Pavement Materials

Lecture 09

Pavement Layers

- ***Why Surface Course ?***
- ***Why Base Course ?***
- ***Why Sub-Base Course ?***

Pavement Unbound Layers

- **Granular (Physical) Stabilization**
- **IDENTIFICATION**
- **EVALUATION**
- **SELECTION**
- **CONSTRCUTION**

Granular (Physical) Stabilization

- ***<u>Why ?</u>***
- ***<u>How ?</u>***

Why ?

Granular (Physical) Stabilization

- Soils with particle sizes greater than 0.075 mm are designated as medium to coarse-grained soils.
- 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**".

GRANUALR 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.***

GRANUALR STABILIZATION

- 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.

How ?

GRANUALR STABILIZATION

- **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**:
- $s=(d/d_{max})^m$
- where
- s = weight percent of the particles with diameter less than d.
- d_{max} = 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.

GRANUALR STABILIZATION

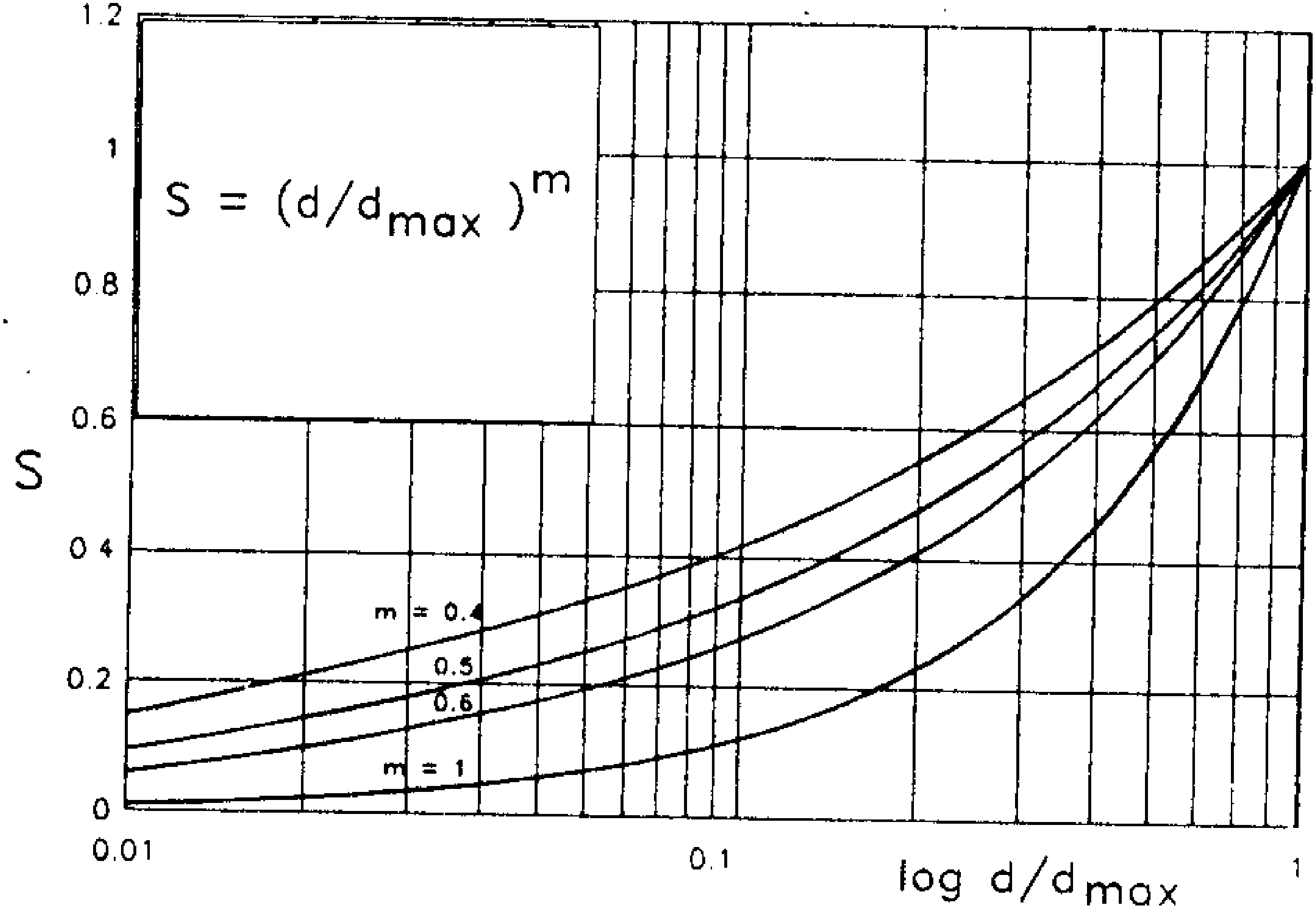
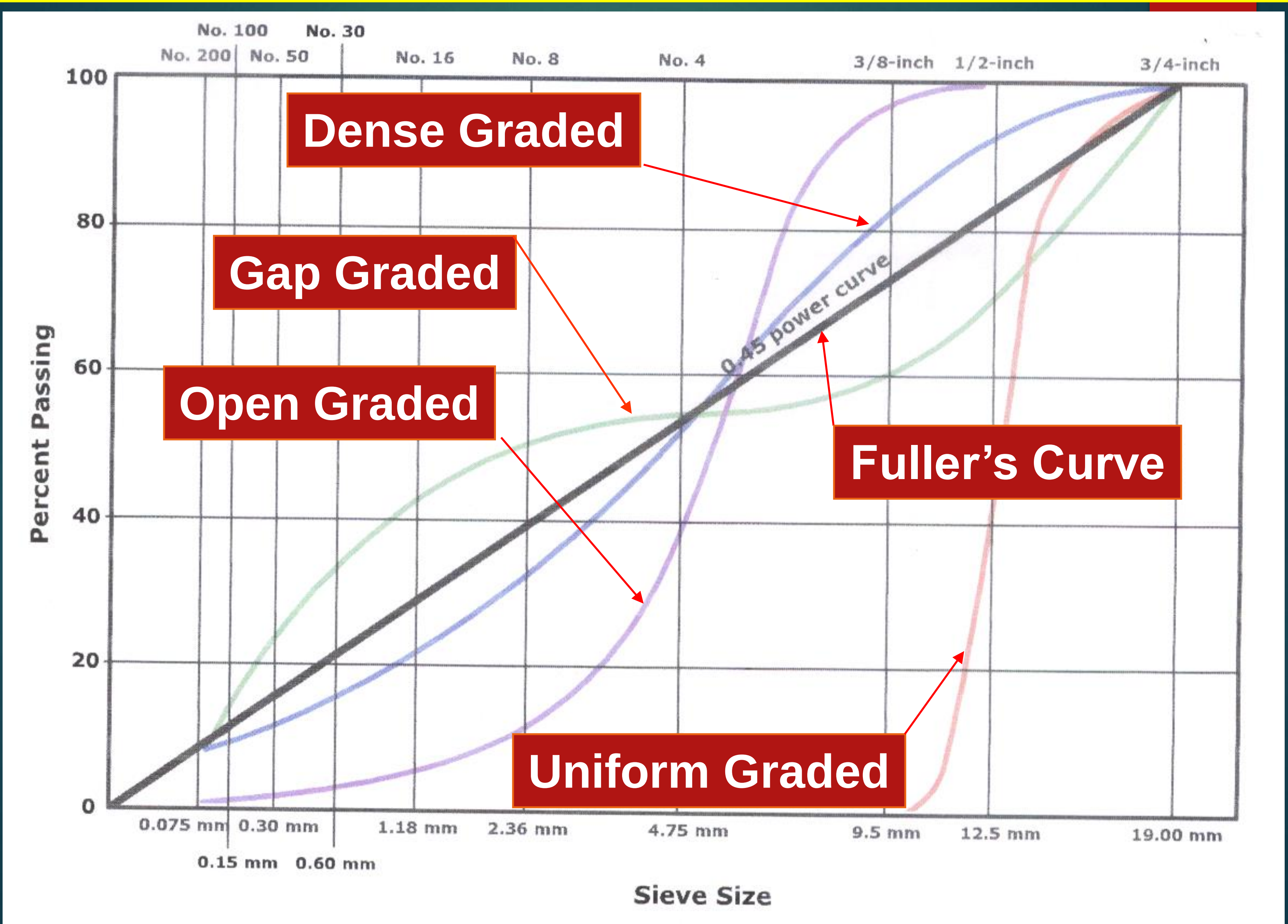


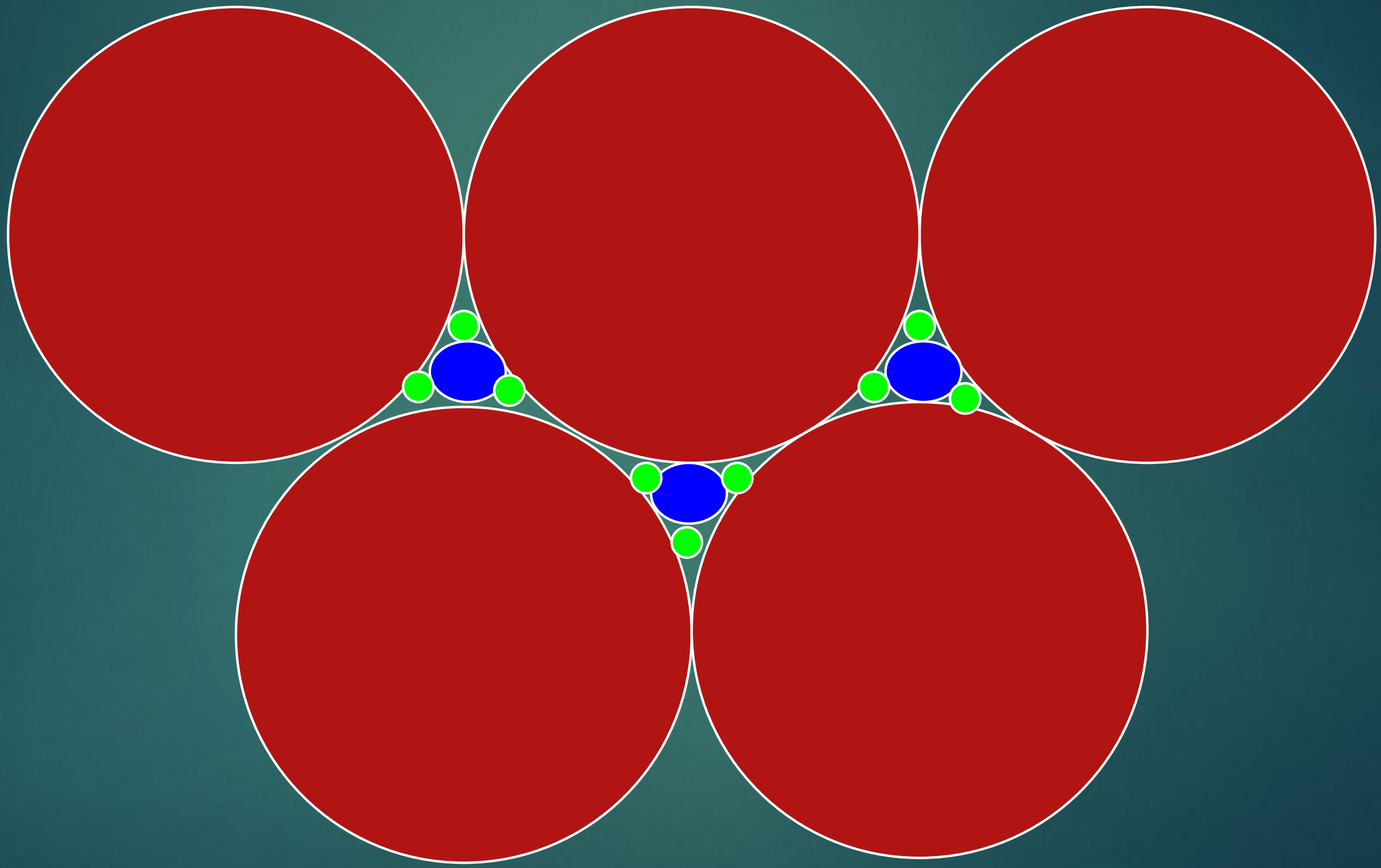
Fig. 9.1 **Curve satisfying the Talbot formula**

Types of Gradations



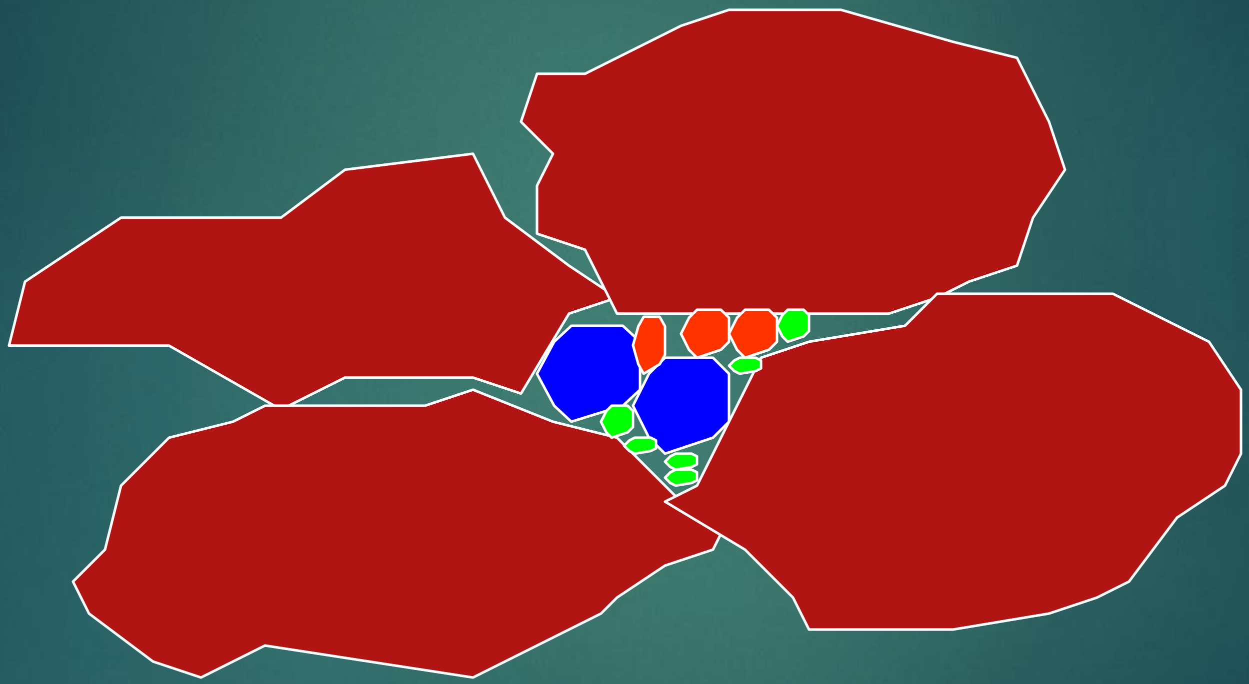
AGGREGATES

- **FABRIC (*Ideal*)**



AGGREGATES

- **FABRIC (*Actual*)**



GRANUALR STABILIZATION

- **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 (4.76 mm),**
- **"MORTARS"** **if the largest particles are of fine sand size or the size of the openings of No. 40 sieve (0.425 mm).**

GRANUALR STABILIZATION

- **Soil Binder**
- The latter type 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.***

GRANUALR STABILIZATION

- **COLLAMERITICS**

TABLE 9.2 COLLAMERITICS—THE SCIENCE OF COMPOSITION AND PROPERTIES OF NONMETALLIC CONSTRUCTION MATERIALS[a].

Properties of the Particles	*Properties of the Cementing Agents*	*Examples of Cemented Systems*
A. Physical I. Granulometry Laws of arrangement and packing as functions of size, gradation and shape factors II. Mechanical Strength, toughness abrasion resistance B. Physicochemical and chemical I. Interaction and bonding with cementing agents II. Reactivity with deleterious substances in environment	A. Inorganic I. Simple Gypsum and lime plasters II. Complex Sorel-, hydraulic and other cements III. Clay and binder soil B. Organic I. Bituminous Asphalts, pitches, tars II. Natural and synthetic resins and other polymers III. Gums, glues of various types, etc.	1. Mortars with inorganic and organic cements including natural and artificial sand stones 2. Concretes Portland cement, bituminous, resinous, clay, etc., including naturally cemented conglomerates 3. Plastics Powder, paper-, cloth-, and fiber-filled; also natural wood in which cellulose fibers are bonded together by lignin

[a] After Winterkorn (1955a).

GRANUALR STABILIZATION

- **<u>Specifications on Gradation and Selection of Soil Elements</u>**

- In Nature?
- More Frequently **<u>NO!</u>**
- **How to get the Desired Mixtures??**
- **By addition of proper proportions of the aggregates or fines**
- **Treatment with waterproofing of cementing material**

- 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.***

GRANUALR STABILIZATION

- **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 ??**
- **Formulae for Mixing of Aggregates ??**

GRANUALR STABILIZATION

- **Specifications on Gradation and Selection of Soil Elements**

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

GRANUALR STABILIZATION

- **Specifications on Gradation and Selection of Soil Elements**

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

GRANUALR STABILIZATION

- **Specifications on Gradation and Selection of Soil Elements**

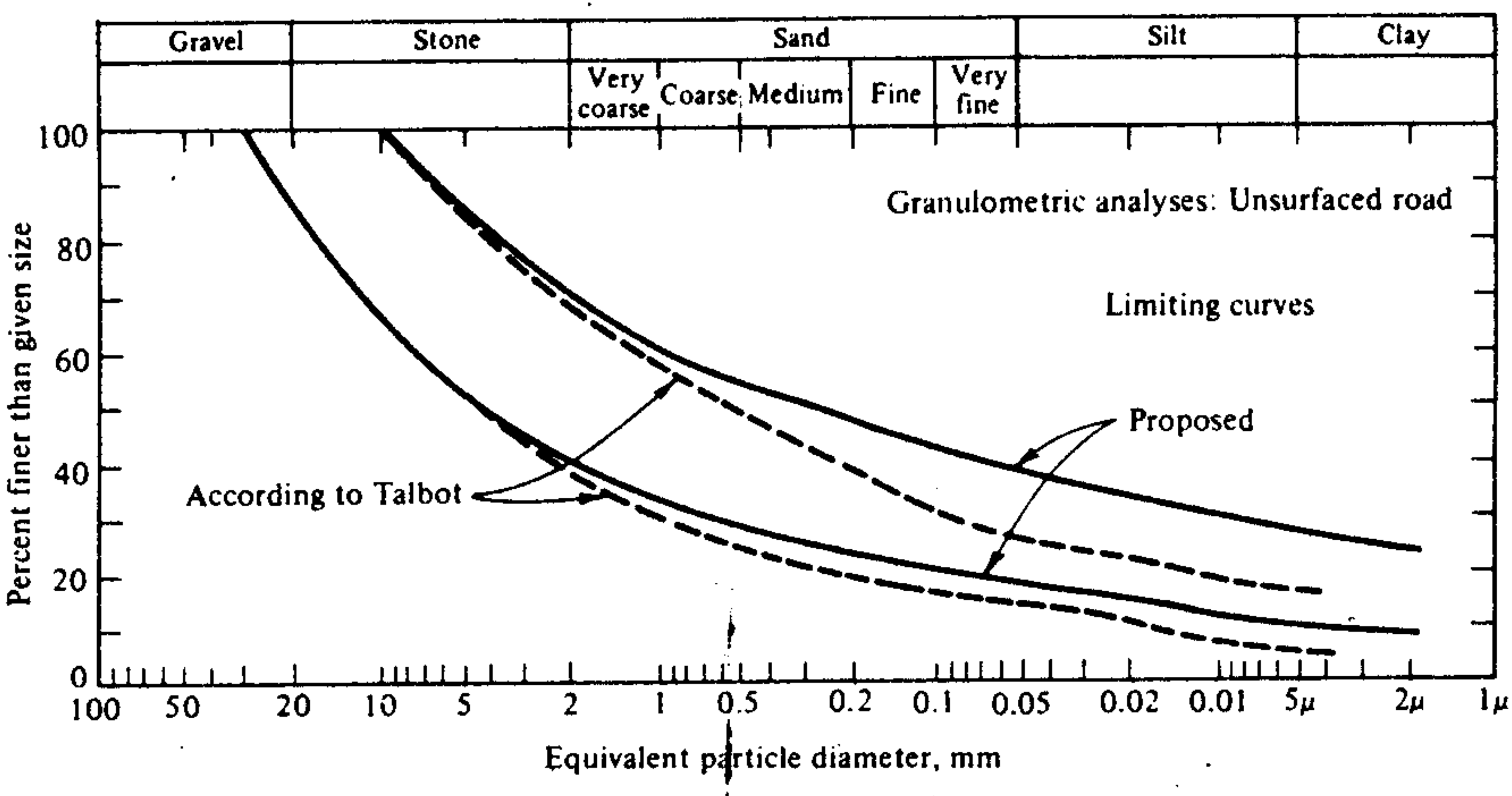


Fig. 9.3 Clay–concrete for laterite soil binder.

GRANUALR STABILIZATION

- **Specifications on Gradation and Selection of Soil Elements**

- **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.

- **PERFORMANCE RELATED SPECIFICATIONS ??**

Thank You