TOPIC 6

Bituminous Materials

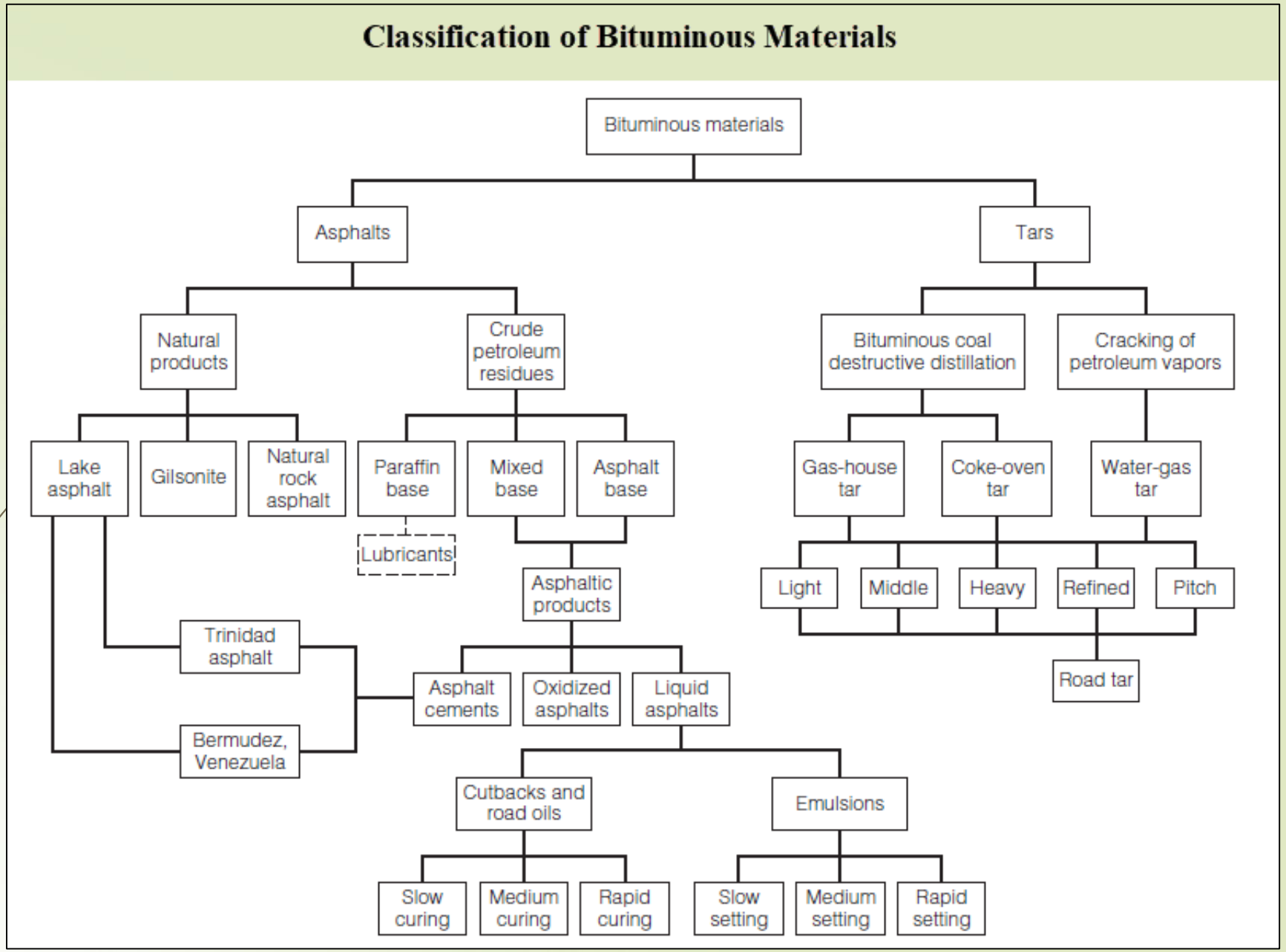
General Introduction

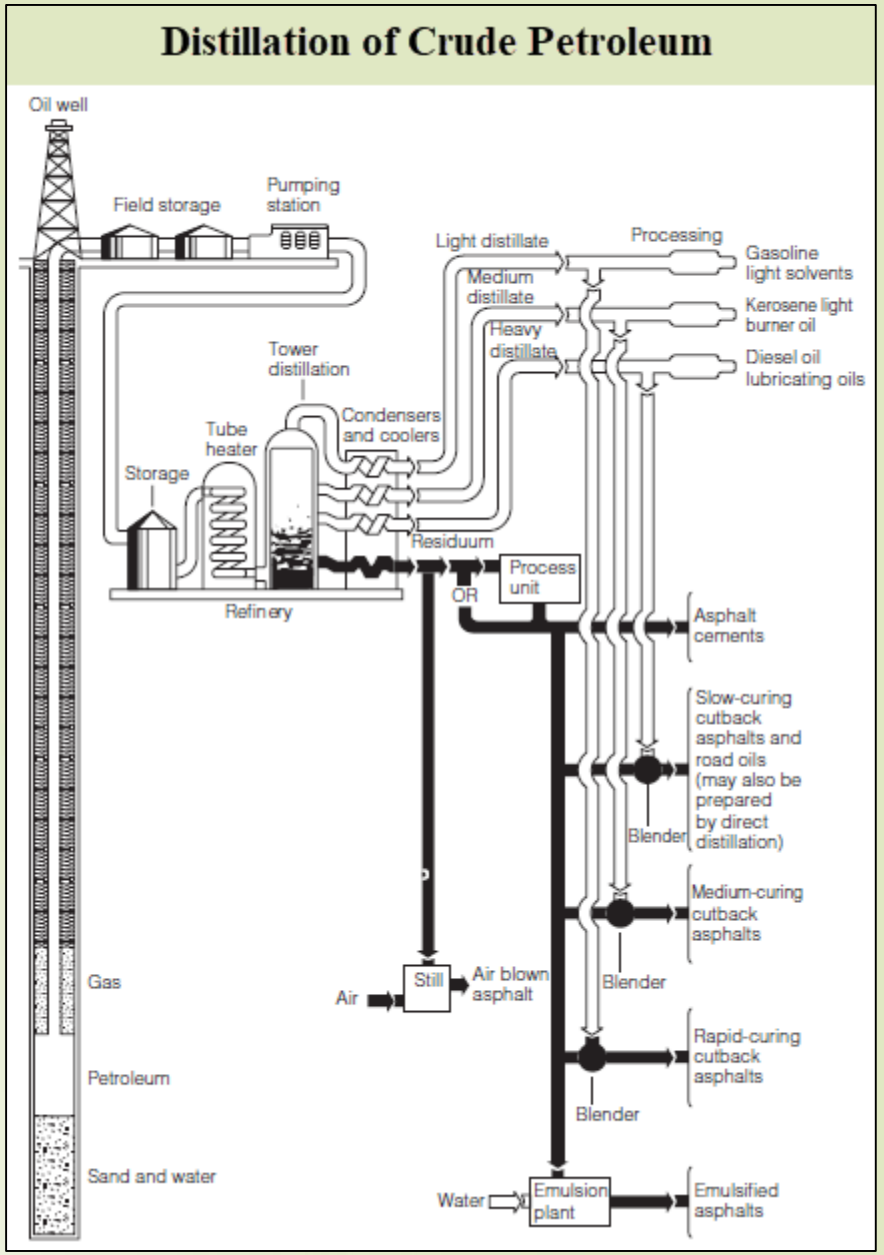
- Bituminous materials are classified as:
  - Asphalts and
  - Tars
- **Asphalt** is one of the oldest materials used in construction
- In the past, asphalt cement came from natural deposits and refineries
- Presently, practically all asphalt cement is from refined petroleum
- Asphalt is used mostly in pavement construction, but is also used as sealing and waterproofing agents
- **Tars** are produced by the destructive distillation of bituminous coal or by cracking petroleum vapors

General Introduction

- Tar is used primarily for waterproofing membranes, such as roofs
- Tar may also be used for pavement treatments, particularly where fuel spills may dissolve asphalt cement, such as on parking lots and airport aprons (area at the airport where aircrafts are parked, refueled, loaded, etc.)
- In the fractional distillation process of crude petroleum, different products are separated at different temperatures
- The main products of fractional distillation include gasoline, kerosene, diesel oil, and asphalt residue (asphalt cement).
- Since asphalt is a lower-valued product than other components of crude oil, refineries are set up to produce the more valuable fuels at the expense of asphalt production

Classification of Bituminous Materials




Distillation of Crude Petroleum
Oil well
Field storage
Pumping station
Light distillate
Processing
Gasoline light solvents
Medium distillate
Kerosene light burner oil
Heavy distillate
Diesel oil lubricating oils
Tower distillation
Condensers and coolers
Tube heater
Storage
Residuum
Process unit
OR
Refinery
Asphalt cements
Slow-curing cutback asphalts and road oils (may also be prepared by direct distillation)
Blender
Medium-curing cutback asphalts
Blender
Gas
Still
Air
Air blown asphalt
Petroleum
Rapid-curing cutback asphalts
Blender
Sand and water
Water
Emulsion plant
Emulsified asphalts

Types of Asphalt Products

- Asphalt used in pavements is produced in three forms:
  1. Asphalt cement,
  2. Asphalt cutback, and
  3. Asphalt emulsion

Asphalt cement

- Asphalt cement is a blend of hydrocarbons of different molecular weights.
- At room temperatures, asphalt cement is a semisolid material that cannot be applied readily as a binder without being heated.
- Softest grade asphalts used for road construction have penetration value of 200-300, and the hardest has penetration values between 60 to 70
- Asphalt cement has excellent adhesive characteristics, which make it a superior binder for pavement applications but becomes hard and brittle when over-heated or aged and loses some ability to adhere to aggregates

Types of Asphalt Products

Emulsified Asphalts

- Emulsified Asphalts are liquid asphalt products at room temperature
- They have been developed to be used without heating
- **Emulsified asphalts** are a suspension solution of small asphalt globules (60-70%) in water (30-40%) which is assisted by a soap-like emulsifying agent (About 1%)
- Emulsifiers are think and brown liquids that reduce the viscosity (thickness) of asphalt.
- When the water evaporates, asphalt cement starts adhering to aggregates

Cutback Asphalts

- Similar to emulsified asphalts, cutbacks are liquid asphalt products at room temperature

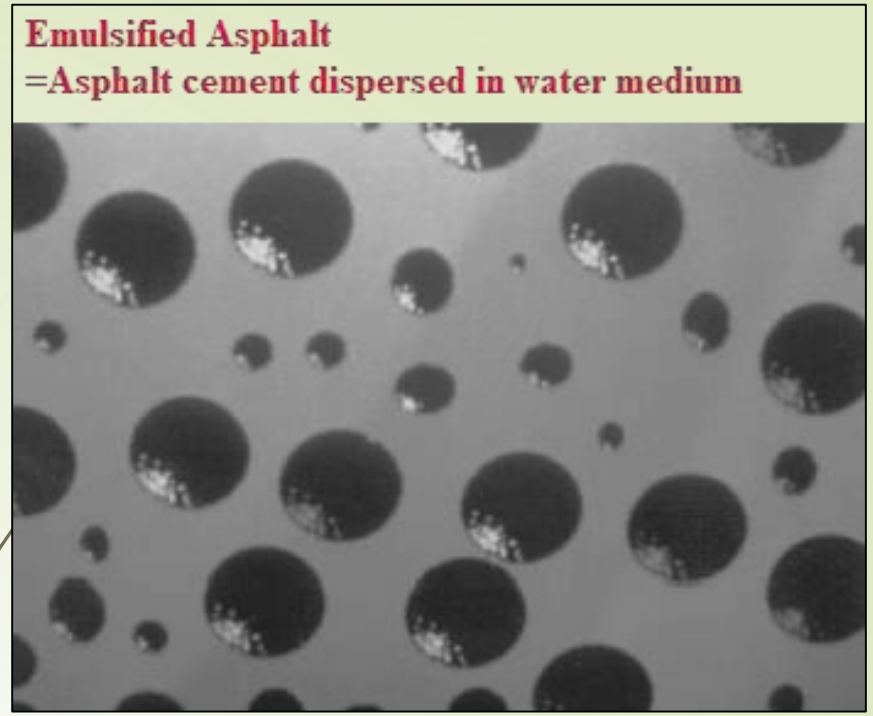
Types of Asphalt Products

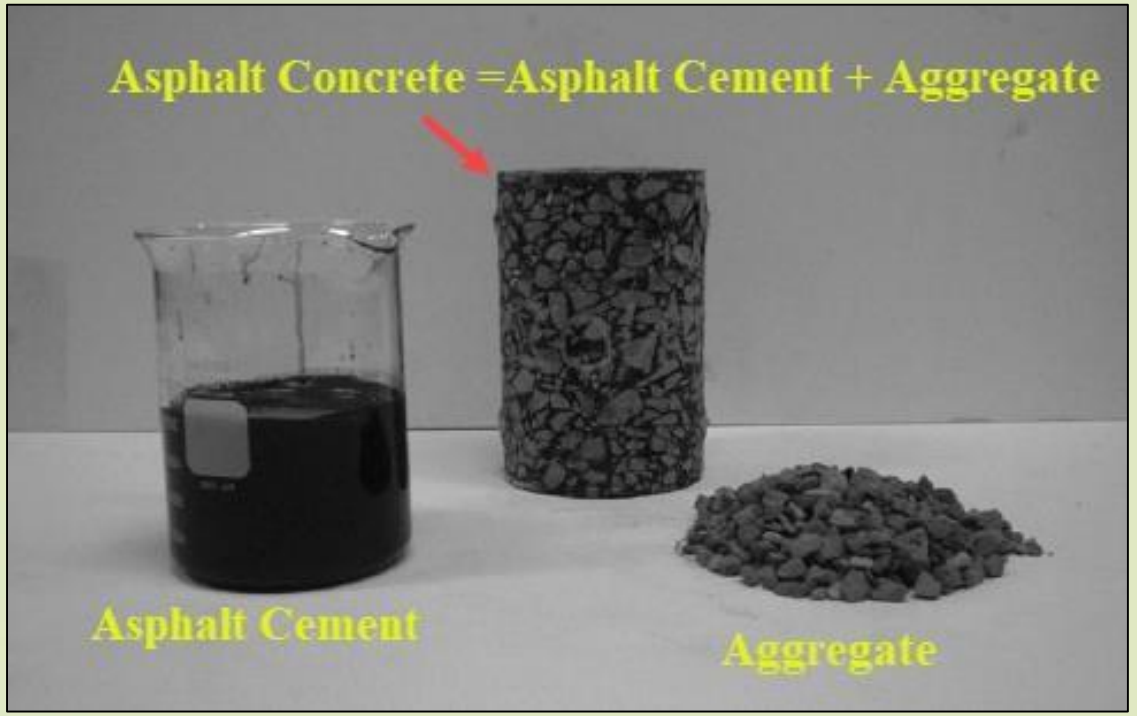
- In cutback asphalts, the asphalt cement is mixed with a diluent (thinning agent) that liquifies the asphalt making it ready for application
- After application, the diluent evaporates, leaving the asphalt cement to do its job
- Depending on the rate of curing, cutbacks can be classified as Slow-Curing (SC), Medium-Curing (MC), or Rapid-Curing (RC) Cutback Asphalts.
- These cutbacks are usually designated as SC-70, MC-30, or RC-70 where the number relates to the approximate Kinematic viscosity in centistockes at 60°C
- The fluidity of MC cutbacks depends on the amount of solvent in the material
- MC cutback asphalts can be used in the construction of pavement bases, surfaces, and surface treatments

Types of Asphalt Products

- Liquid asphalts are convenient. In the past, cutbacks were widely used for highway construction. They were effective and could be applied easily in the field.
- However, they cannot produce a quality of asphalt concrete comparable to what can be produced by heating neat asphalt cement and mixing it with carefully selected aggregates.
- Although emulsions and cutbacks can be used for the same applications, the use of emulsions is increasing because they do not include hazardous and costly solvents.
- The three main disadvantages of cutback asphalts include the following:
  i. Petroleum costs have escalated, thus, the use of these expensive solvents as a carrying agent for the asphalt cement is no longer cost effective (Emulsified asphalts - dispensing asphalt in water are an alternative to dissolving asphalts in expensive solvents)
  ii. Second, cutbacks are hazardous materials due to the volatility of the solvents.
  iii. Finally, application of the cutback releases environmentally unacceptable hydrocarbons into the atmosphere.

Types of Asphalt Products





Properties of Asphalt Materials

- Properties of asphalt materials pertinent to pavement construction can be grouped into four:
  - Consistency
  - Aging and temperature sustainability
  - Rate of curing
  - Resistance to water action

Consistency

- Consistency properties refer to:
  - Variation of properties with temperature
  - Properties at a specified temperature
- The change in properties (consistency) of different asphalt materials differ considerably even at same temperature
- Temperature of asphalt materials is inversely proportional to the viscosity of the asphaltmaterial
- When asphalt is mixed with aggregates, the mixture will perform properly only if the asphalt viscosity is within an optimum range

Properties of Asphalt Materials

- If the viscosity of asphalt is higher than the optimum range, the mixture will be too brittle and susceptible to low-temperature cracking
- If the viscosity is below the optimum range, the mixture will flow readily, resulting in permanent deformation in the wheel path (rutting)
- Due to temperature susceptibility, the grade of the asphalt cement should be selected according to the climate of the area.
- The viscosity of the asphalt should be mostly within the optimum range for the area's annual temperature range;
  - soft-grade asphalts are used for cold climates and
  - hard-grade asphalts for hot climates

Aging and temperature sustainability

- Aging is when asphalt loses its plasticity and becomes brittle due to chemical and physical reactions that take place when the material is exposed to environmental elements

Properties of Asphalt Materials

- Two common reactions are:
  - Oxidation when asphalt material is attacked by oxygen in the air
  - Volatilization which is the loss of lighter hydrocarbons from the asphalt material
- These two reactions cause loss of plastic characteristics of the asphalt material
- Temperature affects the rate of these reactions
- The higher the temperature, the higher the rate of oxidation and volatilization
- Asphalt gets hard and brittle at low temperatures and soft at high temperatures
- The viscosity of the asphalt decreases when the temperature increases.

Rate of Curing

- Curing is the process by which asphalt material increases its consistency as it loses solvent by evaporation. The smaller the quantity of solvent, the faster the curing rate

Properties of Asphalt Materials

Resistance to water action

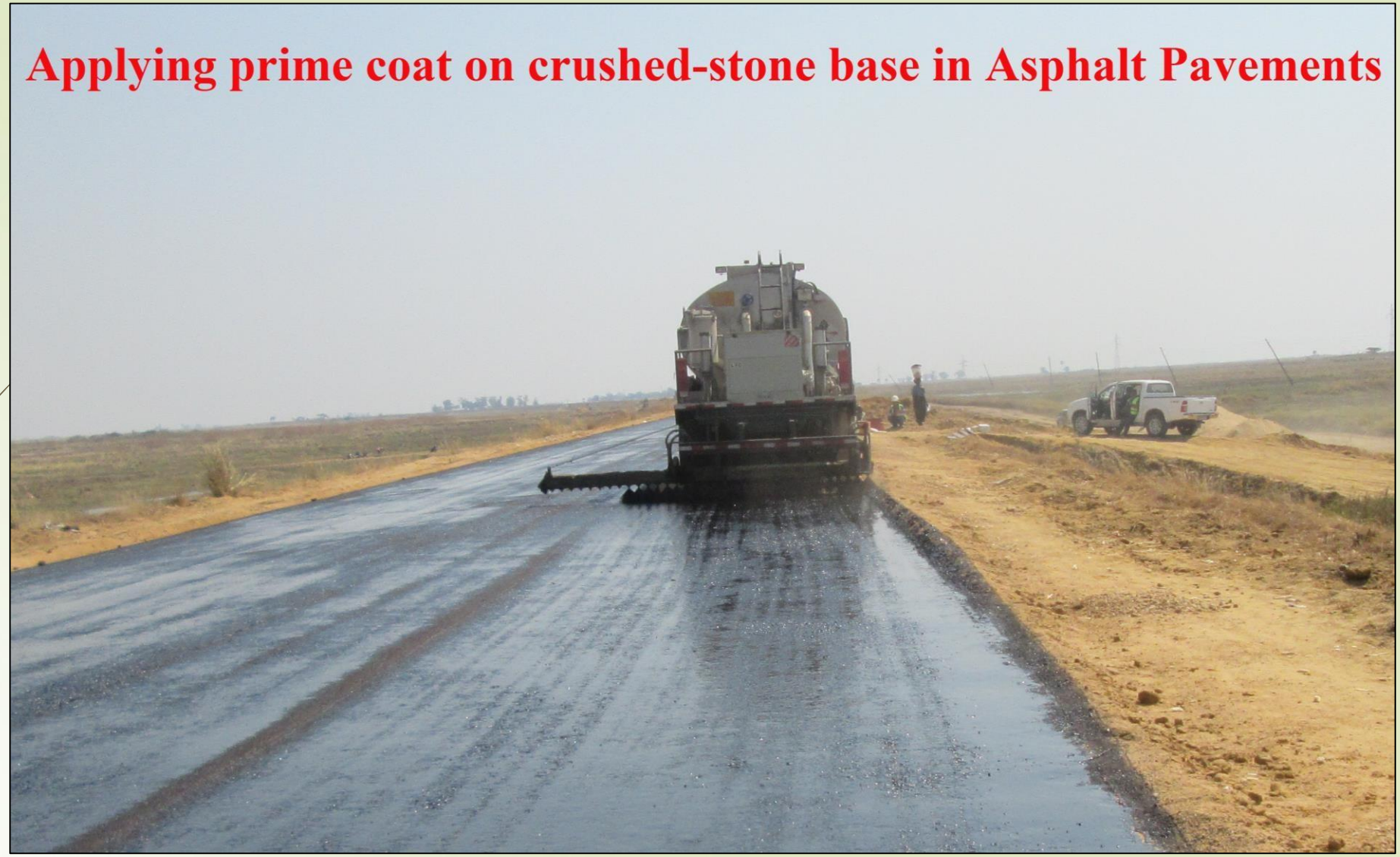
- When asphalt materials are used in pavement construction, it is important that the asphalt continues to adhere to the aggregates even with the presence of water
- If this bond between the asphalt and the aggregates is lost, the asphalt will strip from the aggregates, resulting in the deterioration of the pavement
- The asphalt therefore must sustain its ability to adhere to the aggregates even in the presence of water.
- In hot-mix, hot-laid asphalt concrete, where the aggregates are thoroughly dried before mixing, stripping does not normally occur and so no preventive action is usually taken.
- However, when water is added to a hot-mix, cold-laid asphalt concrete, commercial antistrip additives usually are added to improve the asphalt's ability to adhere to the aggregates.

Uses of Asphalt

- The main use of asphalt is in pavement construction and maintenance.
- In addition, asphalt is used in sealing and waterproofing various structural components, such as roofs and underground foundations
- The selection of the type and grade of asphalt depends on the type of construction and the climate of the area.
- Asphalt cements, also called asphalt binders, are used typically to make hot-mix asphalt concrete for the surface layer of asphalt pavements
- Asphalt concrete is also used in patching and repairing both asphalt and portland cement concrete pavements.
- Liquid asphalts (emulsions and cutbacks) are used for pavement maintenance applications, such a fog seals, chip seals, slurry seals, and microsurfacing. Also to seal cracks in pavements
- Liquid asphalts are mixed with aggregates to produce cold mixes, as well.
- Cold mixtures are normally used for patching (when hot-mix asphalt concrete is not available), base and subbase stabilization, and surfacing of low-volume roads

Uses of Asphalt

Uses of Asphalt



Uses of Asphalt

Common Paving Applications for Asphalts

Term	Description	Application
Hot mix asphalt	Carefully designed mixture of asphalt cement and aggregates	Pavement surface, patching
Cold mix	Mixture of aggregates and liquid asphalt	Patching, low volume road surface, asphalt stabilized base
Fog seal	Spray of diluted asphalt emulsion on existing pavement surface	Seal existing pavement surface
Prime coat	Spray coat asphalt emulsion to bond aggregate base and asphalt concrete surface	Construction of flexible pavement
Tack coat	Spray coat asphalt emulsion between lifts of asphalt concrete	Construction of new pavements or between an existing pavement and an overlay
Chip seal	Spray coat of asphalt emulsion (or asphalt cement or cutback) followed with aggregate layer	Maintenance of existing pavement or low volume road surfaces
Slurry seal	Mixture of emulsion, well-graded fine aggregate and water	Resurface low volume roads
Microsurfacing	Mixture of polymer modified emulsion, well-graded crushed fine aggregate, mineral filler, water, and additives	Texturing, sealing, crack filling, rut filling, and minor leveling

Tests of Asphalt

- Several tests are conducted on asphalt materials to determine both their consistency and quality to ascertain whether materials used in highway construction meet the prescribed specifications.
- The common tests for asphalt;
  - i. **Viscosity** – This is a property used to describe asphalt materials in liquid state. Viscosity can be determined by the following methods
    1. Saybolt Furol Viscosity Test
    2. Kinematic Viscosity Test or
    3. Ring and Ball Softening Point (Not used often in highway specification)
  - ii. **Penetration Test**
    - The test gives an empirical measurement of the consistency of a material in terms of the distance a standard needle sinks into that material under a prescribed loading and time.

Tests of Asphalt

iii. **Ring-and-Ball Softening**

- Used to measure the susceptibility of blown asphalt to temperature changes by determining the temperature at which the material will be adequately softened to allow a standard ball to sink through it

iv. **Ductility Test**

- This test measures the property of asphalt binders to elongate under traffic load without getting cracked in road construction works. Ductility test on bitumen measures the distance in centimeters to which it elongates before breaking

v. **Thin-Film Oven Test (TFO)**

- One test used to evaluate the susceptibility characteristics of asphalt materials to changes in temperature and other atmospheric factors

vi. **Flash-Point Test**

- This is the temperature at which the asphalt material vapors will ignite instantaneously in the presence of an open flame

Asphalt Concrete

- Asphalt concrete, also known as hot-mix asphalt (HMA), consists of **asphalt binder** and **aggregates** mixed together at a high temperature and placed and compacted on the road while still hot
- The performance of asphalt (flexible) pavements is largely a function of the asphalt concrete surface material
- The objective of the asphalt concrete mix design process is to provide the following properties:
  - Stability or resistance to permanent deformation under the action of traffic loads, especially at high temperatures
  - Fatigue resistance to prevent fatigue cracking under repeated loadings
  - Resistance to thermal cracking that might occur due to contraction at low temperatures
  - Resistance to hardening or aging during production in the mixing plant and in service

Asphalt Concrete

- Resistance to moisture-induced damage that might result in stripping of aggregate particles asphalt from
- Skid resistance, by providing enough texture at the pavement surface
- Workability, to reduce the effort needed during mixing, placing and compaction

- Regardless of the set of criteria used to state the objectives of the mix design process, the design of asphalt concrete mixes requires compromises
- Moreover, the produced mix must be practical and economical.
- If appropriate design asphalt content is not used, the pavement will lack durability or stability, resulting in premature pavement failure
- Typical design asphalt contents range from 4% to 7% by weight of total mix

Hot Mix Asphalt Concrete Production and Construction

- The production and construction of asphalt concrete highways can be described as a three-step process:
  i. production of raw materials – production of asphalt cement at petroleum refineries
  ii. manufacturing asphalt concrete – batch plants or drum (single drum is used for both drying the aggregates and mixing in the asphalt cement)
  iii. field operations - The HMA is transported from the plant to the paving location where it is placed using an asphalt paver
    - Asphalt pavers are designed to produce a smooth surface when operated properly.
    - The keys to proper operation are a constant flow of material through the paver and maintaining constant paver speed
    - The final step in the construction process is compaction of the pavement mat

Hot Mix Asphalt Concrete Production and Construction

Asphalt Additives

- Many types of additives (modifiers) are used to improve the properties of asphalt or to add special properties to the asphalt concrete mixtures
- A relatively recent development in asphalt paving is warm mix, which uses modifiers, or a modified process, to produce asphalt concrete at lower temperatures than conventional hot mix

Recycling of Asphalt Concrete

- In an effort to efficiently use available resources, there was a need to recycle or reuse old pavement materials
- Recycling became more important in the mid-1970s due to the increase in asphalt prices.

Thank You!!!