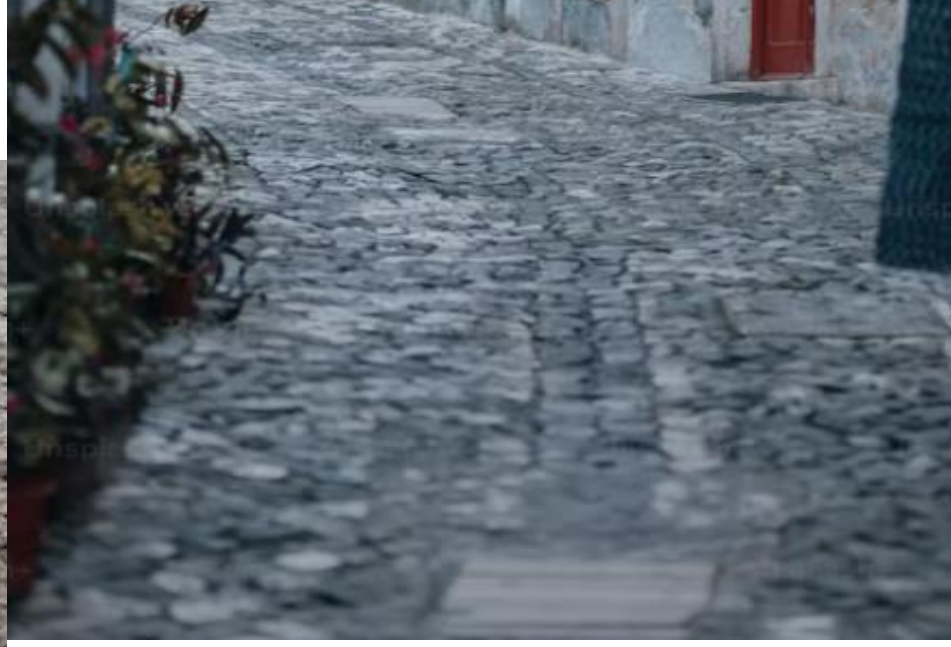
EWC 351

Transportation Engineering

LEC 10_ Pavement_Types, layers,

Pavement









Highway Pavement

What is a pavement

- A **multi-layer** system that distributes the vehicular loads over a larger area. Or
- HW pavement is a **structures consisting of superimposed layers** of selected and processed materials whose primary function is to distribute the **applied load** to subgrade. Or
- Structures which separates the tires of vehicles from under lying foundation.

Function of Pavement

- A highway pavement is designed to support the wheel loads imposed on it from traffic moving over it.
- Additional stresses are also imposed by changes in the temperature of environment.
- Pavement should be strong enough to resists the stresses imposed on it and should be thick enough to distribute the external loads on the subgrade.

Desirable Characteristics of Pavement

- It should be sufficiently thick to distribute the loads and stress to a safe value on the subgrade soil.
- It should be structurally sound enough to withstand the stresses imposed on it.
- It should provide a reasonably hard wearing surface, so that the abrasive action of wheels does not damage the surface.
- It should be dust free so that traffic safety is not impaired.
- Its riding quality should be good.

Desirable Characteristics of Pavement

- It should be smooth enough to provide comfort to the road users at the high speeds at which modern vehicles are driven.
- The surface of the pavement should develop as low a friction as possible.
- The surface of the pavement should have adequate roughness to prevent skidding of vehicles.
- The surface should not produce excessive level of sound.
- The surface should be impervious so that water does not penetrate the pavement.
- The pavement should have long life and low maintenance cost.

History

Footways

Tracks in jungle

1st hard surface in Mesopotomia---3500 BC

Romans 0-300 BC UK Mcadam & Telford REF2

WW 1 & 2

France P.M Treassage

Brick pavement USA

Wood block Europe, Austalia

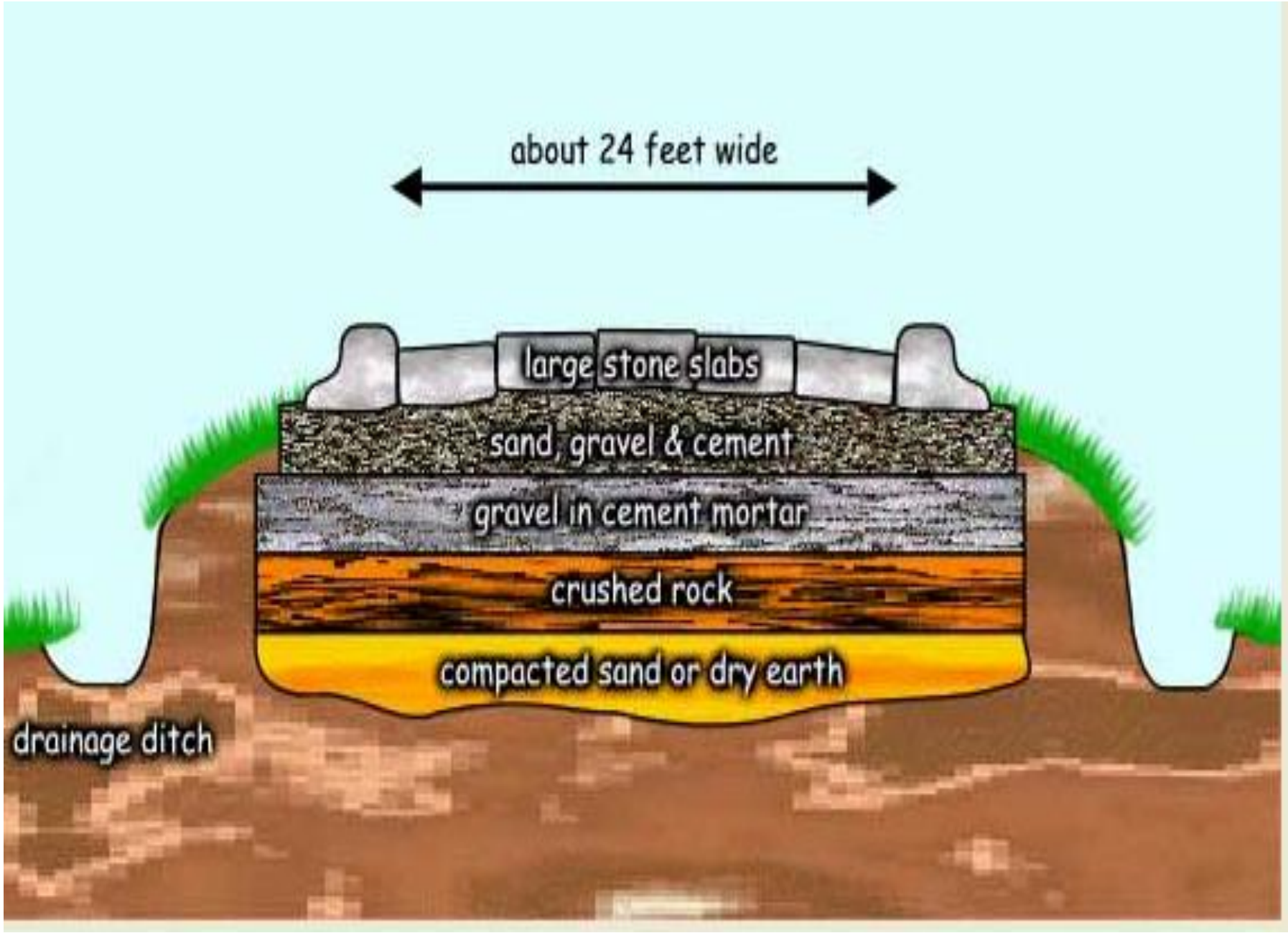
Asphalt Paris (1858), UK (1870), USA (1873)

Concrete Pavement Scotland 1865 USA 1909

Roman Road

Roman Roads

- It is suggested that the Romans took up the practice of a military road system from the Carthaginians. It is estimated that the Romans built about 87,000 km of roads within their empire (about equal to the length of the U.S. Interstate system).
  - Since the primary purpose of these roads was for foot soldiers, the roads were straight, but virtually without regard to grade. They generated high noise levels, were rough and labor intensive (slave and "statue" labor often used).


about 24 feet wide
large stone slabs
sand, gravel & cement
gravel in cement mortar
crushed rock
compacted sand or dry earth
drainage ditch

Roman Road



Types of Pvt

03 types

Flexible Pvt : Layered sys (different layers & overview HMA p-10-22) (HMA, AC, High Type Bit)

Rigid Pvt : Load from flexural str (CC, Conc)

Composite/ Semi-Rigid : Consists of HMA and PCC

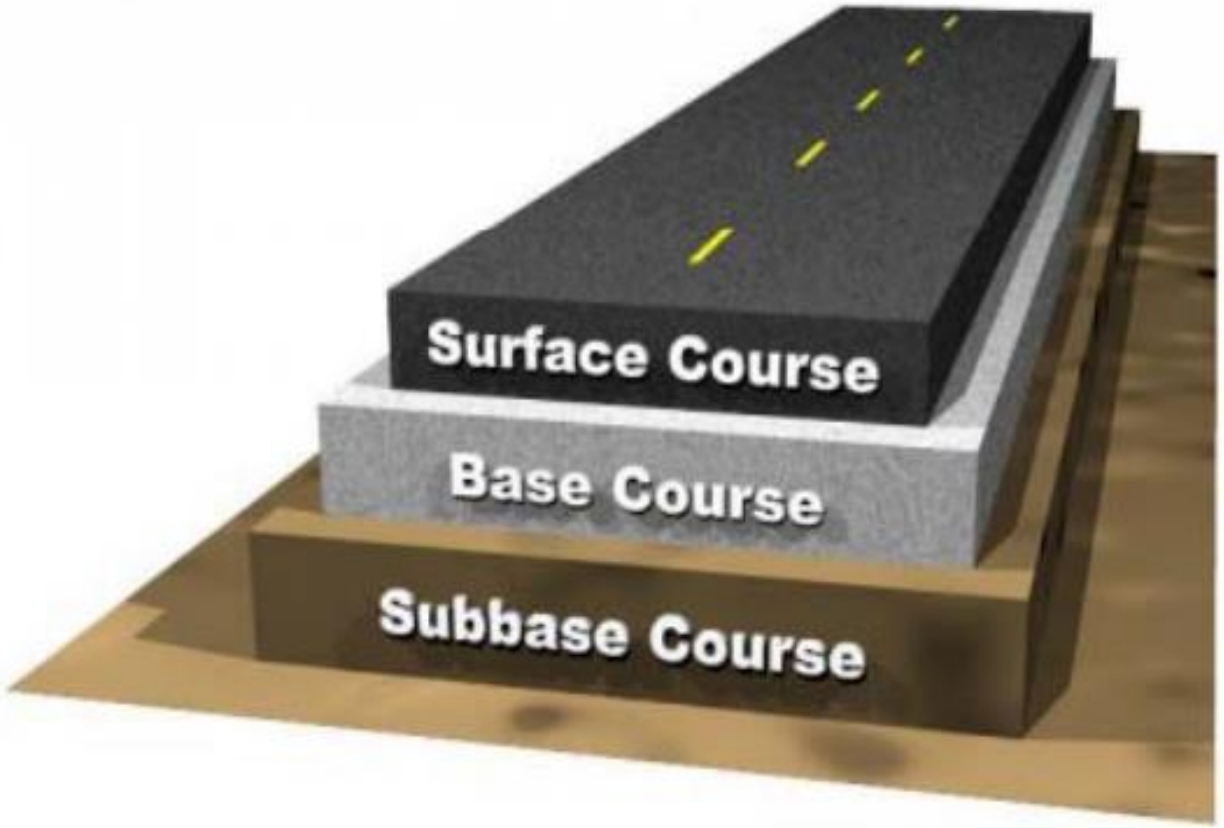
Pavement Types

Pavement Type









Basic Structural Elements of Flexible Pavement

Washington, D.C., with imported asphalt from Trinidad Lake. As of 2001 (FHWA, 2001), there are about 2.5 million miles of paved roads in the United States, of which 94% are asphalt surfaced.

Flexible Pavement

- Hot mix Asphaltic (HMA) pavements are classified as "flexible" pavements because the total pavement structure deflects, or flexes, under loading.
- A flexible pavement structure is typically composed of several layers of material.
- Each layer receives the loads from the above layer, spreads them out, then passes on these loads to the next layer below.
- Thus, the further down in the pavement structure a particular layer is, the less load (in terms of force per area) it must carry.

Flexible Pvt

- Flexible pavements are those which are surfaced with bituminous (asphalt) materials.
- May be either surface treatment like BST for low volume road, Hot mixed Asphalt (HMA) higher Volm.
- Depending on the temperature at which it is applied, asphalt is categorized as **hot mix asphalt (HMA)**, warm mix asphalt, or **cold mix asphalt**
- A flexible pavement is structure that maintains intimate contact with and distribute load to the sub grade and depends on aggregate interlock, particle friction and cohesion for stability.

Flexible Pavement

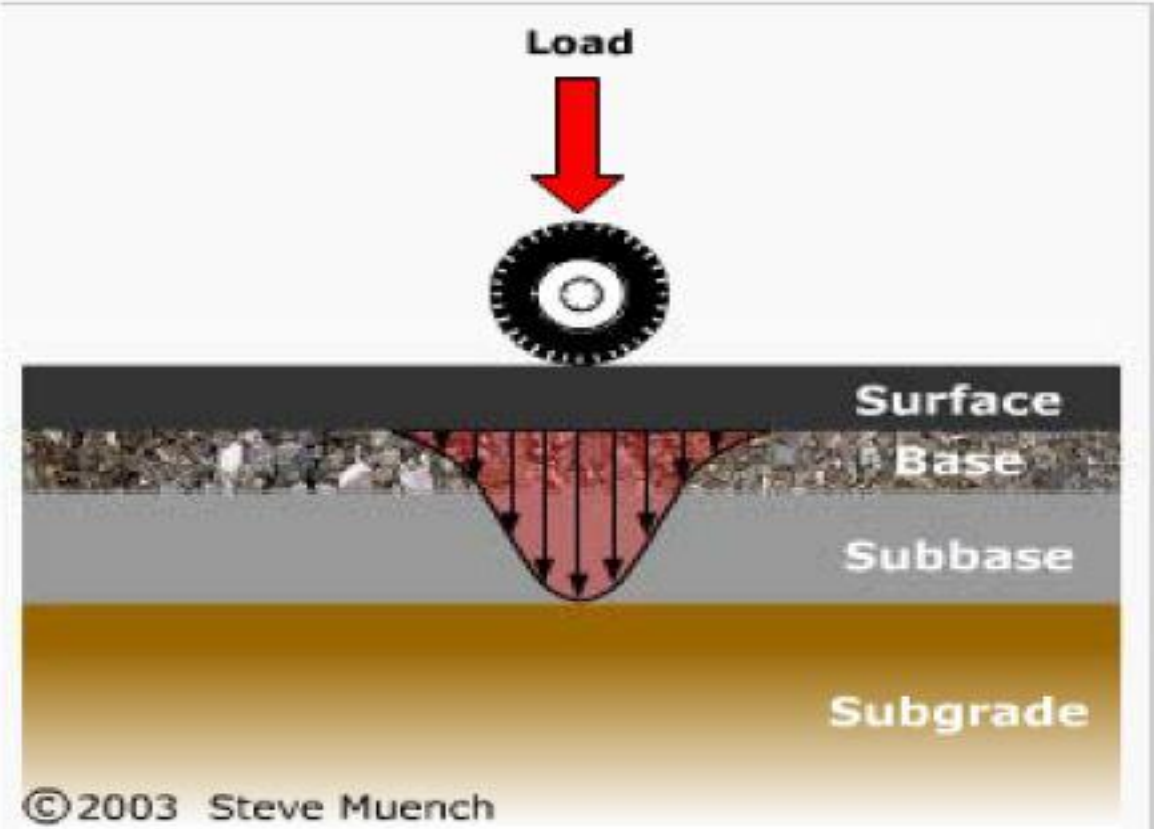


Figure 1. Flexible pavement load distribution.

Load distribution at Surface course

Flexible Pavement

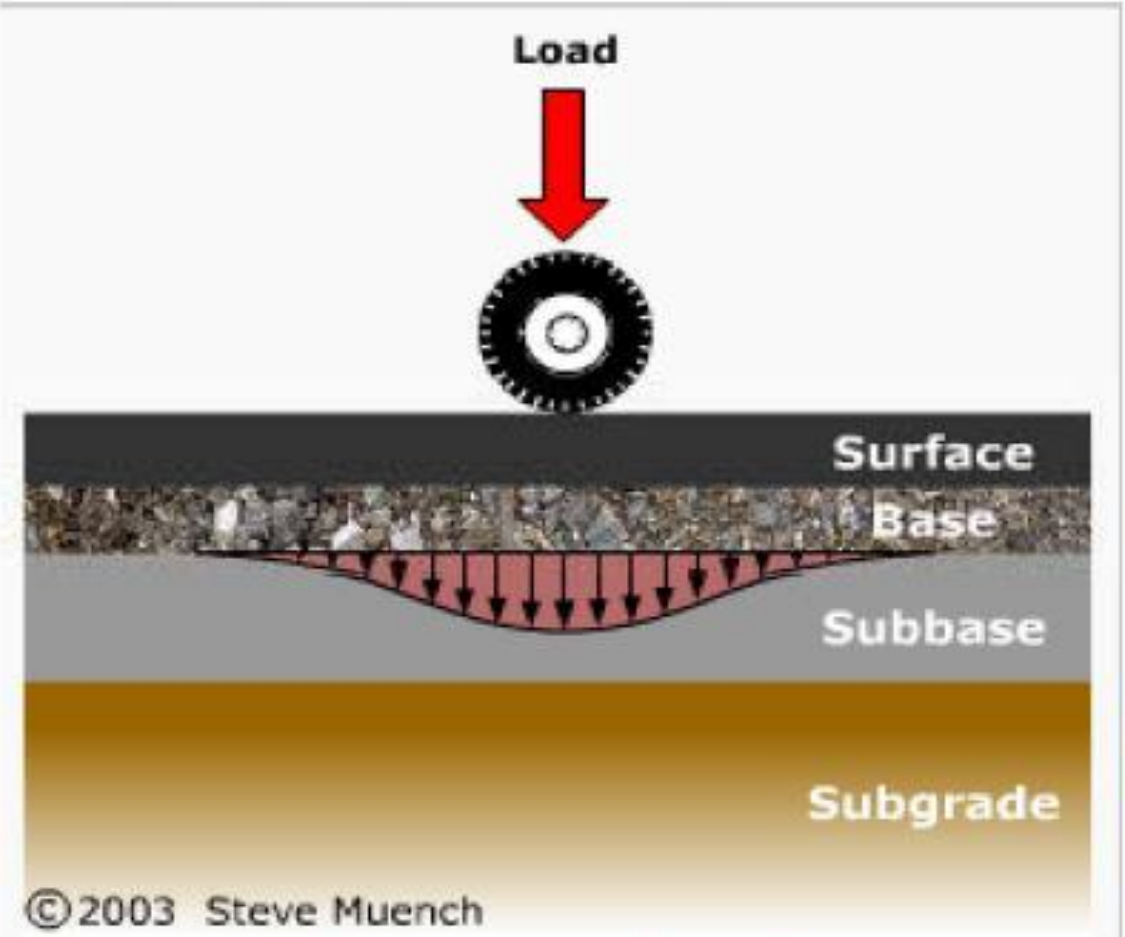


Figure 1. Flexible pavement load distribution.

Load distribution at Base course

Flexible Pavement

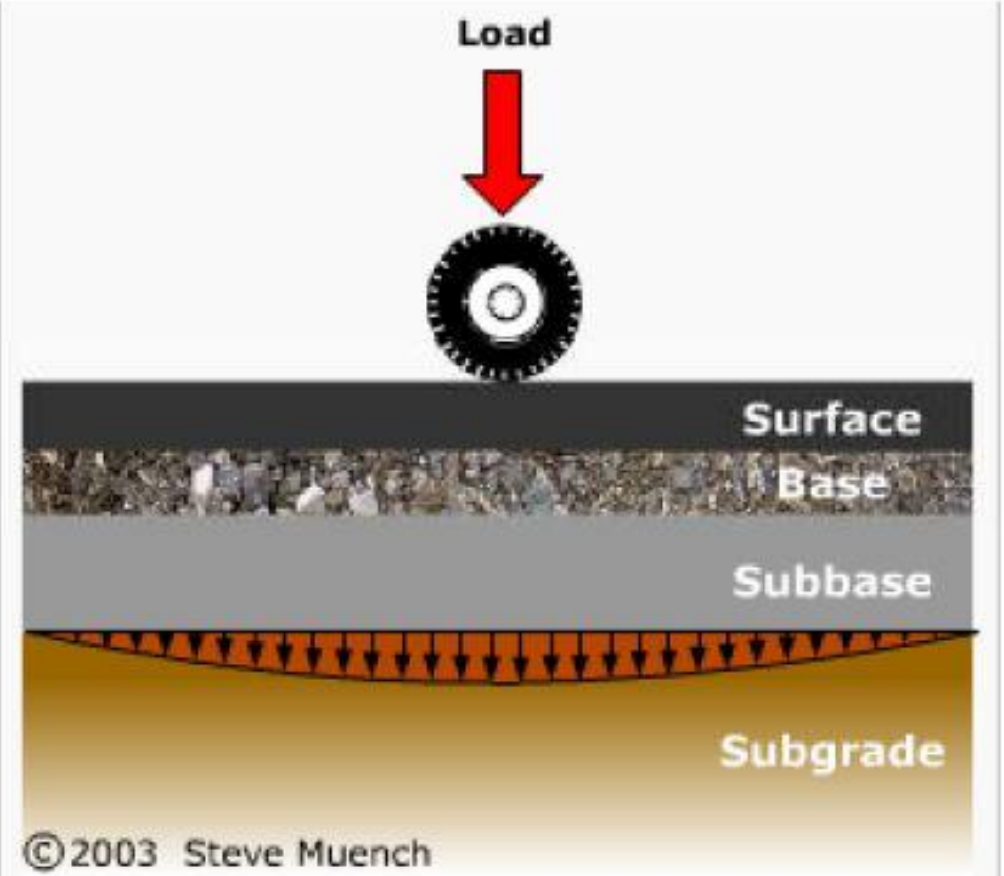


Figure 1. Flexible pavement load distribution.

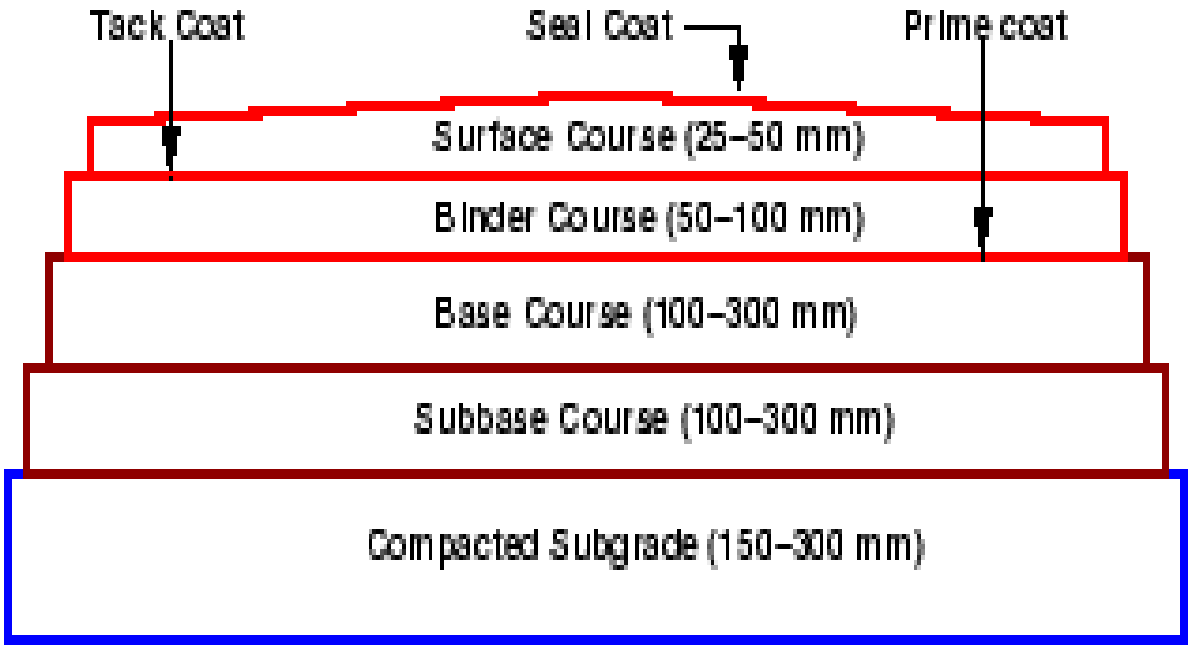
Load distribution at Sub-Base course

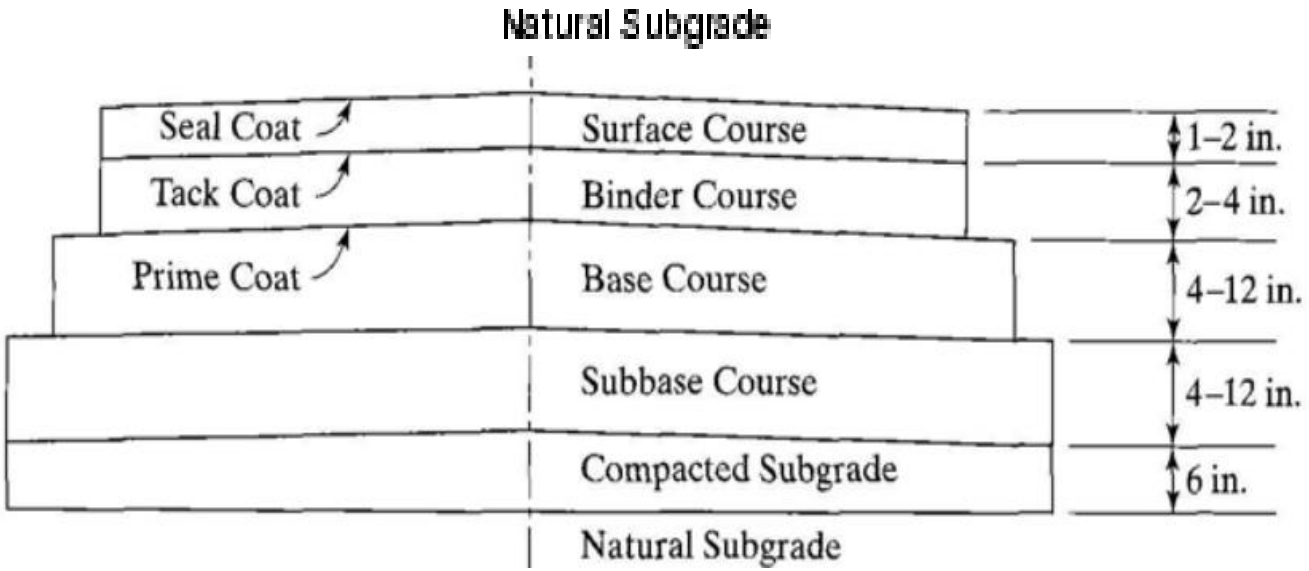
Flexible Pvt

Types:

- Conventional pavement
- Contained Rock asphalt mat (CRAM)
- Full Depth Asphalt Pvt.

Conventional pavement





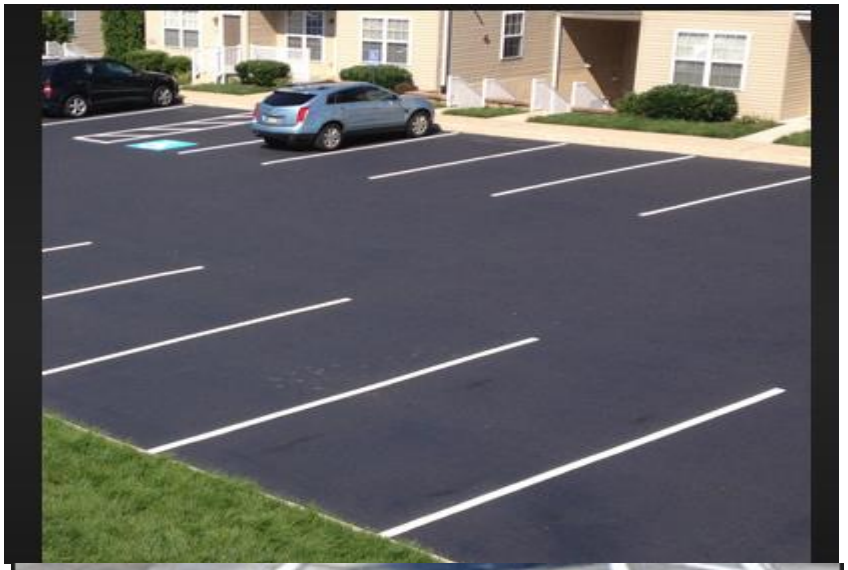
Conventional pavement

Typical layers of a conventional flexible pavement includes **seal coat, surface course, tack coat, binder course, prime coat, base course, sub-base course, compacted sub-grade, and natural sub-grade (Also pg 9--/21 of huang)**

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Seal Coat

Seal Coat: Seal coat is a thin surface treatment used to water-proof the surface and to provide skid resistance.









Conventional pavement

Tack Coat:

- Tack coat is a very light application of asphalt, usually asphalt emulsion diluted with water. It provides proper bonding between two layer of binder course and must be thin, uniformly cover the entire surface, and set very fast.

Prime Coat:

- Prime coat is an application of low viscous cutback bitumen to an **absorbent surface** **like granular bases on which binder layer is placed**. It provides bonding between two layers. Unlike tack coat, prime coat penetrates into the layer below, plugs the voids, and forms a water tight surface.

Prime vs Tack

A prime coat is an application of low-viscosity cutback asphalt to an absorbent surface, such as an untreated granular base on which an asphalt layer will be placed. Its purpose is to bind the granular base to the asphalt layer. The difference between a tack coat and a prime coat is that a tack coat does not require the penetration of asphalt into the underlying layer, whereas a prime coat penetrates into the underlying layer, plugs the voids, and forms a watertight surface. Although the type and quantity of asphalt used are quite different, both are spray applications.

Surface Course

The surface course, also known as the **wearing course**, is the topmost layer of a flexible pavement structure. It directly interacts with vehicular loads and environmental factors, making it crucial for the pavement's performance and longevity

Functions of the Surface Course

- **Load Distribution**: Evenly spreads traffic loads to prevent localized stress concentrations.
- **Skid Resistance**: Provides a textured surface to enhance vehicle traction and reduce accidents.
- **Waterproofing**: Prevents water infiltration into underlying layers, protecting the pavement structure.
- **Durability**: Resists wear and tear from traffic, weather, and environmental conditions.

Materials Used in Surface Course

1. **Hot Mix Asphalt (HMA):** A blend of bitumen and aggregates, HMA is the most commonly used material for surface courses. It offers good durability, flexibility, and resistance to deformation under traffic loads. The mix design can be adjusted to suit specific traffic conditions and environmental factors.

2. **Stone Mastic Asphalt (SMA)**
   SMA is **a gap-graded** asphalt mix with a high content of coarse aggregates, providing a stone-on-stone contact structure. This design enhances resistance to permanent deformation and rutting, making it suitable for heavily trafficked roads.

Materials Used in Surface Course

3 Polymer-Modified Asphalt

This type of asphalt includes **polymers to enhance** the binder's properties, improving elasticity, durability, and resistance to deformation. It is beneficial in areas with extreme temperatures or heavy traffic loads.

4. Recycled Asphalt Pavement (RAP)

RAP involves reusing existing asphalt materials, reducing environmental impact and material costs. When properly processed, RAP can provide comparable performance to new materials.

5. **Open-Graded Friction Course (OGFC)**

OGFC is a **porous asphalt mix** that allows water to drain through, reducing **hydroplaning and improving skid resistance**. It is particularly effective in wet conditions and is often used in regions with high rainfall.

Conventional pavement

Binder course

- This layer provides the bulk of the asphalt concrete structure. It's chief purpose is to distribute load to the base course The binder course generally consists of aggregates having less asphalt and doesn't require quality as high as the surface course, so replacing a part of the surface course by the binder course results in more economical design.

the asphalt layer below the surface course. There are two reasons that a binder course is used in addition to the surface course. First, the HMA is too thick to be compacted in one layer, so it must be placed in two layers. Second, the binder course generally consists of larger aggregates and less asphalt and does not require as high a quality as the surface course, so replacing a part of the surface course by the binder course results in a more economical design. If the binder course is more than 3 in. (76 mm), it is generally placed in two layers.

Base course

The base course is the layer of material immediately beneath the surface of binder course and it provides additional load distribution and contributes to the sub-surface drainage.

Composition of the Base Course

The base course is typically constructed using durable materials that ensure strength and stability:

- **Crushed Stone or Gravel**: These materials offer excellent interlocking properties, enhancing the layer's strength and load-bearing capacity.
- **Stabilized Materials**: In some cases, the base course may be stabilized using additives like cement, lime, or asphalt to improve its durability and resistance to moisture and frost action

Functions Base Course

- **Load Distribution**: It evenly spreads the loads from the **surface layer to the underlying layer** preventing excessive stress and potential failure.
- **Structural Support**: Provides a stable foundation for the surface layer, ensuring the pavement's integrity under traffic loads.
- **Drainage**: Facilitates water movement through the pavement structure, reducing the risk of water accumulation and subsequent damage.
- **Frost Resistance**: In colder climates, the base course helps prevent frost heave by allowing water to drain away, minimizing the risk of pavement damage due to freezing.

Conventional pavement

Sub-Base course

- The subbase generally consists of lower quality materials than the base course but better than the subgrade soils.
- A subbase course is not always needed or used. For example, a pavement constructed over a high quality, stiff subgrade may not need the additional features offered by a subbase course so it may be omitted from design.
- However, a pavement constructed over a low quality soil such as a swelling clay may require the additional load distribution characteristic that a subbase course can offer.
- In this scenario the subbase course may consist of high quality fill used to replace poor quality subgrade.

Conventional pavement

Sub-Base course

The subbase course is between the base course and the subgrade. It functions primarily as structural support but it can also:

- Minimize the intrusion of fines from the subgrade into the pavement structure.
- Improve drainage.
- Minimize frost action damage.
- Provide a working platform for construction.

Conventional pavement

Sub-grade

The top soil or sub-grade is a layer of natural soil prepared to receive the stresses from the layers above. It is essential that at no time soil sub-grade is overstressed. It should be compacted to the desirable density, near the optimum moisture content

Subgrade The top 6 in. (152 mm) of subgrade should be scarified and compacted to the desirable density near the optimum moisture content. This compacted subgrade may be the in-situ soil or a layer of selected material.

27 jul

CRAM

- **Contained rock asphalt mats** are constructed by placing dense/open graded aggregate layers in between two asphalt layers. Modified dense graded asphalt concrete is placed above the sub-grade will significantly reduce the vertical compressive strain on soil sub-grade and protect from surface water.
-

Full Depth Asphalt

Full-Depth Asphalt Pavements Full-depth asphalt pavements are constructed by placing one or more layers of HMA directly on the subgrade or improved subgrade. This concept was conceived by the Asphalt Institute in 1960 and is generally considered the most cost-effective and dependable type of asphalt pavement for heavy traffic. This type of construction is quite popular in areas where local materials are not available. It is more convenient to purchase only one material, i.e., HMA, rather than several materials from different sources, thus minimizing the administration and equipment costs.

Figure 1.3 shows the typical cross section for a full-depth asphalt pavement. The asphalt base course in the full-depth construction is the same as the binder course in conventional pavement. As with conventional pavement, a tack coat must be applied between two asphalt layers to bind them together.

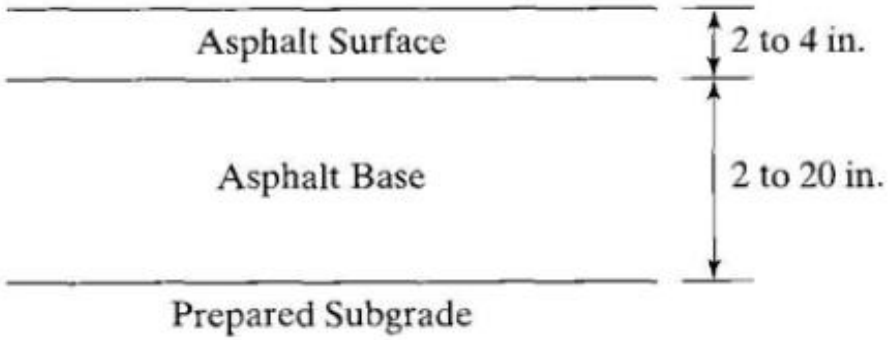


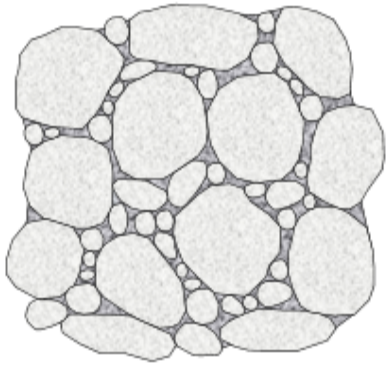
FIGURE 1.3

Typical cross-section of a full-depth asphalt pavement (1 in. = 25.4 mm).

Types of Pvt (Gradation)

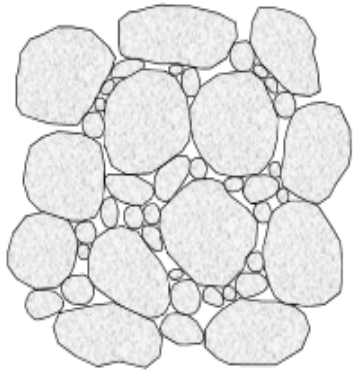
- **Dense Graded**: Well graded HMA for general use
- **Open Graded**: Used as drainage layer under dense graded. Water permaeable, Uses crashed stone or gravel.
- **Gap graded** or Stone matrix/mastic asphalt (SMA): Gap graded HMA to reduce rutting.
- **Uniformly Graded**:
- Details gradation

Dense-Graded Aggregate



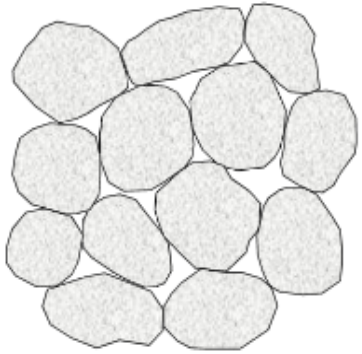
Wide range of sizes
Grain-to-grain contact
Low void content
Low permeability
High stability
Difficult to compact

Open-Graded Aggregate



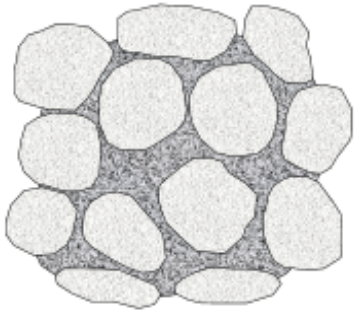
Few fine particles
Grain-to-grain contact
High void content
High permeability
High stability
Difficult to compact

Uniformly Graded Aggregate



Narrow range of sizes
Grain-to-grain contact
High void content
High permeability
Low stability
Difficult to compact

Gap-Graded Aggregate



Missing middle sizes
No grain-to-grain contact
Moderate void content
Moderate permeability
Low stability
Easy to compact

Discussion