

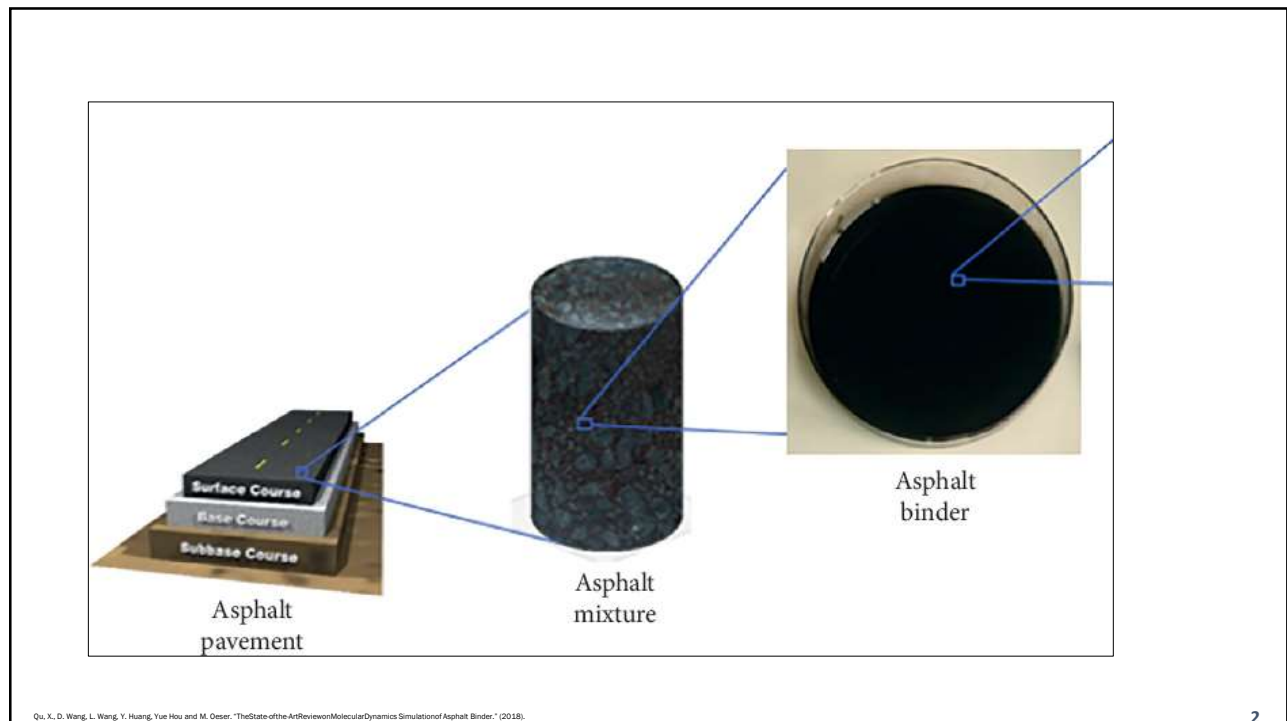
Pavement Materials & Design

Asphalt Materials

Getting to know Asphalt Materials

Dr. Hamza Alkuime

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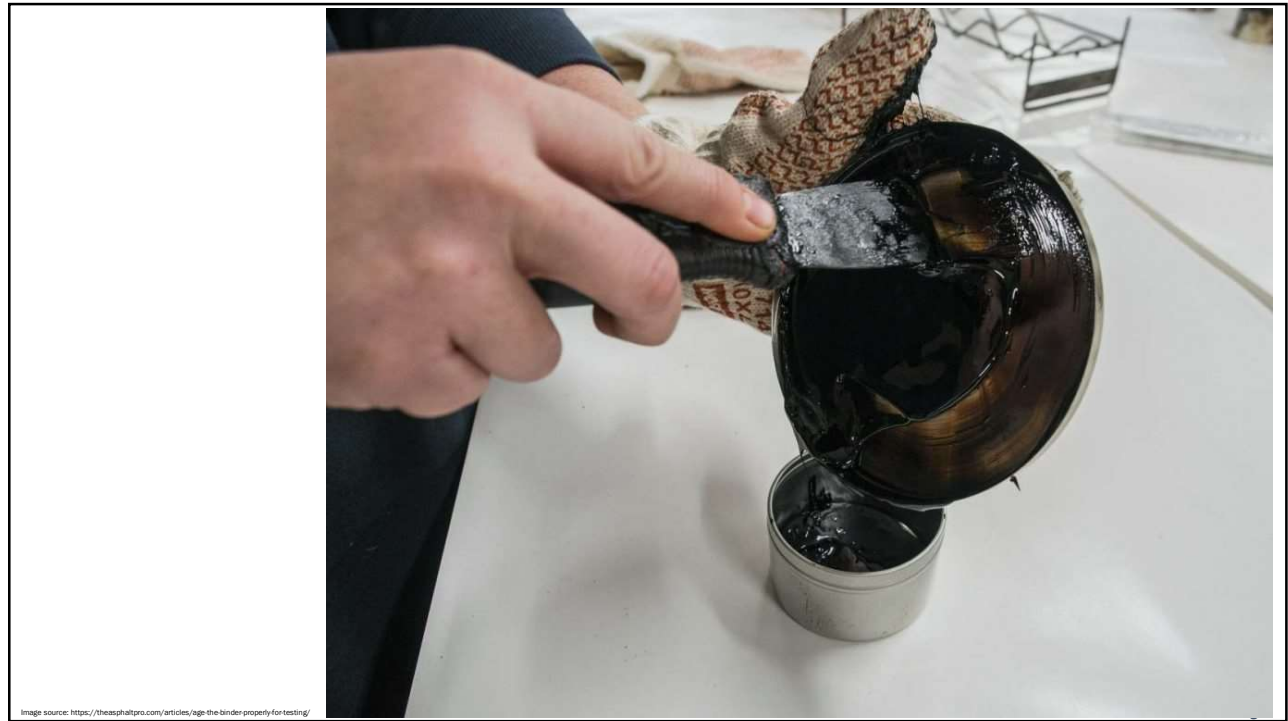


Image source: <https://theashaltpro.com/articles/age-the-binder-properly-for-testing/>

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Image source: <https://theashaltpro.com/articles/age-the-binder-properly-for-testing/>

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7

Pavement Materials & Design

Asphalt Materials

1.2 The History Of Asphalt

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8

The History of Asphalt

- ❑ Asphalt is well known and used **since ancient times**,
 - because it is the **oldest and widely accepted structural material**
- ❑ It is used since 6000 B.C.
 - As a **waterproofing and binder material** of great quality

9

9

The History of Asphalt

History

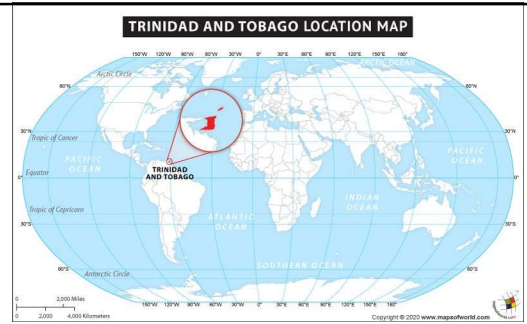
- ❑ The **Sumerians** used to use it in the prosperous shipbuilding industry
- ❑ The **Babylonians** used it as a binder in the mixture production for castle construction (Babel Tower).
- ❑ The **Egyptians** used asphalt to mummify the dead bodies and to waterproof tanks.
- ❑ Around 3000 B.C., the **Persians** also used asphalt for road construction.
- ❑ The **Greek** word **asphaltos** was used during Homeric times
 - ❖ which means a **stable or solid substance**.
- ❑ Afterwards, it was used by the **Romans** (**asphaltus**)
 - ❖ hence, the term *asphaltic*, or even its root, exists until now in all modern languages

10

10

The History of Asphalt

- ❑ Later on, around 13th to 14th century AD,
 - the largest surface deposits of natural asphalt in the world were discovered in **Trinidad island** (Lake Asphalt of Trinidad), as well as in the coasts of Venezuela.



Oron, A., Galili, E., Hadas, G. et al. Early Maritime Activity on the Dead Sea: asphalt Harvesting and the Possible Use of Reed Watercraft. *J Mari Arch* 10, 65–88 (2015). <https://doi.org/10.1007/s11457-015-9135-2>

11

11

Natural Asphalt



<https://theconstructor.org/building/asphalt-bitumen-tar-types-difference-comparison/17273/>

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12

Trinidad island



<https://www.youtube.com/watch?v=xuq3a0fuj8>

15

15

The History of Asphalt

- ❑ Until the beginning of the 20th century
 - *The asphalt or asphalt used was a natural product*
 - *The first natural deposits were found at the **Dead Sea (or Salt Sea)** where asphalt used to *emerge from the bottom of the sea, floated to the surface and discharged into the banks*
 - ❖ This was the reason why the ancient Greeks called this lake "Lake Asphaltites"*



Large asphalt mass floating on the Dead Sea in 1969 (Gideon Hadas)

Oron, A., Gallil, E., Hadas, G. et al. Early Maritime Activity on the Dead Sea: asphalt Harvesting and the Possible Use of Reed Watercraft. J Mari Arch 10, 65–88 (2015). <https://doi.org/10.1007/s11457-015-9135-2>

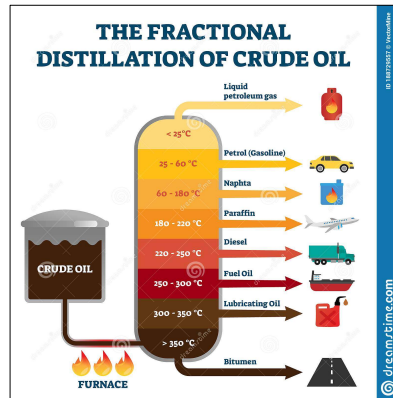
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16

The History of Asphalt

□ Apart from the natural asphalt

- ❖ there is also the 'artificial asphalt', which is a residue of fractional distillation of crude oil (petroleum oil)
- simply called asphalt or bitumen nowadays



17

17

Pavement Materials & Design

Asphalt Materials

Terminology Today

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27

Terminology Today

According to American specifications

- ❑ More often the term asphalt **is used**
- ❑ 'asphalt' or 'asphalt cement' is
 - ❖ 'a dark brown to black cement-like residuum obtained from the distillation of suitable crude oils'.
- ❑ Asphalt binder
 - ❖ An asphalt which may or may not contain an asphalt modifier
- ❑ Native asphalt is
 - ❖ Used instead of the term natural asphalt used in European standards.
 - ❖ The term native asphalt is defined as 'the asphalt occurring as such in nature'.



29

Terminology Today

According to European specifications

- ❑ Bitumen is
 - Virtually an involatile, adhesive and waterproofing material derived from crude petroleum or present in natural asphalt
 - Completely or almost completely soluble in toluene and very viscous or almost solid at ambient temperatures.
- ❑ Asphalt is
 - ❖ A mixture of mineral aggregate and bituminous binder
- ❑ Bituminous binder
 - is the adhesive material containing asphalt
- ❑ Bituminous is
 - the adjective applicable to binders and mixtures of binders and aggregates containing asphalt

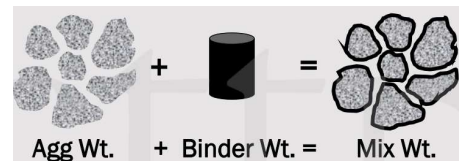


Image source: Center of training transportation professionals (cttp), Hot Mix Asphalt Testing Technician course, 2020. Available at <https://cttp.uark.edu/technicians/HMAclassroom-slide-presentation.pdf>

31

31

من نحن خدماتنا منتجاتنا علاقات المستثمرين والمساهمين

شركة مصفاة البترول الأردنية المساهمة المحدودة
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32

Pavement Materials & Design

Asphalt Materials

Classification

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33

Classification

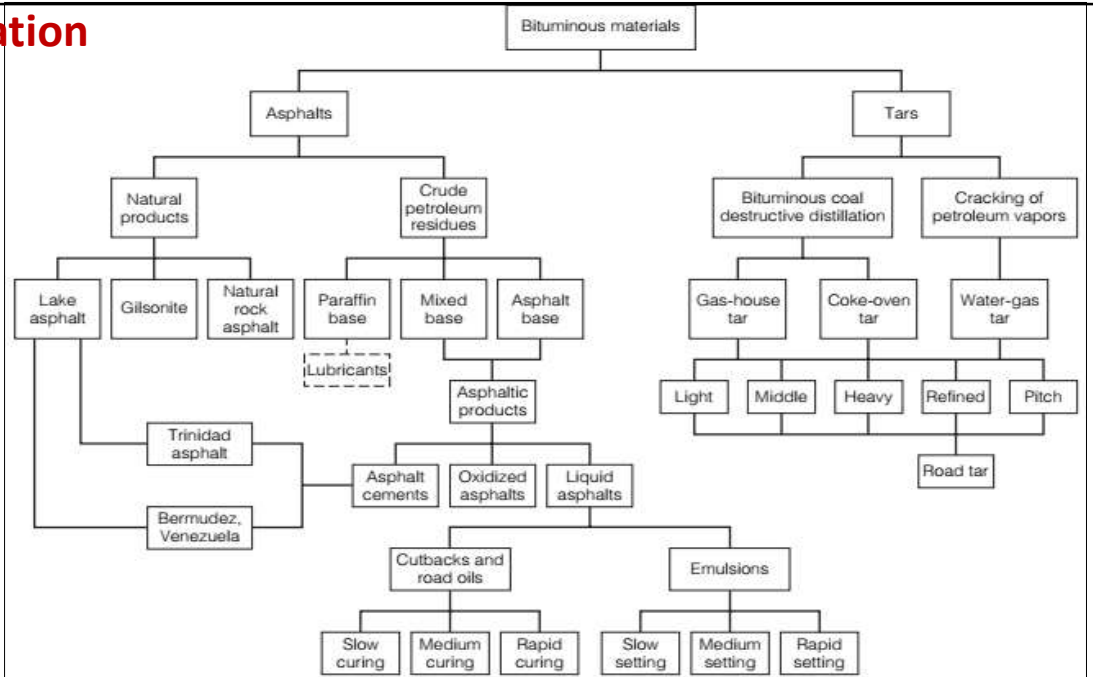


FIGURE 9.1 Classification of bituminous materials (Goetz and Wood, 1960).

34

Classification

Asphalt VS. Tars

❑ Tar

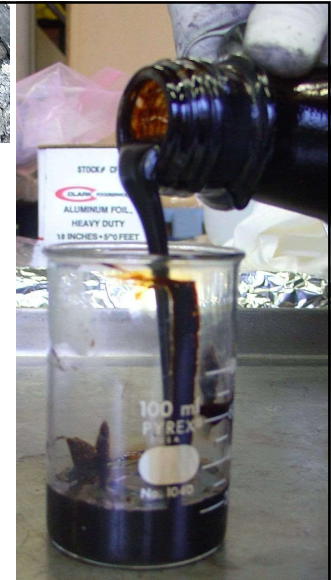
- is a dark brown or black viscous liquid of hydrocarbons and free carbon
- It obtained from a wide variety of organic materials through destructive distillation.

❑ Tar can be produced from

- Coal
- Wood
- Petroleum

❑ Therefore,

- the chemical composition of tar varies, though it is always made of organic matter of some sort.



A tar-like substance can be produced from corn stalks by heating them in a microwave

Image source: <https://chijungle.com/difference-between-asphalt-and-tar/>

35

35

Classification

Tars from wood



<https://www.youtube.com/watch?v=1V0e07A>

36

36

Classification

Tars from wood



<https://www.youtube.com/watch?v=1V0e07A>

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Classification

How is tar made for roads



38

38

Classification

Asphalt V.S. Tars

Asphalt

- It is obtained by partial distillation of crude petroleum

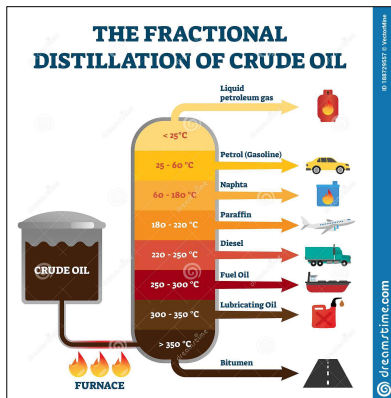


Image source: <https://civijungle.com/difference-between-asphalt-and-tar/>

39

39

Hi:

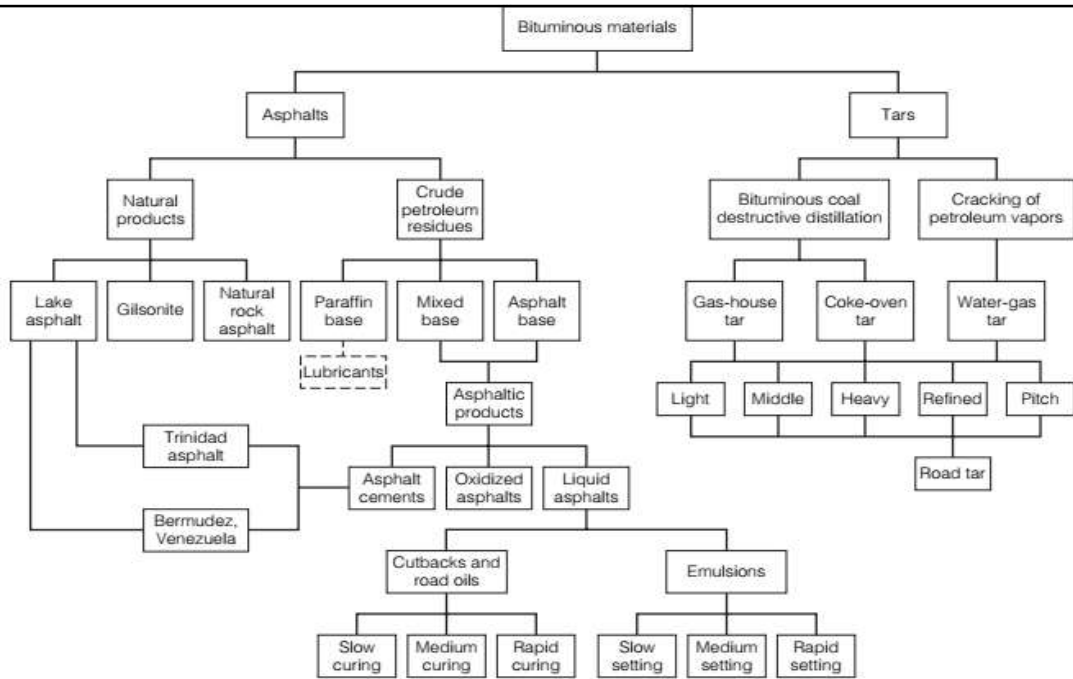


FIGURE 9.1 Classification of bituminous materials (Goetz and Wood, 1960).

40

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Refinery Operation

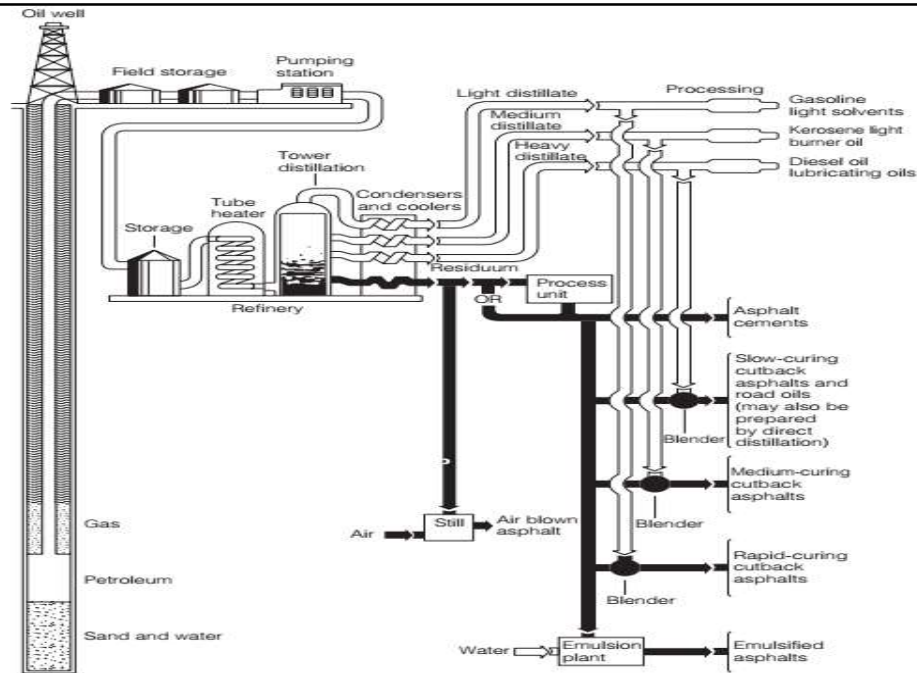
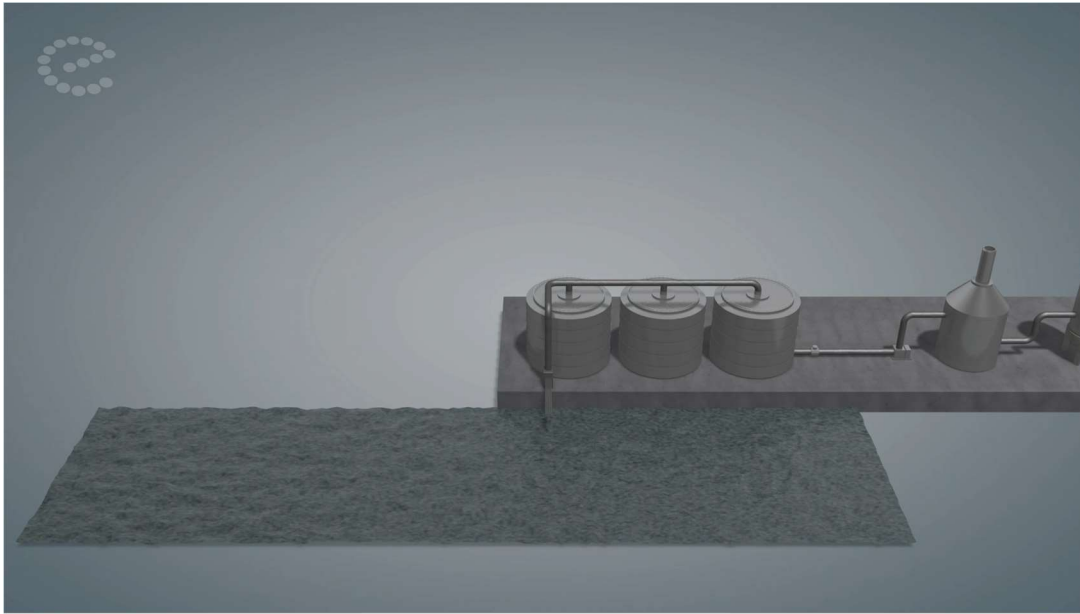


FIGURE 9.2 Distillation of crude petroleum (The Asphalt Institute, 2007).

42

Refinery Operation



[Refinery production of gasoline - YouTube](#)

43

Jordan Petroleum Refinery CO. LTD



Image source: <http://www.jopetrol.com.jo/EchobusV3.0/SystemAssets/9911a549-3ef6-45d0-b761-ef6c0d4c9e6d.pdf>

46

Pavement Materials & Design

Asphalt Materials

Asphalt Types : Asphalt Cement

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47

Asphalt types

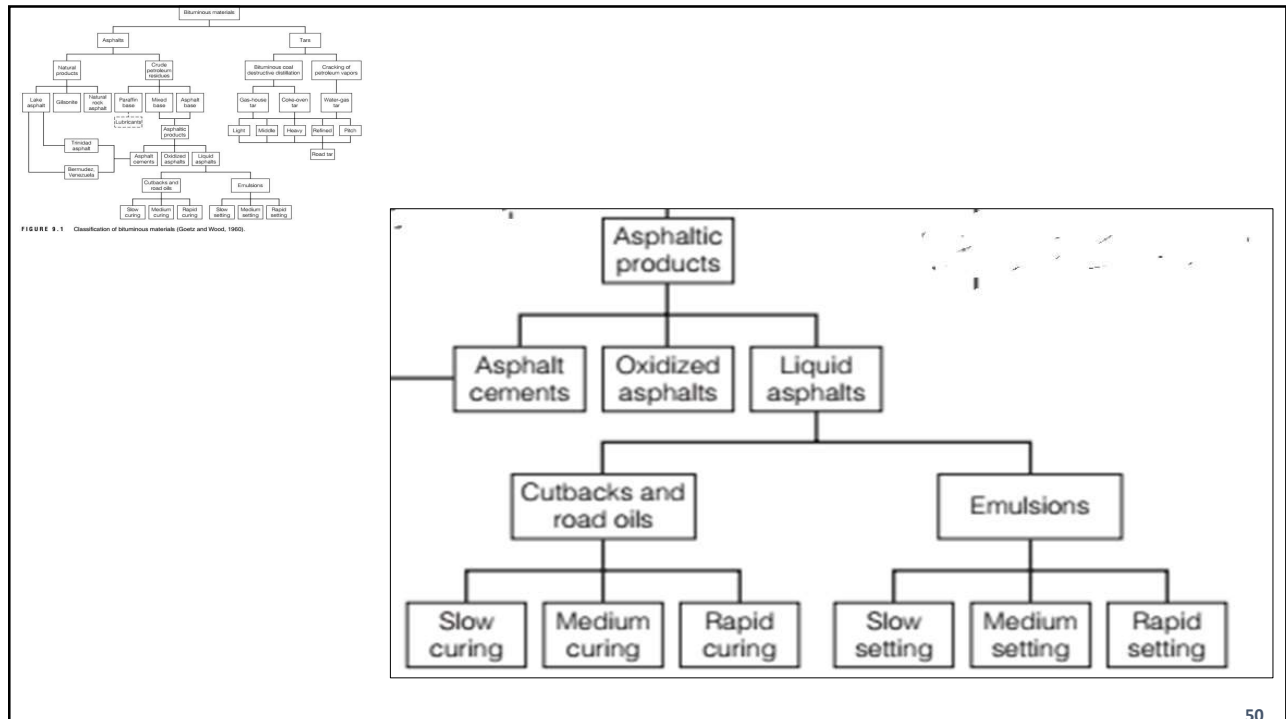
- Refining produces asphalt with specific characteristics for varied uses
 - *Roofing asphalt*
 - *Paving asphalt*
 - *Other special uses*

48

Roofing asphalt



<https://www.youtube.com/shorts/nD98cm05A>



Asphalt types

Paving asphalt

- ❑ Asphalt most commonly used in **flexible pavement construction** can be divided into:



Asphalt cement (binder)



Emulsified asphalt



Cutback asphalt

Image source <https://vasphalt.org/liquid-asphalt/>

Images source <https://pavementinteractive.org/sovereign-emulsion-how-asphalt-and-water-combine/>

<https://www.watersysgroup.com/productdetail/11>

51

51

1.1 Asphalt Materials

Asphalt cement

52

52

Asphalt cement

- ❑ Asphalt can be described as a **dark-coloured** petroleum-like material that has a **consistency** ranging from **sticky liquid** to a **glossy solid**.



<https://www.pronadglobal.com/en/performance-grade-asphalt-cement-polymer-modified-bitumen/>

53

53

Asphalt cement



Image source: <https://theasphaltpro.com/articles/age-the-binder-property-for-testing/>

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54

Asphalt cement



Image source: <https://theasphaltzoo.com/articles/age-the-binder-properly-for-testing/>

55

55

Asphalt types

Asphalt cement

- ❑ At room temperatures,
 - asphalt cement is a **semisolid** material that **cannot** be applied readily as a binder **without being heated**



56

56

Asphalt types

Asphalt cement

- ❑ Asphalt cement has excellent adhesive characteristics as compared to the liquid asphalt (cutback and emulsified asphalt),
 - which make it a superior binder for pavement applications



https://correctveasphalt.com/wp-content/uploads/2018/08/10_Fog_Seal_and_Rejuvenator_Seal_Benefits_and_Differences_Brownridge.pdf

57

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Asphalt types

Asphalt cement

- ❑ Asphalt cements are used mainly in the manufacture of Hot-mix Asphalt (HMA)



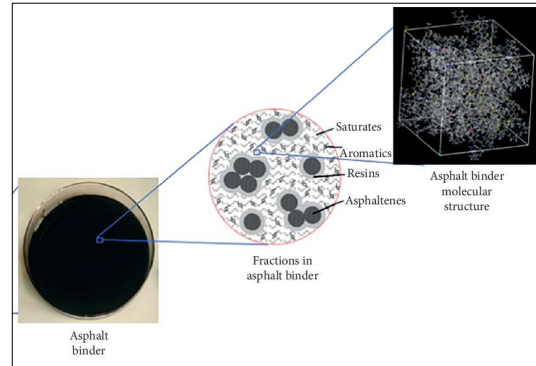
<https://www.youtube.com/shorts/25995e8BWM> <https://www.youtube.com/shorts/q3Xf68s0Y>

clideo.com

58

Chemical Composition of Asphalt

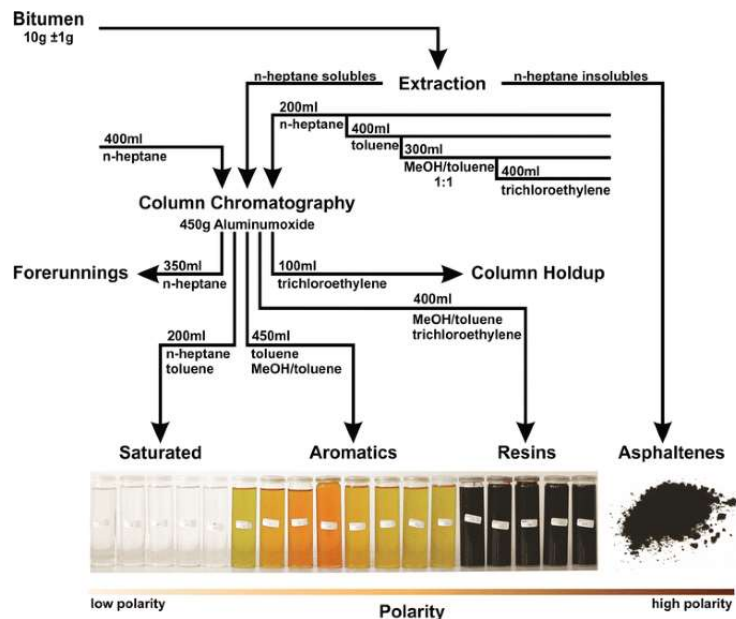
- ❑ Asphalt is a complex chemical compound composed **predominately of carbon and hydrogen (hydrocarbon)**, with a **small amount** of heterocyclic compounds containing sulfur, nitrogen and oxygen
- ❑ The **characteristics** of the asphalt **depend** on
 - The **chemical composition**
 - The **distribution** of the **molecular weight hydrocarbons**.
- ❑ As the distribution shifts toward **heavier molecular weights**
 - *the asphalt becomes **harder and more viscous**.*



Qu, X., D. Wang, L. Wang, Y. Huang, Yue Hou and M. Deser. "The State of the Art Review on Molecular Dynamics Simulation of Asphalt Binder." (2018).

Asphalt cement

- ❑ It is possible to be separated into **two broad chemical groups**
 - ❖ The asphaltenes
 - Saturated hydrocarbons
 - Aromatic hydrocarbons
 - Resin
 - ❖ The maltenes



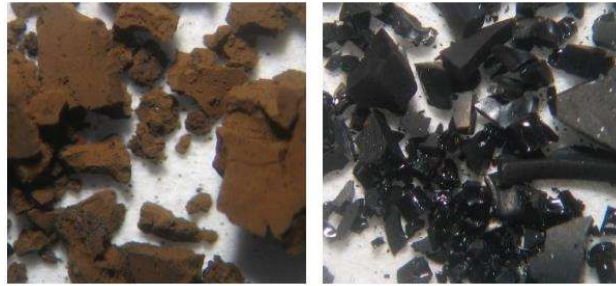
https://media.springernature.com/hw685/springer-static/image/art%3A10.1017%2F11527-014-0484-3/MediaObjects/11527_2014_484_Fig1_HTML.tif

Chemical Composition of Asphalt

Asphaltenes

- The asphaltene content directly affects the rheological properties of the asphalt.
- When asphaltene content **increases**
 - ❖ The asphalt is **harder**
 - Low penetration
 - High softening point
 - ❖ The asphalt is **more viscous**
 - High viscosity
- The percentage of asphaltenes in asphalt usually ranges from **5% to 28%**

Typical images of liquid petroleum (left) and the glassy asphaltene fraction (center). Asphaltene molecules have a condensed aromatic core (right).



(a) (b)
Asphaltenes Separate from the Same Crude Oil Sample in the Laboratory, Using N-C5 (A) and (B) N-C7

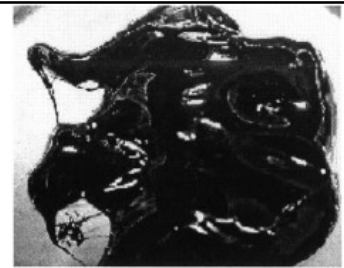


https://www.researchgate.net/publication/369626520_Aspaltene_Precipitation_Investigation_Using_a_Screening_Techniques_for_Crude_Oil_Sample_from_the_Nahr_Umr_FormationinIraq_Oil_Field <https://www.sciencedirect.com/science/article/pii/S0167636921001111> probing the molecular architecture of petroleum asphaltene

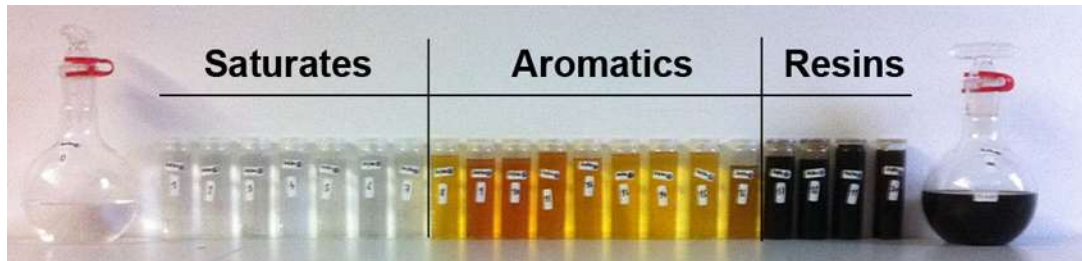
Chemical Composition of Asphalt

Resins

- They are **solid or semi-solid**, dark brown in color and **strongly adhesive**.
- Resins are **dispersing agents** to asphaltenes
- Their proportion to asphaltenes **control** the gel/sol type of character of asphalt.

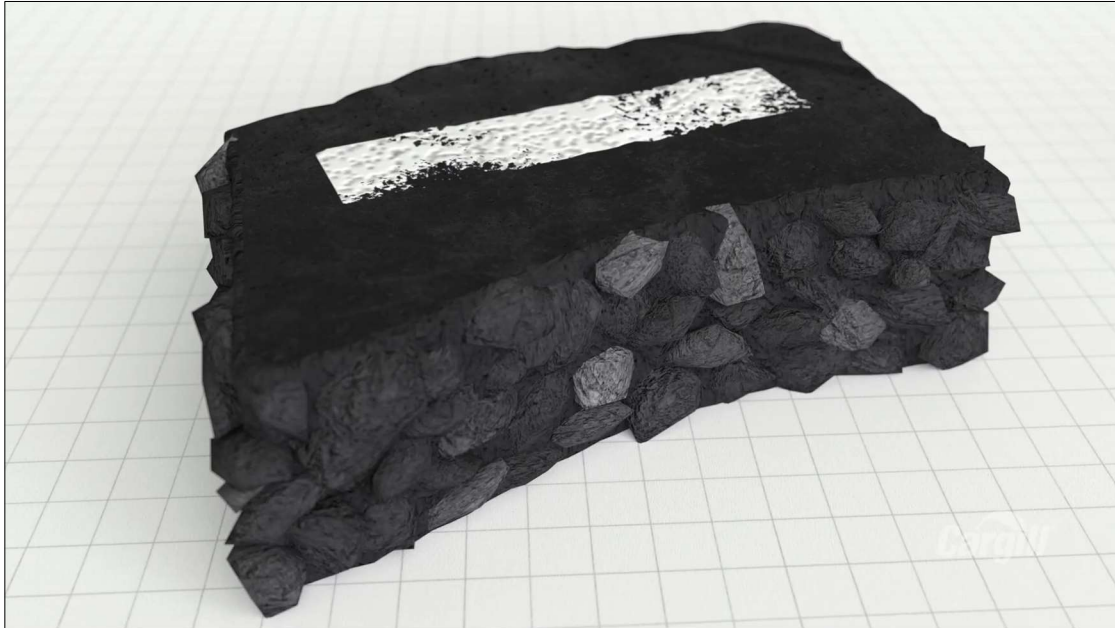


Resins



https://publik.tuwien.ac.at/files/PubDet_230295.pdf

Chemical Composition of Asphalt



<https://www.youtube.com/watch?v=xun7y4PH0U>

63

63

Chemical Composition of Asphalt

- ❑ The **exact composition** of asphalt differs, and it **depends** on
 - *The source of the crude oil*
 - *The modification during its fractional distillation*
 - *The oncoming aging in service*
- ❑ Any variation in the percentage of **asphaltenes** and **maltenes** (particularly of resins and saturates)
 - *influences the viscosity and the temperature sensitivity of asphalt.*
- ❑ The variation of the abovementioned substances takes place **mainly** during **production of asphalt**
 - ❖ [Will be discussed later](#)

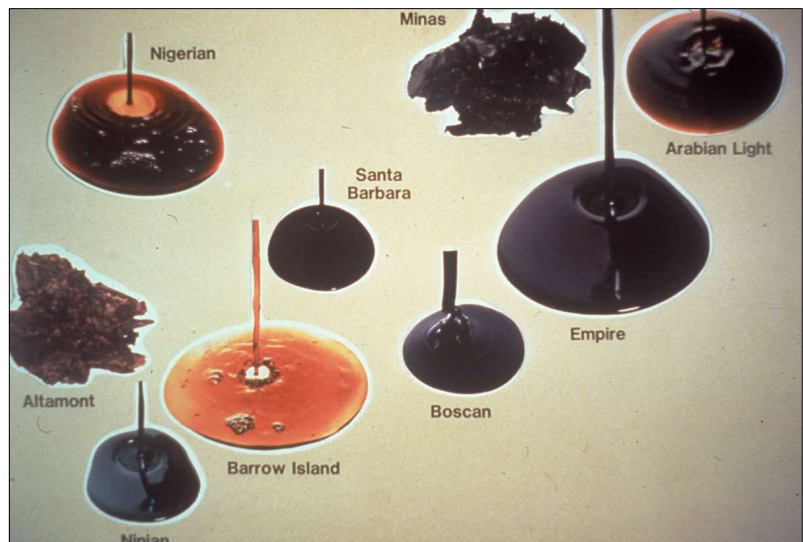


Image source: <https://docs.lib.purdue.edu/cgi/viewcontent.cgi?article=1276&context=roadschool>

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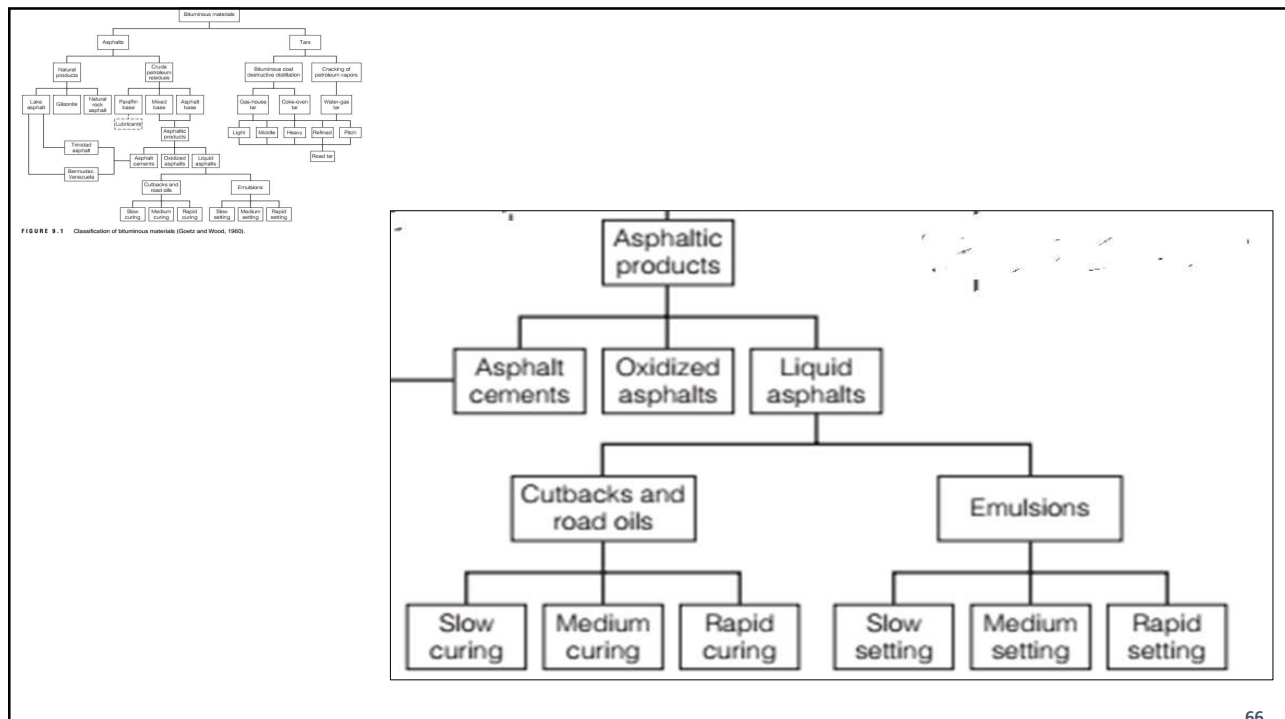
Pavement Materials & Design

Asphalt Materials

Asphalt Types : Liquid Asphalt

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65



66

66

Asphalt - Methods to Liquify

1. Heating

- Temporarily reduces viscosity

2. Dissolving in Solvent

- Cutback Asphalts (type and amount of solvent determines properties and classification)

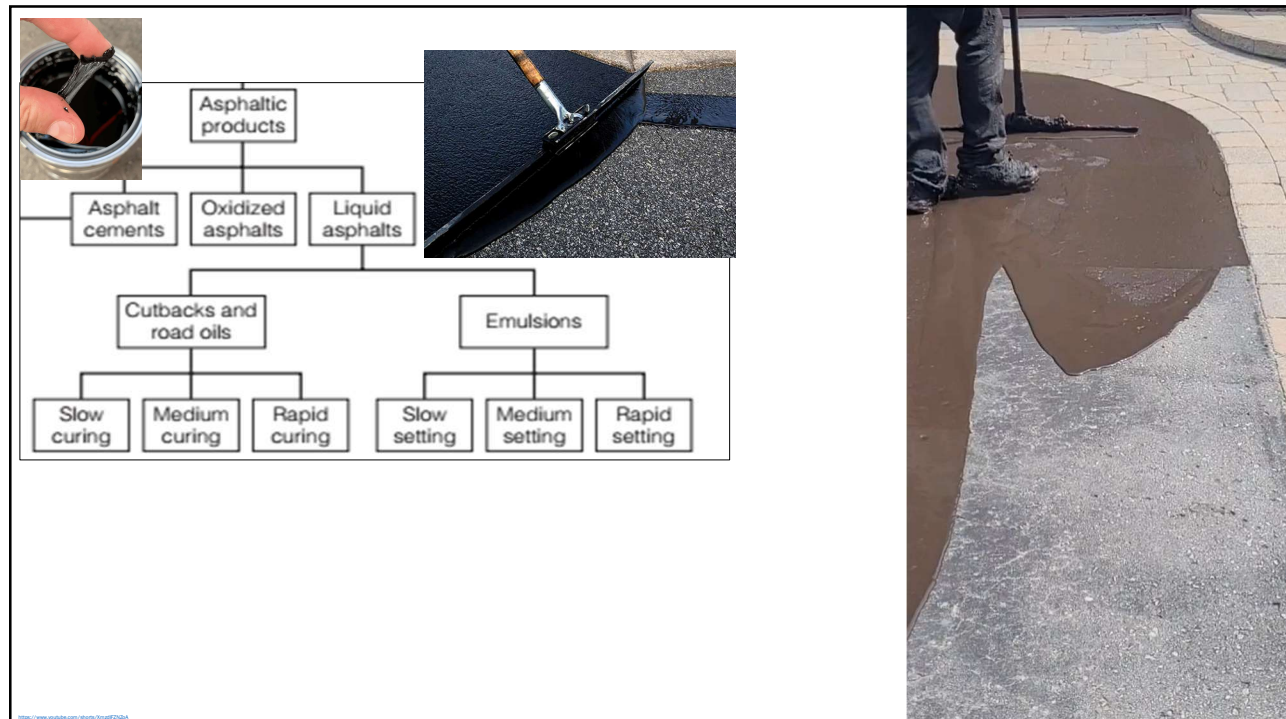
3. Emulsifying with Water

- Emulsified Asphalts (electro-chemical charge, setting characteristics, liquid)
- viscosity and consistency of cured residue determines properties and classification)



<https://www.youtube.com/watch?v=K9wX7gUFE>

67



68

Liquid asphalt



Image source: <https://www.tigerbitumen.com/cutback-bitumen-grades-and-specifications/>

69

69

Liquid asphalt



<https://www.youtube.com/watch?v=8Tewx3y3y00>

71

71

1.1 Asphalt Materials

Emulsified asphalt (Emulsion)

72

72

Asphalt types

Emulsified asphalt (emulsion)

- ❑ It's a mixture of asphalt cement, water, and emulsifying agent (e.g., soap)
 - 1-2% by volume
- ❑ It classified as liquid asphalts because
 - they are liquid at ambient temperatures
- ❑ Emulsions are made to
 - Reduce the asphalt viscosity for lower application temperatures

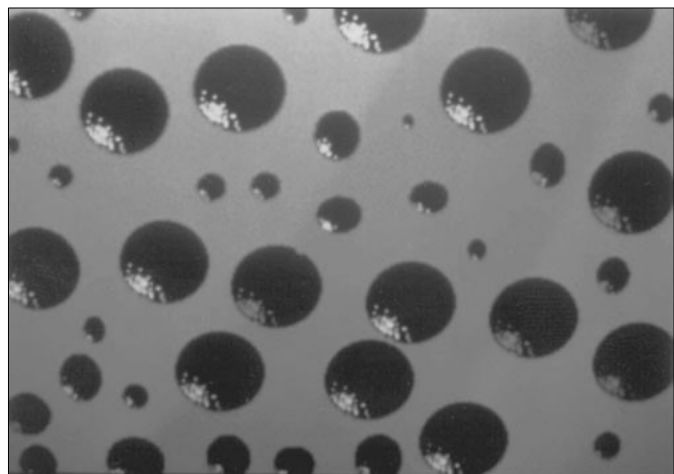


Photo of magnified asphalt emulsion showing minute droplets of asphalt cement dispersed in a water medium.

73

73

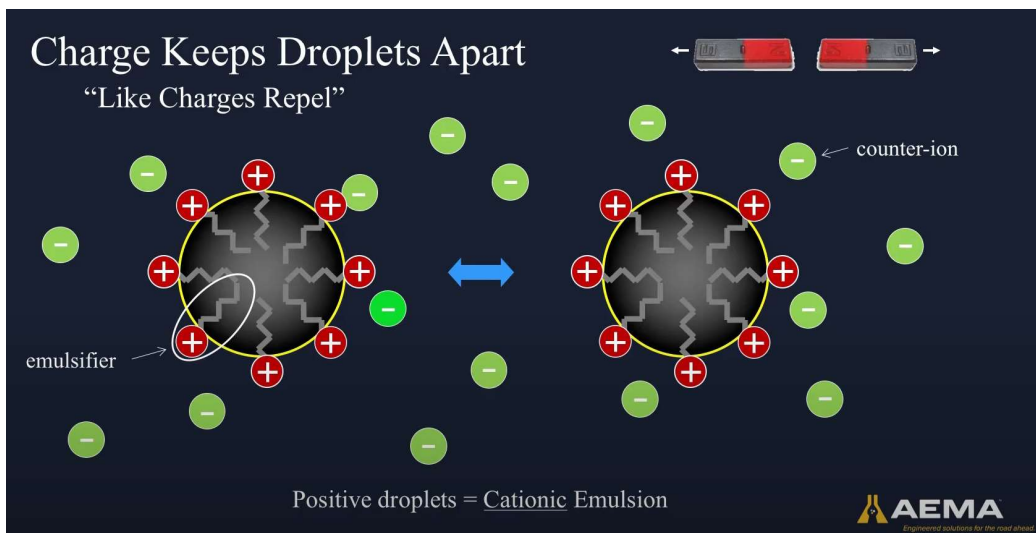
Emulsified asphalt (emulsion)

WHAT IS BITUMEN EMULSION ?

74

Asphalt types

Emulsified asphalt (Emulsion)



Emulsifier gives surface charge to asphalt droplets suspended in water medium

75

Asphalt types



76

76

Bitumen Emulsion Plant



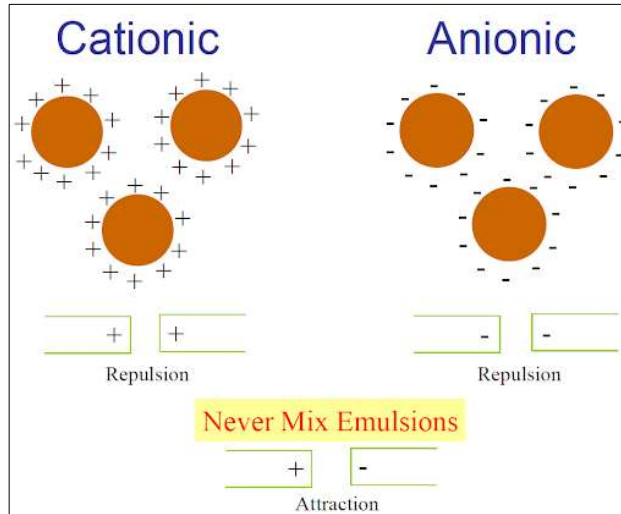
[Bitumen Emulsion Plant - YouTube](#)

77

77

Asphalt types

Emulsified asphalt (emulsion)



Emulsifier gives surface charge to asphalt droplets suspended in water medium

Image source: <https://rahbitumen.com/bitumen-emulsion/>

Emulsified asphalt (emulsion)

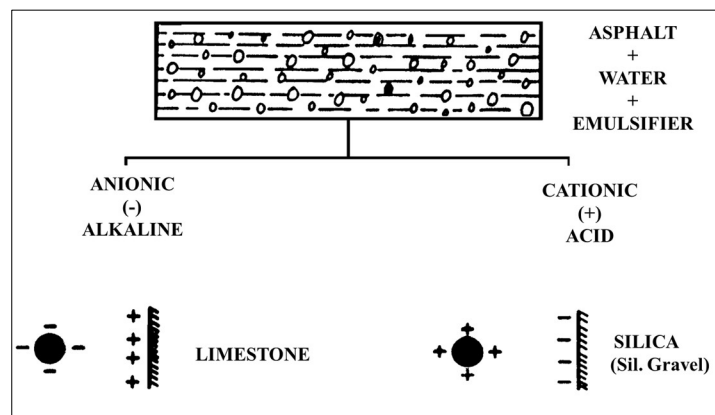
Types

Anionic

- *Electro-negatively charged asphalt droplet*
- *Good with aggregate that have a positive charge*
 - ❖ (limestones) which finally causes the anionic emulsified asphalt to "break or "set" and produce a continuous film of asphalt on the aggregate or pavement

Cationic

- *Electro-positively charged asphalt droplet*
- *Good with aggregate that have a negative charge*
- *Siliceous aggregate [sandstone, quartz, and siliceous gravel*



Asphalt types

Emulsified asphalt (emulsion)

- ❑ Emulsified asphalts are further **graded according to their “setting” rate** including
 - *The **setting rate** is controlled by **the type and amount of the emulsifying agent***
- ❑ Emulsified asphalts classified to
 - ***Anionic emulsified asphalts** are classified into*
 - ❖ Rapid setting (RS)
 - ❖ Medium setting (MS)
 - ❖ Slow setting (SS)
 - ***Cationic emulsified asphalts** are classified into*
 - ❖ Rapid setting (CRS)
 - ❖ Medium setting (CMS)
 - ❖ Slow setting (CSS)

80

80

Emulsified asphalt (emulsion)

Asphalt Emulsion Chemical Reaction Test



**Vance Brothers, Inc
Presents...**

<https://www.youtube.com/watch?v=NqWkFQ3J3eg>

81

81

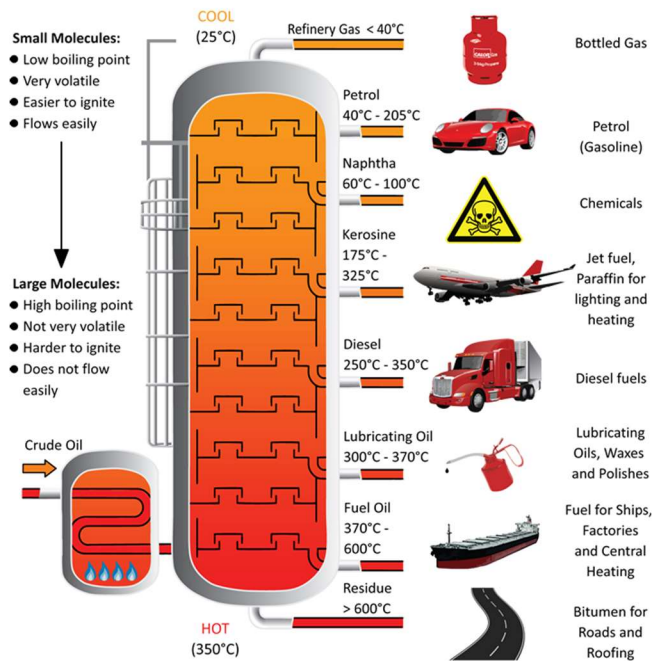
1.1 Asphalt Materials

Cutback asphalt

Definition

- ❑ A cutback
 - "A cutback is a decrease in something,"
- ❑ A cutback asphalt
 - Reducing the *viscosity* of asphalt binder

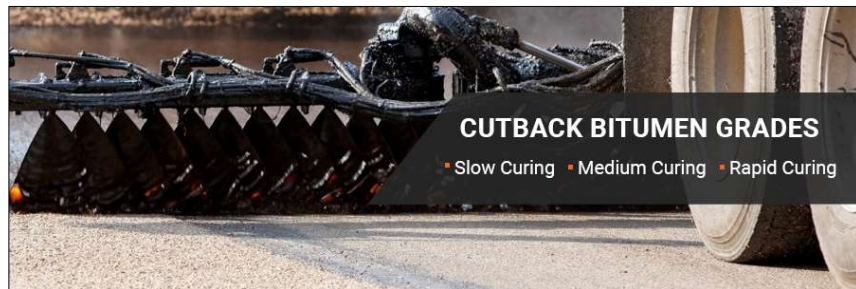
Fractional Distillation of Crude Oil



Asphalt types

Cutback asphalt

- ❑ A liquid asphalt which are manufactured by adding (cutting back) petroleum solvents to asphalt cement
 - *Cutback asphalt = AC + Petroleum solvent*
- ❑ They are made to reduce the asphalt viscosity for lower application temperature
- ❑ Application to aggregate or pavement causes the solvent to escape by evaporation, thus leaving the asphalt cement residue on the surface



97

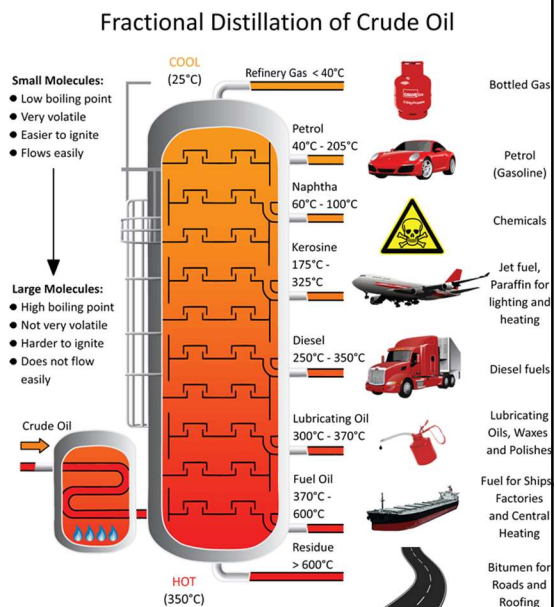
97

Asphalt types

Cutback asphalt

Based on the relative rate of evaporation, cutback asphalts are divided into

1. Rapid –Curing (RC)
 - Produced by adding a high volatility solvent (generally gasoline or naphtha)
2. Medium – Curing (MC)
 - Produced by adding an intermediate volatility solvent (generally kerosene)
3. Slow-Curing (SC) (or road oils)
 - Produced by adding a low volatility solvent (generally diesel or other gas oils)



98

98

Asphalt Types

Cutback VS. Emulsions

Cutback Asphalts **used less frequently now** and use of **emulsions** becoming more common because of :

- Environmental Concerns (especially with RC's)
 - *Hydrocarbons evaporate into air.*
- Economic
 - *costly to buy 2 petroleum products.*
- Safety
 - *low flash pts - danger of fire.*
- Higher application temp, dry conditions required

99

99

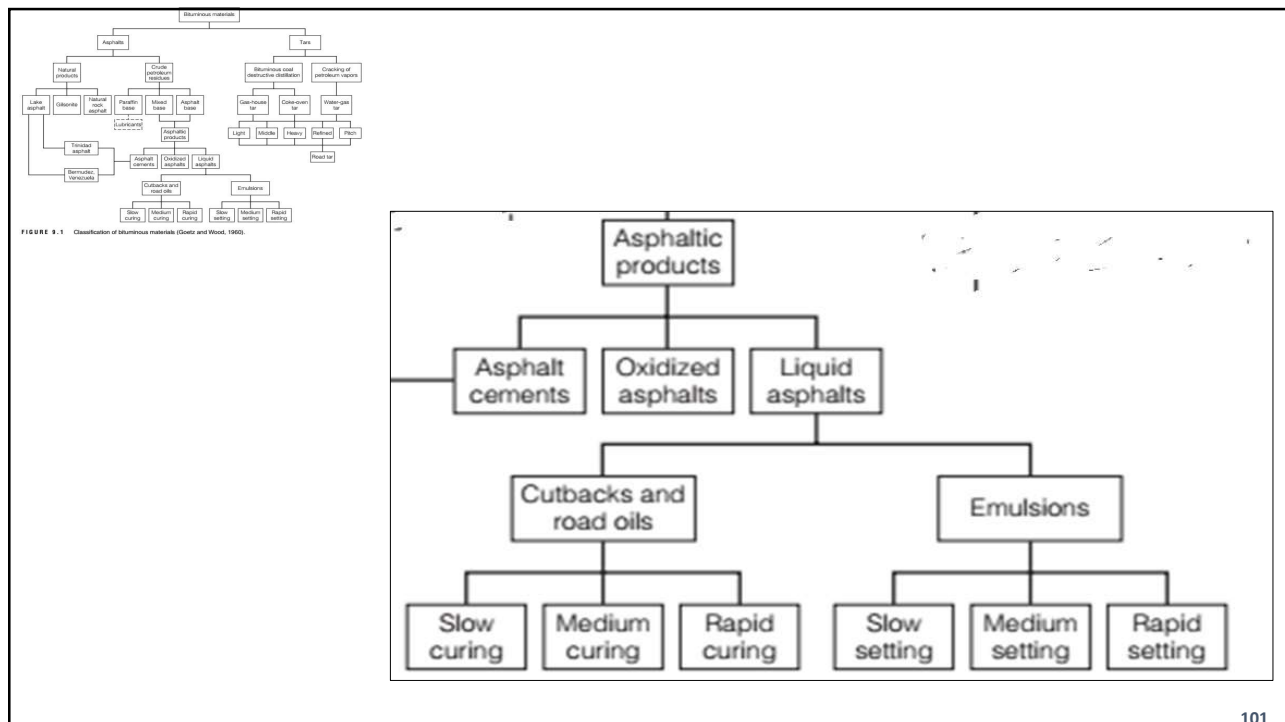
Pavement Materials & Design

Asphalt Materials

Asphalt Types : Oxidized Asphalt

Dr. Hamza Alkuime

100

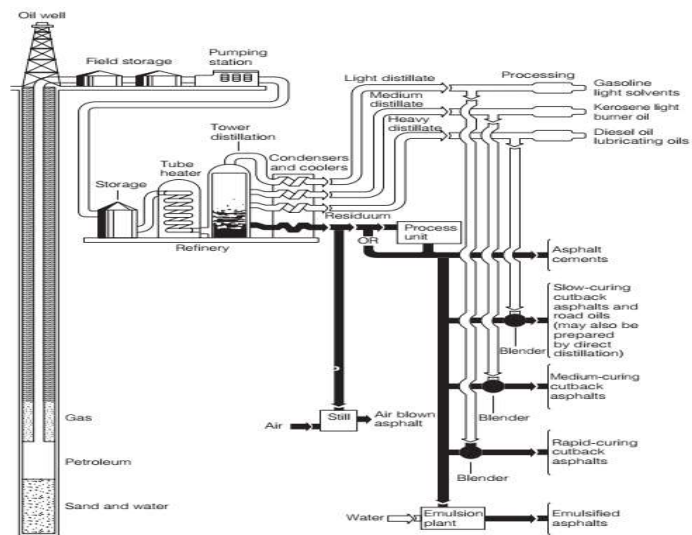


101

Oxidized Asphalt

Production Process

- ❑ This type of bitumen obtains from the blowing hot air with a temperature of 200 to 300 degree Celsius to the penetration grade bitumen in the reactor of Bitumen Blowing Unit (BBU) of the refinery.
- ❑ Hydrogen atoms of bitumen react with oxygen atoms of air when heated with hot air in the reactor.
- ❑ Then it generates some steam that should be removed from the oxidation chamber.
- ❑ Consequently, the bitumen remains.



<https://www.youtube.com/shorts/70P14Z5e60>

102