ID number: 14398
Subject: Pavement Material Engineering
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Question No. 1
Why do we carry out Granular (Physical) stabilization?

Soils which have particle sizes greater than 0.075 mm are nominated as medium to coarse-grained soils. Upon compaction of these soils, 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
- Volume Stability

Stabilization of this class of soils is nominated as **Granular Stabilization.**

Granular stabilization is used in construction of Base, Sub-base, and Surface Courses of paved facilities.
Stone, Gravel, Sand and containing Silt-Clay are compacted to maximum density to get high strength, stability and durability in all weather conditions.
The main objective of granular stabilization is to get well-proportioned mixture of particles with continues gradation and desired plasticity.

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?

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

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)

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.

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

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.

The below Figure 9.3 gives different type of materials Gravel, Stone, Sand, Silt and clay .

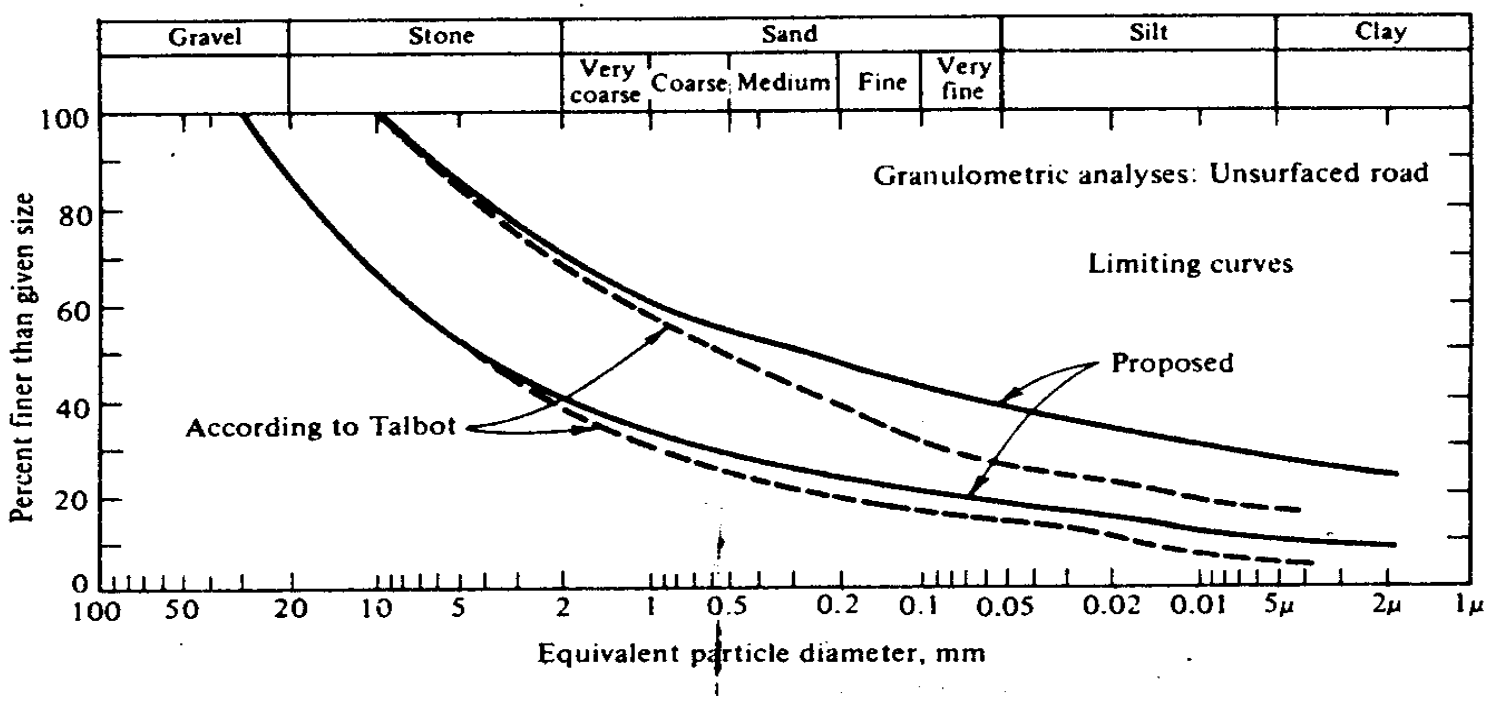

Fig. 9.3 Clay–concrete for laterite soil binder.

Question No. 2

1. 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?

Aggregates can be identified on the basis of

- Origin (Composition)

- Mode of formation and Deposition
- Density
- Shape
- Surface Texture

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
They are 98% of Earth Crust. Igneous rock is formed through the cooling and solidification of magma.

Sedimentary Rocks
They are 5% of Earth's Crust & 75% of Earth's Surface. They are formed by the deposition of small particles.

Metamorphic Rocks
igneous or sedimentary rocks that undergone transformations due to heat and pressure.

The weathering product may be of two general types:

Residual Materials

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

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

2.In aggregate investigation Material sourcing is referred to Filed investigation. Discuss Material sourcing in detail.

Field Investigation for concrete materials prior to construction are chiefly confined to

a) Prospecting for Aggregates
b) Exploration and Sampling of Available Deposit

AGGREGATE SOURCES

1. **Prospect Sources**
2. **Existing Sources**

1. **<u>Aggregate Prospecting/Prospect Sources</u>**

- Shallow Deposits
- Rock Quarries

Shallow Deposits

- ❖ A grid of test pits/trenches
- ❖ Representative Sampling from different depths and from bottom and sides

Rock Quarries

A grid of boreholes
large sized holes
core sampling

2. **Existing Sources**

- Shallow Deposits
- Deep Deposits

Shallow Deposits

A similar procedure is adopted.

A grid of test pits/trenches

Representative Sampling from different depths and from bottom and sides

Deep Deposits

- ❖ Visual inspection through cuts is carried out. Mechanical machinery like excavator is used to make cuts. The material is inspected for further procedure.
- ❖ Sampling is done from stockpiles

Sampling of aggregates is sometimes done at various production sources in order to avoid the segregation which occurs in stockpiles

Question No.3. 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?

Various types of Macadam bases are

- Water Bound Macadam
- Dry Bound Macadam
- Wet Mix Macadam
- Penetration Macadam

Water Bound Macadam

WBM is constructed by broken aggregates that are interlocked mechanically by rolling and voids filled with screening and binding materials with the help of water.The strength of a water-bound macadam course is primarily due to the thorough mechanical interlock in the aggregate particles and Cohesion between the aggregate particles due to the cementitious film of soil-moisture binder.

Materials used in Water Bound macadam are

- **Coarse Aggregate**

  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

Size and Grading Requirements of Coarse Aggregates

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.
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.

Construction

- Spreading meterial

Manual Method

Mechanical method

- Rolling of Aggregates

Dry Rolling

Wet Rolling

- Application of Screenings
- Application of Binding Material

WET MIX MACADAM

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.

Grading

Well graded aggregates

Moisture Content

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 of Wet Mix Macadam

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.

Difference between Water Bound Macadam and 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.
- 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

  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.

Question No. 4

1. Discuss in detail the Bituminous Materials-Manufacturing?

Bitumen Manufacturing Processes is as under
The major methods used for the production of asphalts

- Atmospheric Distillation
- Distillation at Reduced Pressure
- Air Blowing
- Solvent Refining

Early refinery methods consisted of a simple distillation 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 fractions to boil off leaving a residue which, depending on the type of crude, could be axle 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.

The consistency of the material is controlled by

- Temperature
- Quantity of Steam
- Pressure
- Amount of Reflux
- Type of Crude
- 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 asphalt, 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.

2.Bituminous Materials-Chemistry is referred to chemical composition of bitumen. Elabourate in detail.

With regard to the chemical composition of the semi-solid materials. According to Simpson they generally consist of

- Carbon (70-85%)
- Hydrogen (7-12%)
- Nitrogen (0-1%)
- Sulfur (1-7%)
- Oxygen (0-5%)

small amounts of metals either dispersed in the form of oxides and salts or in metal containing organic compounds

For convenience, the wide spectrum of organic compounds contained in an asphalt are separated into a number of components, one commonly used classifications states that asphalts can be separated into:

Asphaltenes

Resins

Oils

ASPHALTENES

Asphaltenes are the high molecular weight materials and are primarily of an aromatic nature with very few side chains attached. The hypothetical asphaltene molecule shown in Figure illustrates qualitatively, at least, this composition. It will be noted that sulfur and nitrogen are incorporated in the ring structure in this type of material.

RESINS

Resins are the intermediate molecular weight materials and contain more side chains than the asphaltenes. Some sulfur and nitrogen is also included in these materials, but to a lesser extent than in the asphaltenes. The resins are polar molecules resulting from their aromaticity and the inclusion of sulfur. This polar nature gives resins the ability to be adsorbed by and to dissolve the asphaltenes.

OILS

Oils are the lightest molecular weight materials in the asphalt and generally have a large number of chains in proportion to the number of rings. A number of the materials in this range are naphthenic-type closed chains.