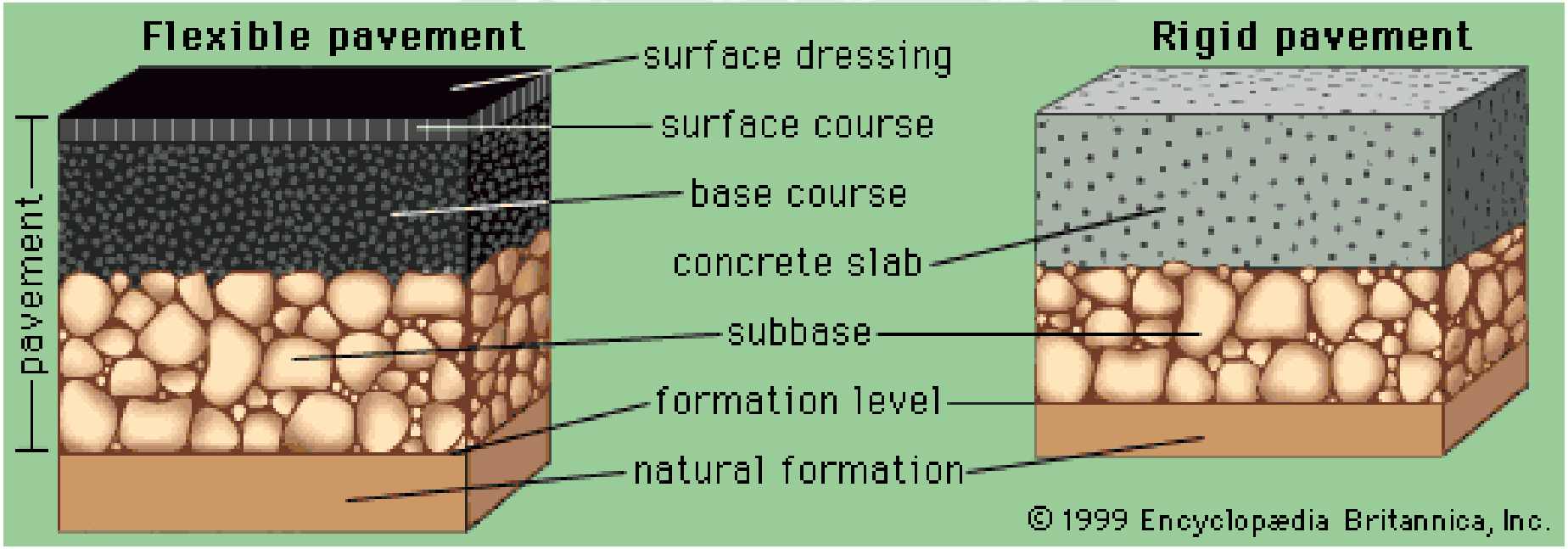
# Pavement Types

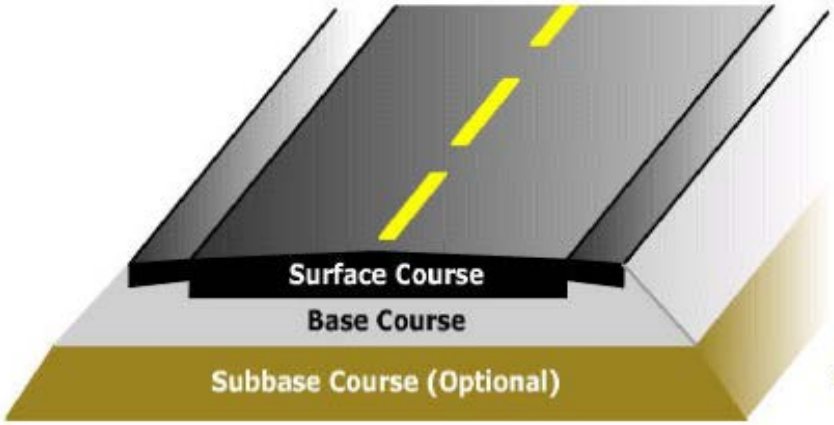
1. Flexible Pavements
2. Rigid Pavements

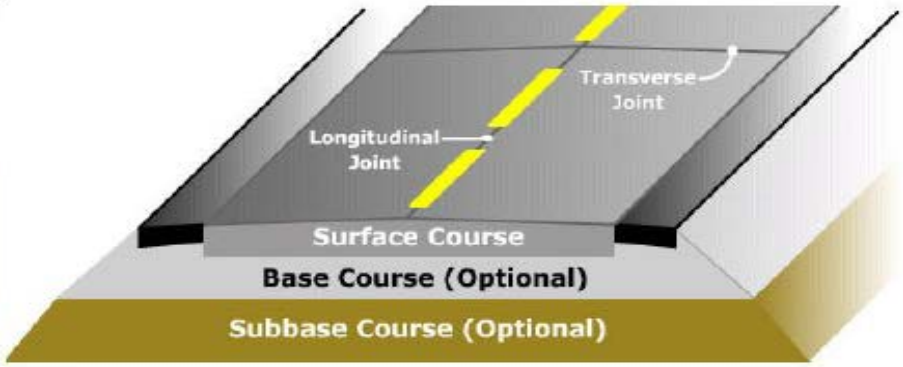


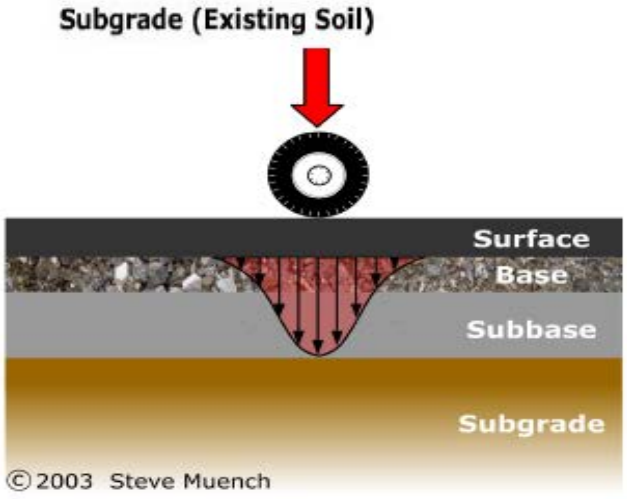
# Pavement Types

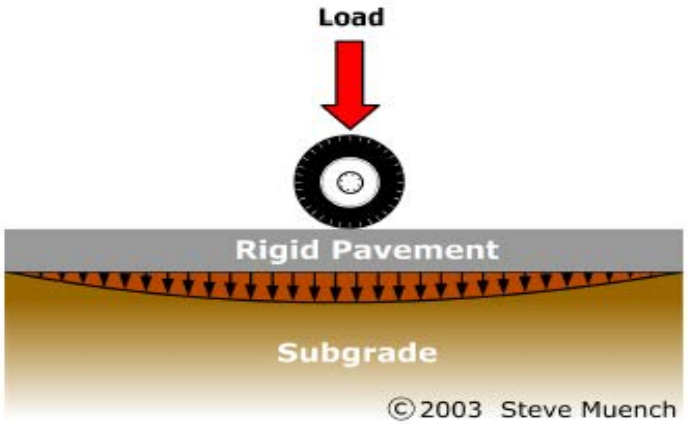
- **Flexible pavements** typically **distribute wheel loads** to **lower layers** of the pavement section and consists generally of bituminous material.
- **Rigid pavements** are typically **distribute wheel loads** over a **wide area of the subgrade** and consists generally of cement concrete and may be reinforced with steel.

# Pavement Types



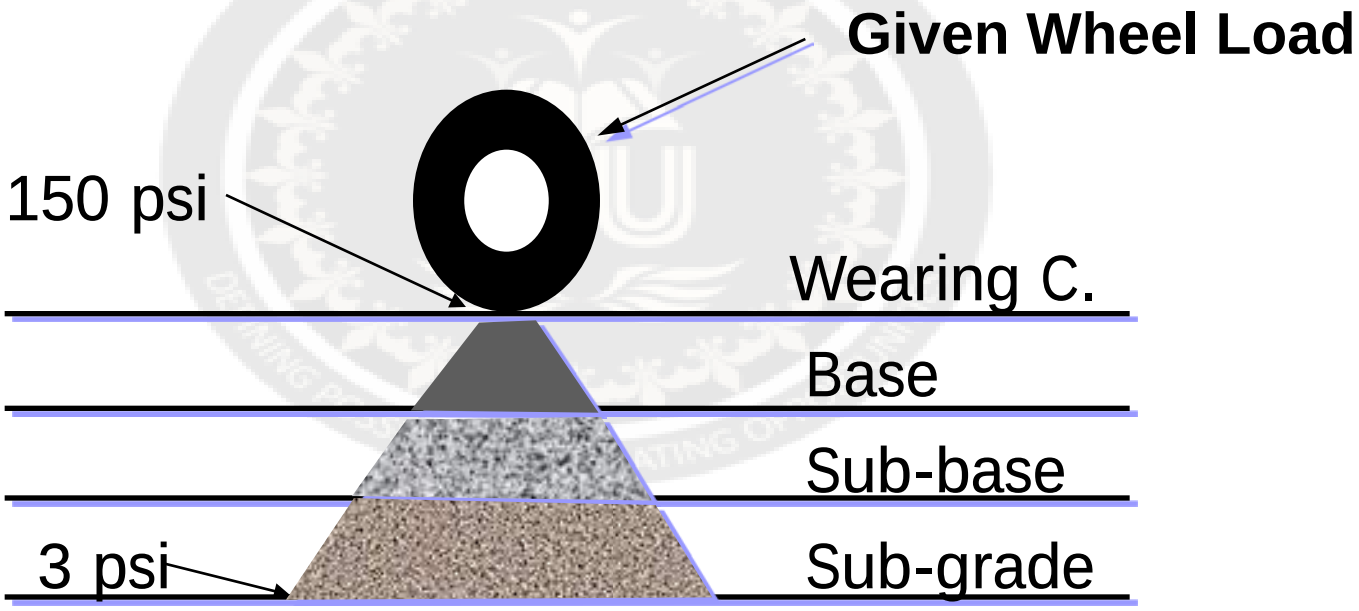




Flexible

Rigid

# Pavement Responses

## Flexible Pavements




**Load Distribution in Flexible Pavements**

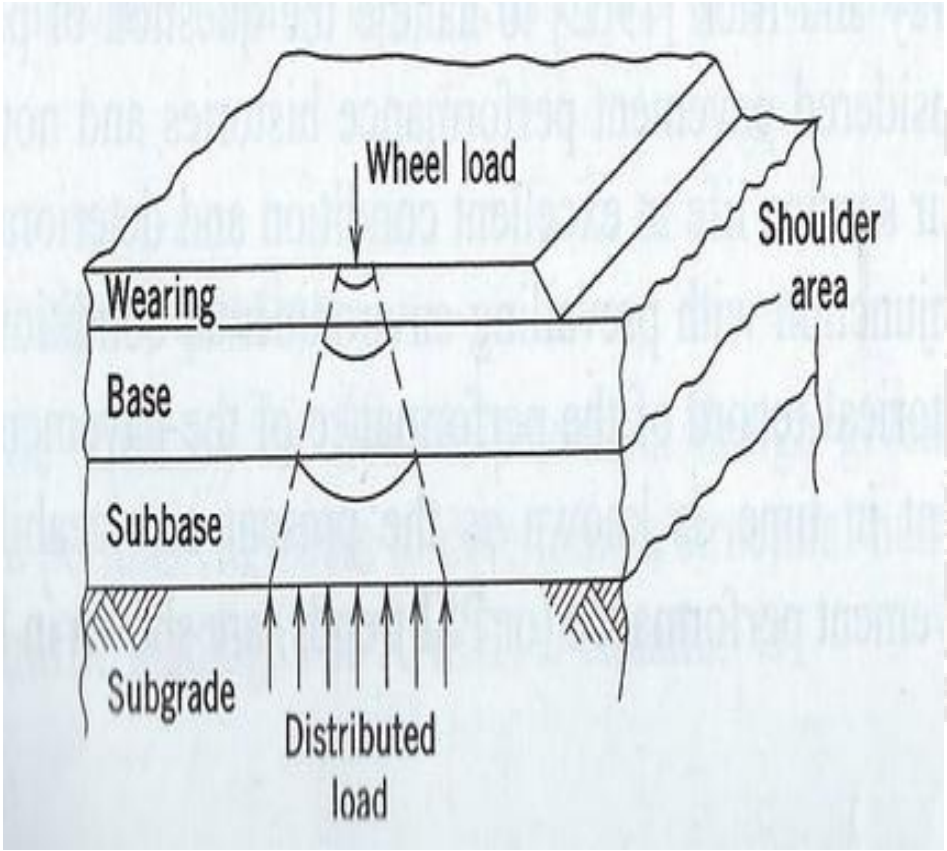
# Flexible Pavement

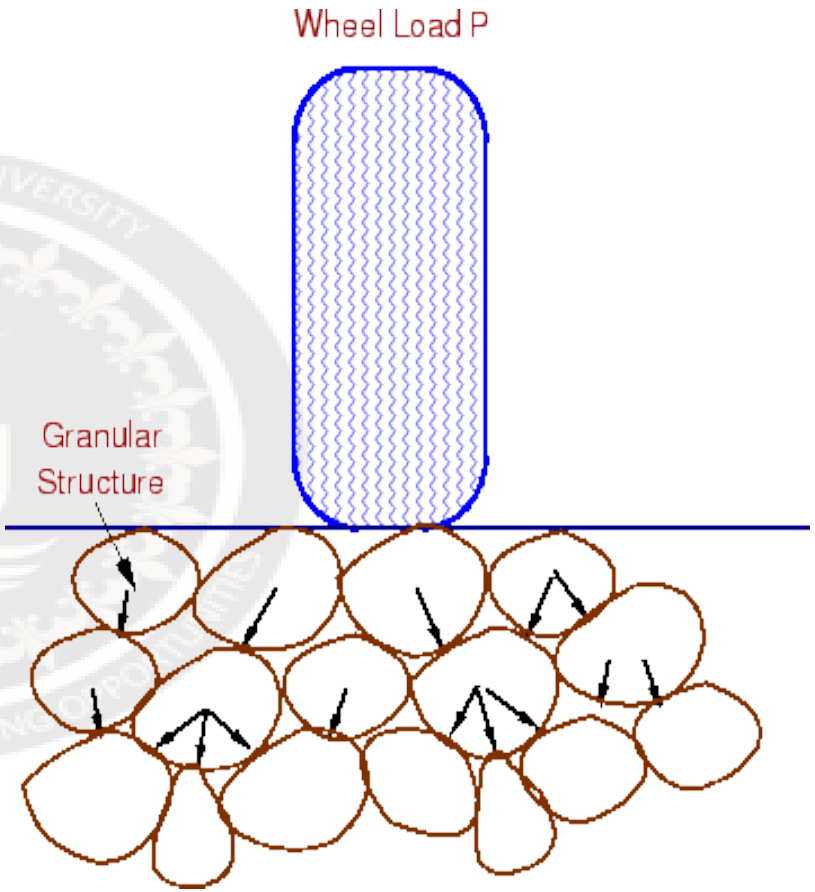
# Rigid Pavement

# Comparison of Flexible vs Rigid Pavement

| Sr. | Flexible Pavement | Rigid Pavement |
|---|---|---|
| 1 | **Bitumen** is used a binder in Flexible Pavement | **Cement** is used as a binder in rigid pavements |
| 2 | Deformation in the sub grade is transferred to the upper layers | Deformation in the sub grade is not transferred to subsequent layers |
| 3 | Load is transferred by grain to grain contact | No such phenomenon of grain to grain load transfer exists |
| 4 | Flexible pavements have low initial construction costs but have high maintenance cost | Rigid pavements have low maintenance cost but have high initial construction costs. |
| 5 | Have low life span usually 10-15 years | Life span is more as compare to flexible usually 30+ years |
| 6 | Surfacing cannot be laid directly on the sub grade but a sub base is needed | Surfacing can be directly laid on the sub grade |
| 7 | In flexible pavements strength of road highly dependent on strength of sub-grade. | Strength of road less dependent on strength of sub-grade in rigid pavements |
| 8 | Road can be used for traffic within 24 hours | Road cannot be used until 14 days of curing |

# Load Transfer in Flexible Pavement



# Flexible Pavement Layers

# Flexible Pavement


Typical cross section of a flexible pavement

# Subgrade

# Subgrade Construction

***Subgrade:*** this is the native soil (or improved soil), usually compacted, on which the pavement structure is placed

1. **Establishment of Grade Line**
   - Natural Ground (Cut)
   - Embankment (Fill)
2. **Compaction**

# Subgrade Construction

1. ***Establishment of Grade Line***

- The subgrade line should be established to obtain the optimum natural support for the pavement, consistent with ***economic utilization of available materials*** and meeting the traffic requirements

***a. Balancing Cut and Fill***: Optimizing subgrade support and drainage should take precedence over balancing cut and fill.

# Subgrade Construction

***Ground Water***:

The subgrade line will be **above the flood plain** and a **minimum of 2feet above wet season ground water level**. Where not practicable, provide for permanent lowering of water table by drainage.

***Rock:***

Rock excavation is to be **avoided** for economic reasons. Where excavation of rock is unavoidable, **undercut to provide for full depth of base course** under surface courses .

# CBR Test

- The **California bearing ratio test** is penetration **test** meant for the evaluation of subgrade strength of roads and pavements.

- $$\text{CBR} = \frac{\textit{Load Sustained by the soil at 2.5mm penetration}}{\textit{load sustained by standard aggregate by the same penetration}}$$

- $$\text{CBR} = \frac{\textit{Load Sustained by the soil at 5mm penetration}}{\textit{load sustained by standard aggregate by the same penetration}}$$

- Subgrade >10%
  - Good if >10
  - Fair if b/w 5-9
  - Poor if b/w 3-5
- Subbase >30%
- Base > 80%

# Subgrade Construction

## ***Compaction***

## ***Purpose:***

- In engineering practice the *soils at a given site do not often meet the ideal requirements* or the intended purpose.
- They may be weak, highly compressible, or have a higher/lower permeability than desirable from an engineering or economic point of view.

# Subgrade Construction

***Compaction***

***Purpose:***

- It would seem reasonable in such instances to simply **relocate** the structure or facility. If not the engineer has to adapt and design according to the geotechnical conditions at the site.
- The geotechnical condition of the site can be improved by **stabilizing techniques** of the soil and/or by **compaction** of the existing soil.

# Subgrade Construction

- ***Objectives of Compaction***

1. Detrimental settlements can be reduced or prevented.
2. Soil strength increases and slope stability can be improved.
3. Bearing capacity of pavement subgrades can be improved.
4. Undesirable volume changes, for example, caused by frost action, swelling, and shrinkage may be controlled.

Usually greater than 95% of the compaction is achieved on site

# Subgrade Construction

- ***Compaction***
- Compaction is a function of four variables:

1. Dry Density
2. Water Content
3. Compactive Effort/Type
4. Soil Type (gradation, presence of clay minerals, etc).

Lab test for determining maximum dry density and optimum moisture content

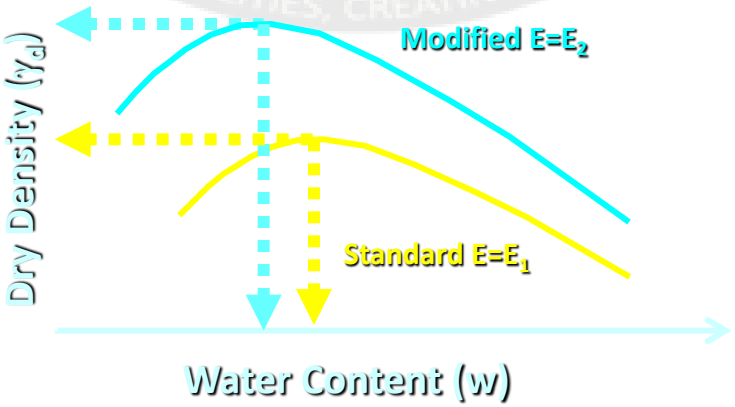
1- Standard Procter Test

2- Modified Procter Test

# Moisture Density Relationship

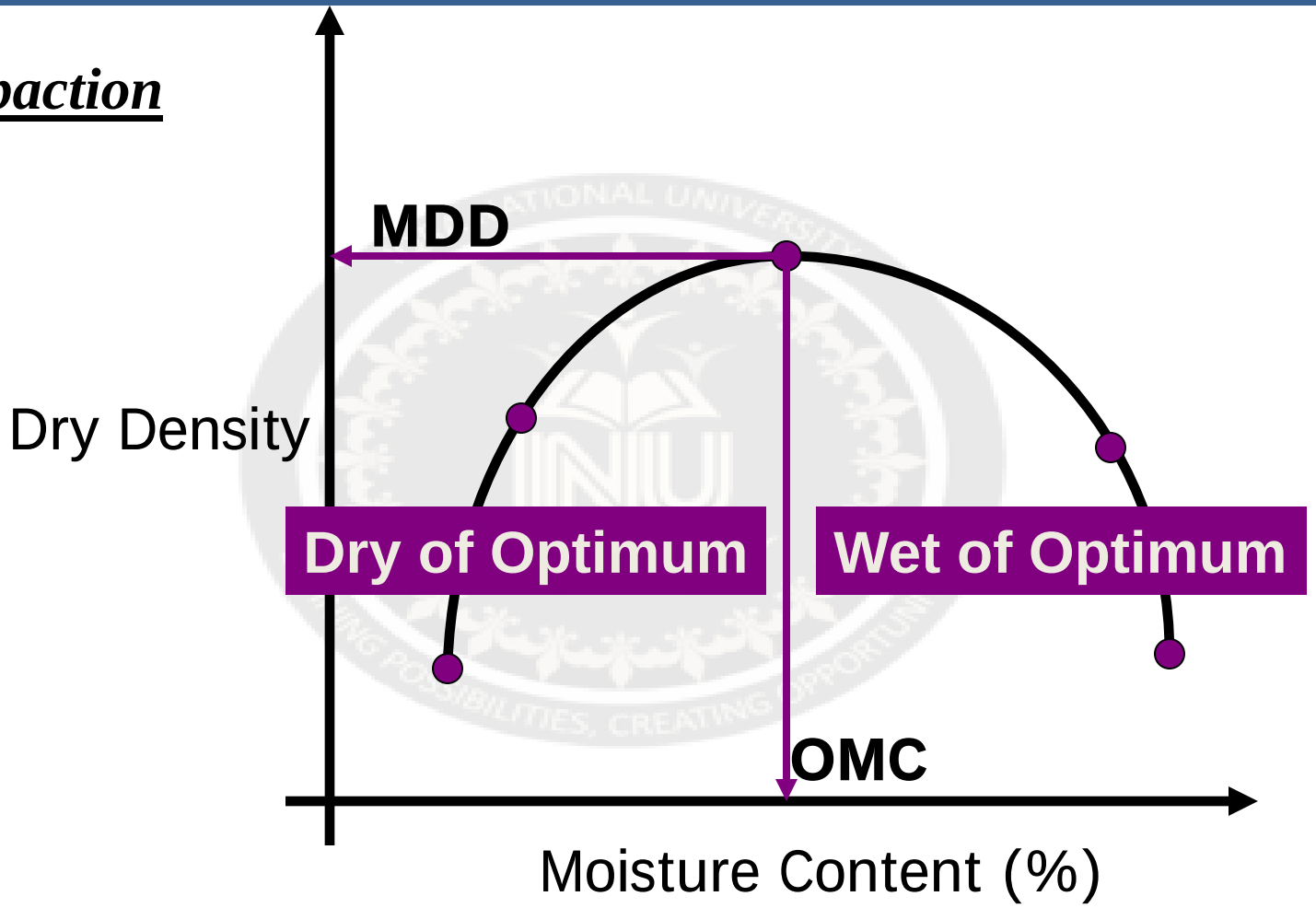
## Comparison-Summary

| Standard Proctor Test | Modified Proctor Test |
| --- | --- |
| • Mold size: 1/30 $ft^3$ | • Mold size: 1/30 $ft^3$ |
| • 12 in height of drop | • 18 in height of drop |
| • 5.5 lb hammer | • 10 lb hammer |
| • 3 layers | • 5 layers |
| • 25 blows/layer | • 25 blows/layer |
| • Energy 12,375 $ft \cdot lb/ft^3$ | • Energy 56,250 $ft \cdot lb/ft^3$ |



# Subgrade Construction

- ***Compaction***



# Base And Subbase

# Subbase

- A subbase is **layer** of material **between base and subgrade**. Sometimes a **granular material** under a **rigid pavement** is called a subbase.
- Subbase may consist of select materials, such as **natural gravels**, that are stable but that *have characteristics which make them not completely suitable as base course*. They may also be of stabilized soil/ borrow material

# Subbase

- The **purpose** of a subbase is to permit the building of relatively **thick pavements at low cost**. Thus , the quality of subbase can vary within wide limits, as long as the thickness design criteria are fulfilled

# Base Course

- A base course is defined as a layer of granular material which lies immediately below the wearing surface of a pavement.
- **Purpose of base and subbase**
- Base and subbase courses under flexible pavements are primarily to **increase the load supporting capacity** by distributing the load through a finite thickness of pavement this will reduce shear and consolidation deformation in the subgrade.

# Construction of Base Coarse

- ***Macadam Bases-History***
- The concept of water bound macadam road was suggested by **John Macadam,** who was a **Scottish engineer**.
- The road whose wearing course consists of clean crushed aggregates, mechanically interlocked by rolling and bound together with filler material and water laid on a well compacted base course, is called water bound macadam (W.B.M) road.

# Construction of Base Course

- ***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.

# Water Bound Macadam

- 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.

# Water Bound Macadam

- The strength of a water-bound macadam course is thus
  - Primarily due to the thorough **mechanical interlock** in the aggregate particles.
  - **Cohesion** between the aggregate particles due to the **cementitious film** of soil-moisture binder.
- The water-bound macadam is constructed by spreading loose metal which gives a consolidated thickness of 75 mm-100 mm.

# 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.
- The aggregate is generally crusher-run, and includes fines also. Because of the close grading, the course will have good interlock with excellent density.

# 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.

# Water Bound vs. Wet Mix Macadam

- 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.

# Surface Course

# Surface Course

- ***BITUMEN***
- A class of black or dark-colored (solid, semi-solid or viscous) cementitious substances, natural or manufactured, composed principally of high molecular weight hydrocarbons found in Asphalts, Tars, Pitches, and Asphaltites are typical.
- ***ASPHALT***
- A dark brown to black cementitious material in which the predominating constituents are bitumens which occur in nature or are obtained in fractional **distillation of petroleum** (crude oil) alongwith certain mineral matter.
- In American Terminology
- Both Asphalt and Bitumen are same and are “ASPHALT”

# Asphalt vs Bitumen

- In some literature Bitumen is actually the liquid binder that holds asphalt together.
- Asphalt is generally used as a term to refer to the combination of bitumen and gravel specifically for road construction.

# Asphalt Composition

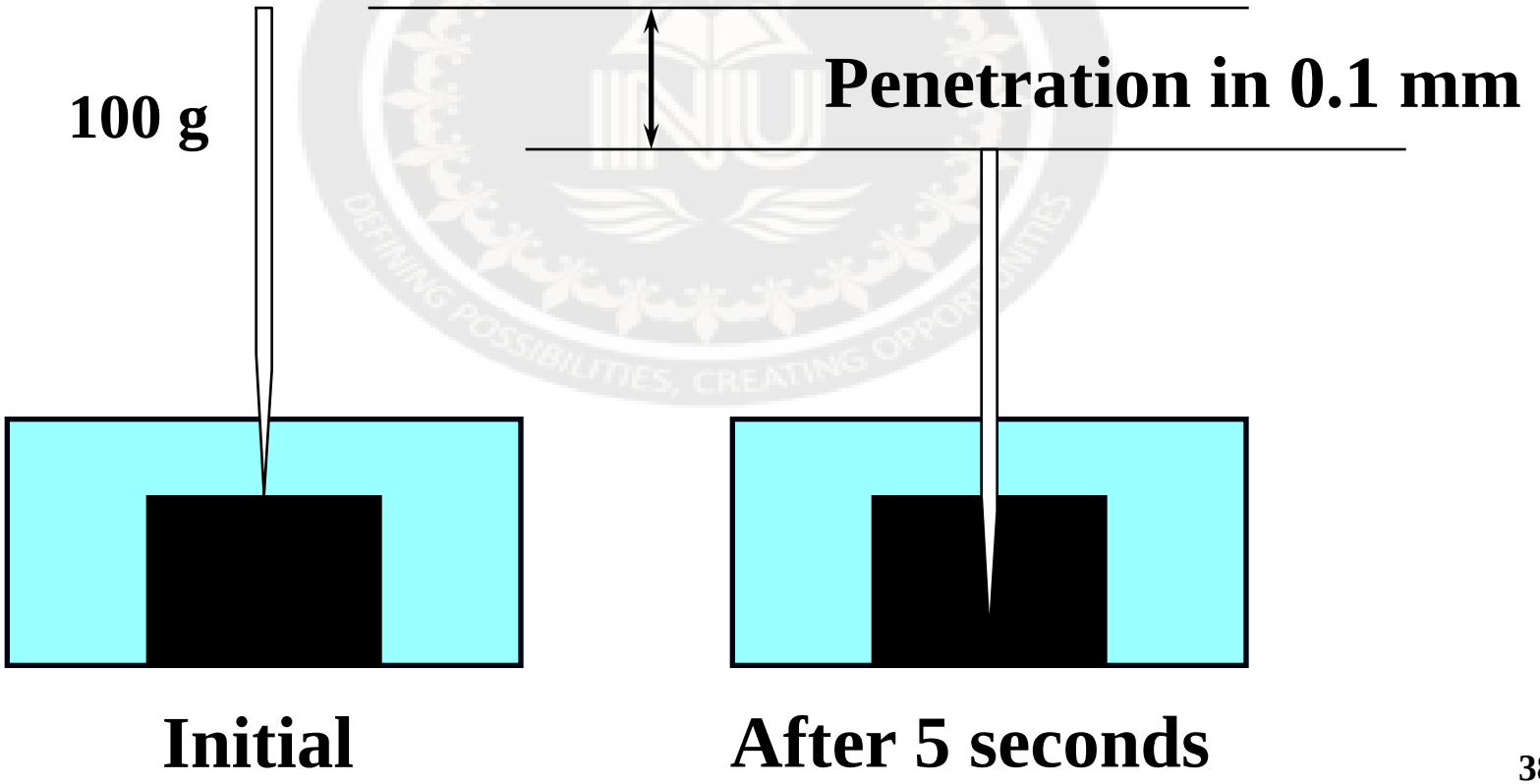
- Some generalizations can be made, however, with regard to the chemical composition of the semi-solid materials. According to Simpson they generally consist of
- Carbon (70-85%)
- Hydrogen (7-12%)
- Nitrogen (0-1%)
- Sulfur (1-7%)
- Oxygen (0-5%)
- and small amounts of metals either dispersed in the form of oxides and salts or in metal containing organic compounds

# Asphalt Types

- ***Asphalt Cement***
- A fluxed or unfluxed asphalt specially prepared as to quality and consistency for direct use in the manufacture of **bituminous pavements**, and having a penetration between 5 and 300.
- ***Bituminous Emulsions***
- a suspension of **minute globules of bituminous material in water** or in an aqueous solution
- a suspension of minute globules of water or of an aqueous solution in a liquid bituminous material.
- ***Cut-Back Products***
- Petroleum or Tar residuum which have been blended with distillates

# Penetration Test

- Sewing machine needle
- Specified load, time, temperature



# Penetration Test

- Measure the penetration of a standard needle into the asphalt binder sample under the following conditions:
- *Load = 100 grams*
- *Temperature = 25° C (77° F)*
- *Time = 5 seconds*
- The depth of penetration is measured in units of 0.1 mm and reported in penetration units (e.g., if the needle penetrates 8 mm, the asphalt penetration number is 80).

# Penetration Test

- Five Grades
  - 40 - 50
  - 60 - 70
  - 85 - 100
  - 120 - 150
  - 200 - 300


Q
A
Answer