LECTURE 7

HIGHWAY PAVING MATERIALS

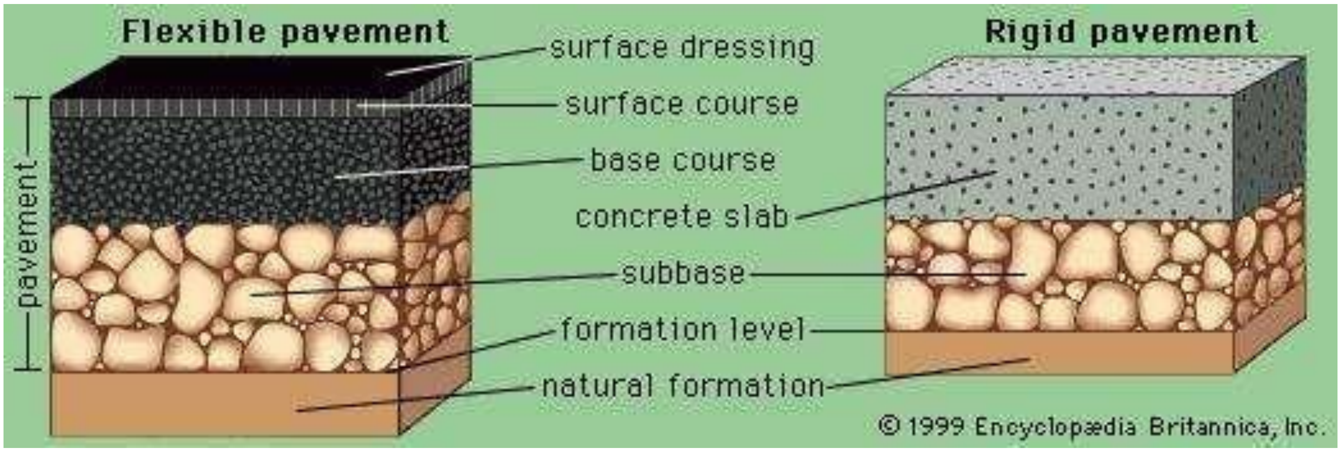
Types of Pavements:

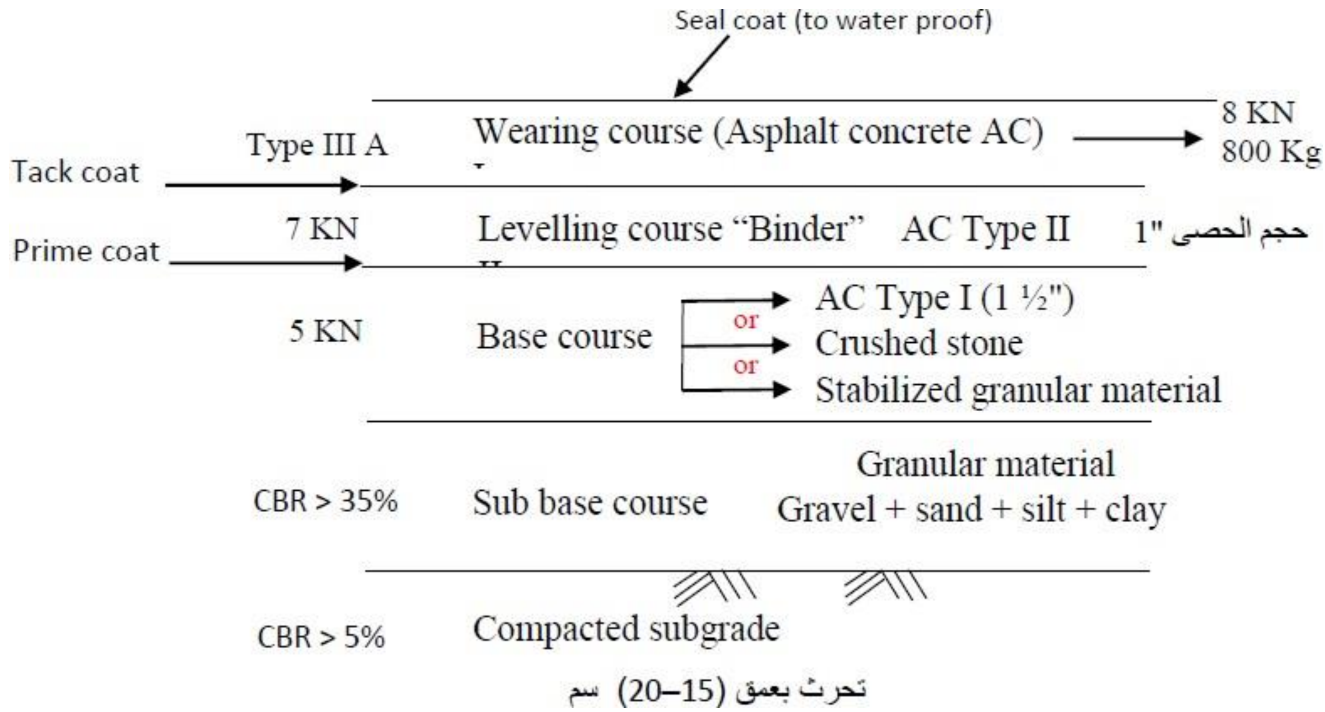
- **Rigid pavement (Concrete Slab)**

The wearing surface of a rigid pavement is usually constructed of Portland cement concrete such that it acts like a beam over any irregularities in the underlying supporting material.

- **Flexible pavement (Asphalt Concrete)**

The wearing surface of **flexible pavements** is usually constructed of bituminous materials such that they remain in contact with the underlying material even when minor irregularities occur. Flexible pavements usually consist of a bituminous surface over a layer of granular material and a layer of a suitable mixture of coarse and fine materials. Traffic loads are transferred by the wearing surface to the underlying supporting materials through the interlocking of aggregate, the frictional effect of granular materials, and cohesion of fine materials.





Typical Layers of a Flexible 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.

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

Tack coat: is a very light application of asphalt, usually asphalt emulsion diluted with water. It provides proper bonding between pavement layers, improve pavement strength and must be thin, uniformly cover the entire surface and set very fast.

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 layer below and protect the underlying layers from wet weather by providing a waterproofing layer.

Cutback Bitumen (Liquid Bitumen) is Bitumen that is dissolved in a solvent. Typical solvents include gasoline and kerosene.

Surface course: is a layer directly in contact with traffic loads and generally contains superior quality materials. They are usually constructed with dense graded asphalt concrete (AC). The functions and requirements of this layer are:

- It provides characteristics such as friction, smoothness, drainage. Also, it will prevent the entrance of excessive quantities of surface water into the underlying base, sub-base and sub-grade.
- It must be tough to resist the distortion under traffic and provide a smooth and skid-resistant riding surface.
- It must be waterproof to protect the entire base and sub-grade from the weakening effect of water.

Binder course: This layer provides the bulk of the asphalt concrete structure. Its 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.

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. It may be composed of crushed stone and other untreated or stabilized materials.

Sub-base course: The sub-base course is the layer of material beneath the base course and the primary functions are to provide structural support, improve drainage and to reduce the intrusion of fines from the sub-grade in the pavement structure.

A sub-base course is not always needed or used. For example, a pavement constructed over a high quality, stiff sub-grade may not need the additional features offered by a sub-base course. In such situations, sub-base course may not be provided.

Sub-grade: it is a layer of natural soil prepared to receive the stresses from the layers above. It should be compacted to the desirable density, near the optimum moisture content.

Asphalt Concrete:

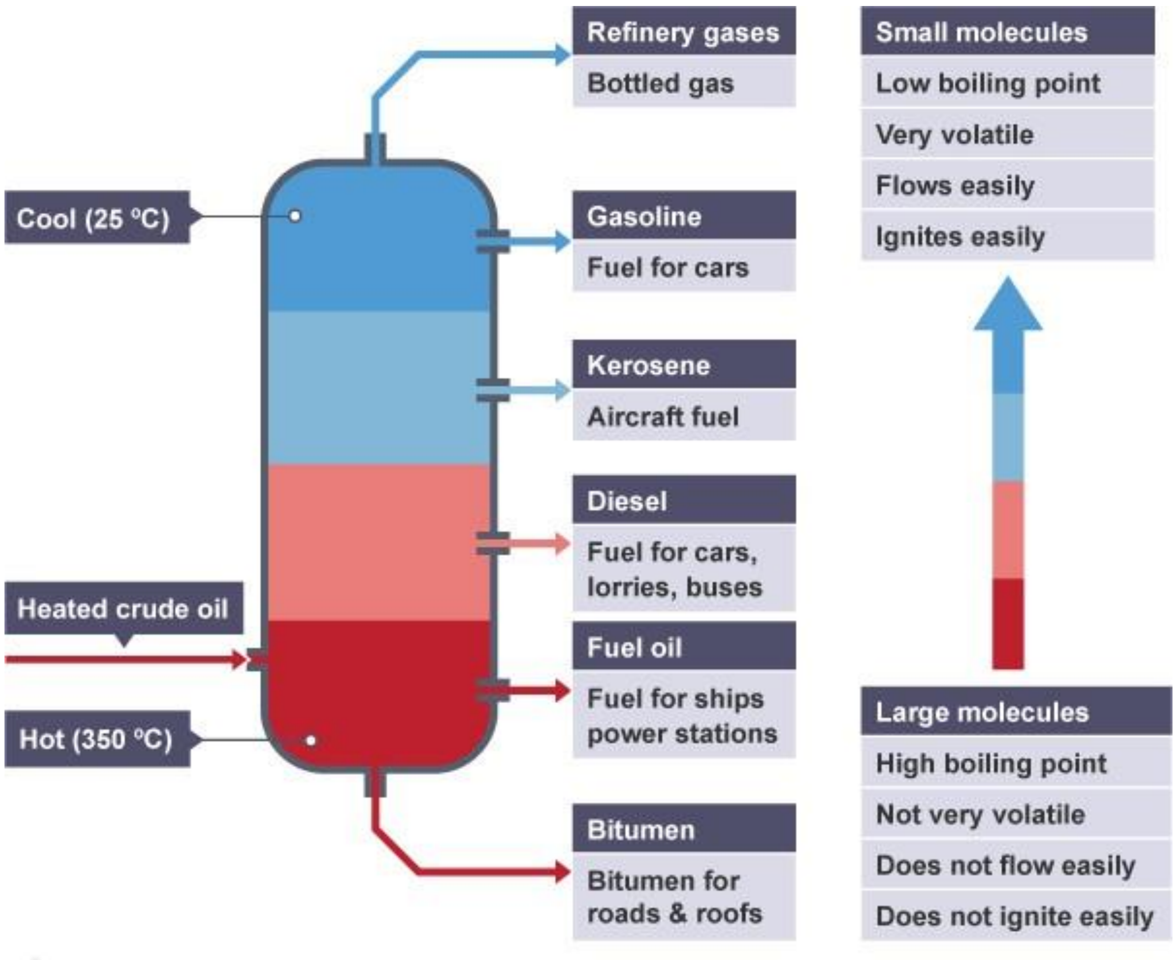
- Crushed gravel (Coarse aggregate): retained on sieve No. 4
- Sand (Fine aggregate): pass sieve No. 4 and retained on sieve No. 200
- Mineral filler: مادة مالئه للفراغات Non plastic material that pass sieve No. 200
- Additives (optional)
- Asphalt cement

Bitumen

Properties:

- Cementitious material
- Complex mixture of hydrocarbon. $C_{89} H_{104} S_3 N_2 O_2$.

- Liquid, semi solid or solid
- Completely soluble in (SC_2) ثنائي كبريتيد الكربون or (CCL_4) رباعي كلوريد الكربون
- ***Asphalt cement***: produced by ***fractional distillation*** of crude oil.
- ***Tar:*** produced by destructive distillation of coal.



Asphalt Types:

- Asphalt cement: used for producing hot mix asphalt concrete for paving works. تسخن للحصول على تغطية كاملة للركام

Penetration grading's basic assumption is that the less viscous the asphalt, the deeper the needle will penetrate. This penetration depth is empirically correlated with asphalt binder performance. Therefore, asphalt binders with high penetration numbers (called "soft") are used for cold climates while asphalt binders with low penetration numbers (called "hard") are used for warm climates.

b* ***viscosity grading***:

AC 40 ← المفضل في العراق

20

10 * 100 → absolute viscosity at 60° C in unit of poise

5

2.5

AC 20 – 30 Hard

40 – 50 ← المفضل في الاستخدام بالعراق

50 – 60 ← يمكن استخدامها

60 – 70

85 – 100

150 – 200

200 – 300 Soft

200 → Penetration in units of 1/10 mm

Thus, AC-5 (viscosity is 500 ± 100 poise at 60° C (140° F)) is less viscous than AC-40 (viscosity is 4000 ± 800 poise at 60° C (140° F)).

c* ***performance grading***:

PG 70 – 10

max min

Pavement temperature

→ Softer grade → permanent deformation (rutting)

→ Harder grade → Low temperature cracking

Desirable Properties of Asphalt Cement

General Requirement	Test	Engineering Significance	Typical (local) requirement
1. Consistency (grading)	a. penetration (100gm, 5 sec, 25°C) b. Absolute viscosity @ 60°C	- Relative Hardness - Tendency to flow at max in service pavement temp	40 – 50 4000 ± 800 poise
2. Temperature susceptibility	a. Kinematic viscosity @ 135°C b. Softening point (Ring & ball)	- Resistance to flow at different temperature →Mixing temp →Compaction temp - Tendency to flow at elevated temp - Max heating temp	≥ 210 cst 52 - 60°C
3. Oxidative Aging (Hardening)	a. Thin – film oven test: (1/8", 163°C, 5 hrs)	- Effect of heat & air on the change of material properties. * Loss in weight * Residual penetration $= \frac{pen\ after\ test}{original\ pen}$	≤ 0.8% ≥ 0.55 (55%)
4. Internal compatibility (Homogeneity)	a. Ductility at 25°C	- Tensile property - Adhesive property	≥ 100 cm
5. Safety	a. Flash point	- Tendency to produce flammable	≥ 232°C
6. Calculation	a. specific gravity	- Mass ⇄ volume - Density – void analysis	1.01 – 1.05

* Absolute Viscosity: resistance to flow under pressure

$$poise = \frac{gm}{cm.sec} \text{ or } \frac{dyne.sec}{cm^2}$$

* Kinematic Viscosity: resistance to flow under gravity

$$Stock = \frac{cm^2}{sec.}, \quad c.st = \frac{1}{100} stock$$

$$\text{Kinematic Viscosity } (stock) = \frac{Absolute\ Viscosity}{Density\ (\frac{gm}{cm^3})}, \quad c.st = \frac{1}{100} stock$$

Max Asphalt cement heating temperature

Softening point (90 - 110°C)

→ Mixing temperature: temperature → kinematic viscosity (η) ≈ 170 ± 20 cst (140 - 150°C)

→ Compaction temperature: temperature → η = 280 ± 30 cst (130 - 140°C) Temp