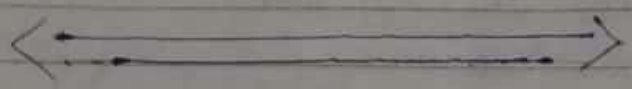
Some existing known sources from where we obtained the required materials, for new sources.

we need

- soil survey maps
- Geological maps
- Aerial photographs
- satellite imagerils.



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- Penetration Macadam

If a bituminous material is sprayed over the stones and allowed to penetrate into the course and by "premix" maccadam if the bitiminous material is mixed with the aggregates prior to laying.

MACADAM BASES

- Sequance

- Concept
- Materials
- Constructions

WATER BOUND MACADAM

- CONCEPT
- Water bound maccadam 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

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- Rolling of Aggregates
- Dry Rolling
- Wet Rolling
- Application of Screenings
- Application of Binding Materials

~~EXP. 3~~ WET MIX MACADAM

- Concept:-
- Wet - Mix macadam is a specification in which a well-graded aggregate is mixed with a water in a mechanical mixer and the resultant mixture is laid by pavers and compacted.
- The aggregate is generally crusher-run, and in cluds fines also. Because of the close grading, the course will have good interlock with excellent density.
- Grading:-
- Well-Graded
- Moisture content:-
- The optimum moisture content for mixing is determined by conducting suitable density tests. The moisture content during mixing is maintained add this optimum ± 0.5 percent. The moisture content is usually in the range 2-5% by weight.

WET MIX MACADAM.

- Construction
- The mixing can be done in a suitable mechanical mixers specially designed mixers can be fabricated for this specification, otherwise a bitiminous macadam

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- The very high molecular weight compounds: consist primarily of the ring type materials with very few side chains of the aliphatic variety present.

- Asphalt Composition:
- For convience, the wide specturm of organic compound contain in an asphalt are seperated into a number of compounds one commonly used Classification states that asphalt can be seperated into.
- ASPHALTENS
- RESINS } MALTENES.
- OILS }

(i) ASPHALTENS:- are the high molecular weight materials & are primarily of an aromatic nature with few side chains attached.

(ii) Resins:- Are the intermediate molecules weight material & contain more side chains than the asphaltens Some sulfur & nitrogen is also include in these molecules.

P.T.O

Q2 (i)

Aggregate is the major component of materials used in road making it is used granular base and subbases Bitiminous courses and cement concrete pavements

Aggregates can be obtained from two sources

(1) Naturally Occuring Deposits

(2) Artificially and industrially prepared deposits.

Aggregates can be identified on the basis of:

(1) origin

(2) mode of formation & Deposition

(3) Density

(4) Shape

(5) Surface Texture

The majority of aggregates used in road construction are obtained from naturally occuring deposits.

Natural aggregates for road making are obtained from rock of the following geological groups

* Igneous Rocks-

Igneous rock posses 95% of earth's crust and are formed by the cooling of molten material.

P.T.O

Q4.
(2)

CHEMICAL COMPOSITION of BITUMEN:

▶ ASPhalt Composition:

▶ Some generalization can be made, however, with regard to the chemical composition of the semi-solid materials. According to Simpson they generally consist of

- ▶ Carbon (78-85%).
- ▶ Hydrogen (7-12%).
- ▶ Nitrogen (0-1%).
- ▶ Sulfur (1-7%).
- ▶ oxygen (0-5%).
- ▶ and small amounts of metals either dispersed in the form of oxides and salts or in the metal containg organic compound.

▶ ASPHALT COMPOSITION.

- ▶ The Lighter molecular weight materials: Contain a considerable amount of Carbon and hydrogen.
- ▶ As the molecular weight increases: The tendency toward ring type organic compounds is more apparent with the side chains.

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- Rate or time of processing
- It is often not economical for a refinery to produce asphalt to a number of paving grades directly. Hence, blending is utilized
- Refineries may stock two grades of asphalts one at each end of the viscosity spectrum and blend to produce intermediate grades.
- Relatively high flash distillates have also been used as blending materials with hard asphalts

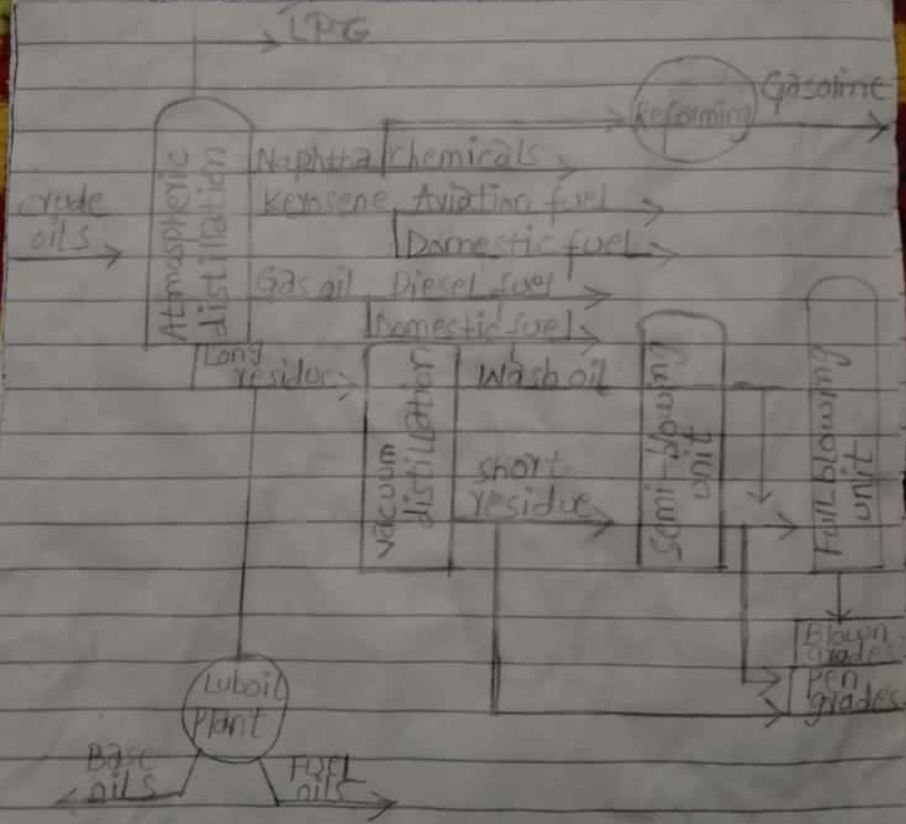

Fig :- Schematic representation of the crude oil distillation process.

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Q No 2 (ii):

Field investigation for concrete material prior to construction are chiefly confined to.

- Propecting for Aggregate
- Exploration and sampling of Available Deposits.

Judgement and thoughness in conducting preliminary field investigation are usually reflected in the Durability and Economy of completed structure. Awarness of the effect of different properties of the aggregate on the behaviour of pavement layers are most for the investigation Team.

Material sources are mainly

(1) Natural deposits
(2) Rock Queries

In Natural deposits we have

- Stream/River deposits
- Glacial deposits
- Fluvial deposits
- Talus deposits
- Wind blown deposits we already

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crust and are formed

* SEDIMENTARY ROCKS:-

5% of earths crust's and 75% of earth surface is composed of sedimentary rocks and are formed by deposition of granular material.

* METAMORPHIC ROCKS:-

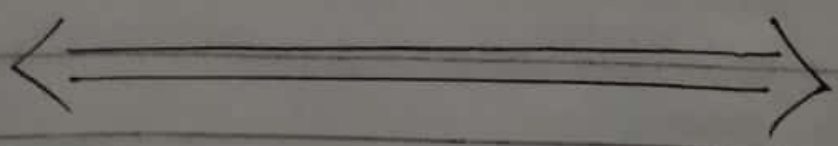
Metamorphic rocks are igneous or sedimentary rocks that have undergone transformation due to heat and pressure

* RESIDUAL MATERIALS:-

Residual materials may be either weathered or unweathered and generally occur in large deposits and are obtained by quarring.

* TRANSPORTED DEPOSITS:-

Transported deposits are weathering product found in stream beds, sand and gravel bars and alluvial fans.



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