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This paper briefly discusses the proper applications, materials used, and equipment requirements for the following for highway pavement construction, rehabilitation, and maintenance in Alaska. Specific topics are listed below.

1. Brief asphalt materials definitions
2. Asphalt concrete pavement
3. Crack sealing and filling
4. Chip seal or single-shot asphalt surface treatment (AST)
5. Bituminous surface treatment (BST) or double-shot asphalt surface treatment
6. High-flow emulsion asphalt surface treatment
7. Reclaimed and recycled asphalt pavement
8. Treated bases
9. Stone mastic (matrix) asphalt pavement (SMA)
10. Superpave hot asphalt pavement
11. Relative costs
12. Life cycle cost analysis
13. Conclusions
For more in-depth discussions, please refer to the Asphalt Institute and other publications.

14.1. Asphalt Material Definitions

Brief definitions for asphalt materials used in road construction are given to help eliminate any confusion.

*Anti-stripping agents* are usually blended with asphalt binders to improve bonding between the binder and the aggregate. Particles of opposite electrical (ionic) charge attract each other and ones of like charge repel. Thus, anti-stripping agents are used to give asphalt cement opposite charges of the aggregates. Chemical anti-stripping agents, such as PaveBond or Arr-Maz, are most commonly used in Alaska. Asphalt cement suppliers usually add anti-stripping agents. Percentage requirements for anti-strip are typically around ¼ of 1 percent by weight of asphalt.

*Asphalt cement or binder* is a black cement material, sometimes called Bitumen, that varies widely in consistency from solid to semi-solid at normal air temperatures. The main product of asphalt is derived from crude petroleum. It is the residue left over from refining processes that remove other petroleum products such as gasoline, kerosene, and fuel oil.

At high temperatures (>140° C), asphalt cement is a liquid, which allows it to be mixed with or coat aggregate particles. As the asphalt cools it stiffens, becoming solid at some point below 0° C. The chemical contents of asphalt are primarily complex hydrocarbon molecules, including asphaltenes, resins, and oils. Some of the molecules contain sulfur, nitrogen, and other elements. The physical properties of asphalt are durability, adhesion, temperature susceptibility, aging, and hardening.

Typical asphalt binder grades used in Alaska are AC-2.5, AC-5, PBA-2, PBA-3, Arctic grades, and performance grades (PG). The AC grades are asphalt cements graded by viscosity at 60° C, with higher numbers indicating higher viscosities. AC-2.5 has been used because it is theoretically more resistant to thermal cracking due to its softer nature, but recent research has not substantiated this theory. Also, AC-2.5 is prone to undesirable softening and rutting when air temperatures exceed 25° C. AC-5 has been found to exhibit thermal cracking characteristics similar to AC-2.5, and has better high-temperature properties. Limited use of stiffer AC-10 and AC-20 grade asphalt in Alaska has shown higher instances of thermal cracking.

The PBA grade stands for “performance-based asphalt.” These grades are a transitional grade between viscosity grade and performance grade (PG) asphalt binder discussed below. A PBA-2 grade is unmodified asphalt with stiffness slightly greater than AC-5 graded binder. PBA is produced in Washington and only available to the Pacific Rim. The PBA-3 grade is modified asphalt, with penetration and viscosity limits designed to resist low-temperature cracking and rutting. Modifiers used in PBA-3 may be natural rubbers (latex) or synthetic rubbers (polymer). These modifiers increase the mix and compaction temperatures for construction and make the mix harder to work. PBA-3 asphalt costs substantially more than unmodified asphalt, thus you must thoroughly consider the benefits of its application.

Arctic grade binders are modified asphalt with particular emphasis on low-temperature cracking characteristics. They are designed with the intent of flattening the slope of the viscosity/temperature relationship in a given binder. Arctic grade binders are often subject to AC grade viscosity requirements and a maximum pen-visc number. The pen-visc number (PVN) is a function of the penetration and viscosity tests on the binder. These binders are usually only used in extreme conditions, such as on the North Slope of Alaska.

Performance grade binders are graded by the temperature range (Degrees C) of intended use. For example, a PG52-28 grade is intended for use in temperatures ranging from 52 to minus 28 degrees Centigrade. Standard grades vary by 6 degrees Centigrade. Typical PG grades used in Alaska include PG52-28, PG58-28, and PG64-28. Higher temperature grades are often made of modified asphalt and used in high-traffic areas. Though temperature extremes in Alaska would dictate use of even lower, low-temperature grades, they are not currently available. Performance grade binders are part of the Superpave system described later.

*Cutback asphalt* contains asphalt particles in a suspension with a solvent. Solvents range from a heavy fuel oil consistency up to naphtha, depending on the curing time desired. Cutback asphalt cures by the evaporation of the solvent, which amounts to from 33 percent to 50 percent by weight of the material. They are classed into SC (slow cure), MC (medium...
cure), and RC (rapid cure), along with a minimum viscosity. Cutback asphalt cures by the evaporation of the solvent. Carefully consider the application of cutback asphalt due to potential environmental problems.

Emulsified asphalt is made by combining asphalt, emulsifying agents, and water. A colloid mill breaks down molten asphalt into minute droplets in the presence of water and the emulsifying agents. Emulsifying agents usually contain a type of soap. They also impart desirable properties and are most influential in maintaining stable asphalt droplet suspension. Asphalt emulsions are categorized into cationic (positive charged), anionic (negative charge), and anionic (no charge). The charge on the emulsion is used to provide for the proper attraction between it and the aggregates used.

Asphalt emulsions normally contain approximately 40 percent water. They cure, or “break,” by evaporation. Asphalt emulsions are further categorized by the relative setting (breaking) time. There are slow setting (SS), medium setting (MS), and rapid setting (RS) emulsions. Each type will have its proper application, which is discussed below.

The amount of residual asphalt is of interest to those constructing emulsified asphalt treated materials. For example, a 3 percent application of emulsified asphalt will yield approximately 1.8 percent residual asphalt after breaking.

Mixtures of aggregates and slow-curing asphalt emulsion are referred to as “cold mix,” since they do not require heating to work. Cold mixes are used for emergency repairs of pavement, such as patching potholes.

Prime coats are applied to prepared aggregate surfaces with the intent of improving the bond between pavement and aggregate. They may be emulsified asphalt or cutback asphalt. Traffic should not be allowed to drive on prime-coated surfaces until they have cured, which may take days. Use of prime coat may be problematic if the weather is cool (slowing cure rates) or if the weather is wet (causing possible runoff).

A tack coat is a thin layer of emulsified asphalt applied prior to placement of asphalt concrete pavement on a hard surface, such as existing pavement or concrete. The purpose of a tack coat is to provide a waterproof bond between new asphalt concrete pavement and existing surfaces. We recommend placing a thin tack coat on any cold edges of new paving such as joints, gutter lines, and around manholes, etc. Use of STE-1 grade (snap tack emulsion) is recommended for any tack coat application. It does not require dilution and breaks rapidly.

14.2. Asphalt Concrete, New Construction and Rehabilitation

14.2.1 Material Used

Asphalt concrete pavement is a combination of asphalt cement and aggregates, mixed in a plant. It may be called hot-mix asphalt, hot asphalt pavement, asphalt concrete, and several other word combinations, sometimes including bitumen or bituminous. The asphalt concrete pavement terminology is used here, since that is the current pay item for Alaska DOT&PF.

It is usually dense-graded, meaning that the aggregate particles have closer contact with each other to stop permeability, and it provides a sound, tough, inert material that will resist disintegration under maximum traffic loads. Asphalt cement usually comprises 4 to 7 percent of asphalt concrete pavement. Higher asphalt content mixes are more durable and resistant to aging. However, high asphalt content mixes may be subject to deformation and rutting. Low asphalt content mixes are less durable and may tend to fatigue crack with repeated loads. It is important that you develop and use optimum asphalt contents.

The aggregates used with the asphalt are classified according to their sizes. These are as follows:

a. **Coarse aggregate** is crushed stone or crushed gravel consisting of sound, durable rocks greater than 4.75 mm (0.19”) in size. The materials must meet quality requirements in terms of wear, degradation, chemical loss, and fracture.

b. **Fine aggregate** (smaller than 4.75 mm) is usually screened aggregate, sand, and soil. It may be natural, uncrushed fines or crusher fines. Fine aggregates are subject to requirements regarding grading variability, plastic index (minimizing clay particles), and chemical loss.

c. **Blended aggregate** is the combination of the coarse and fine aggregates. It must meet gradation requirements for the type of asphalt.
concrete pavement specified. The maximum size (smallest sieve with 100 percent passing) indicates the type of asphalt concrete pavement. A gradation with maximum size of 25 mm (1”) and meeting all other gradation requirements is a Type I. Gradations with maximum sizes of 19 mm (¾”) and 12.5 mm (½”) are Types II and III, respectively.

Asphalt concrete pavement mix designs determine: percent asphalt required, anti-strip requirements, and mix and compaction temperatures for a given aggregate gradation. Mix designs are usually done according to the Marshall mix design methods, where a mechanical hammer is used to compact specimens, the number of hammer drops used according to the expected traffic loading. The mix must meet certain criteria. Three classes; A, B, and C; of asphalt concrete pavement may be designed. Class A pavement is for the highest traffic loading. Class C is for very low traffic levels. Class B is for intermediate traffic levels.

14.2.2 Construction Equipment Requirements for Asphalt Concrete Pavement

- Pit development and extraction equipment will include any necessary equipment to prepare a material site, and extract and haul aggregates to a crushing plant. A crushing plant includes crushers, conveyor belts, screens, loader, hauling equipment, and controls.
- Asphalt mix plant includes aggregate bins, asphalt storage, heating and pumping equipment, conveyors, dryers, mixing equipment, truck loading equipment, storage silos, and a control room. There are two types of asphalt mix plants: batch plants and drum (continuous feed) plants. Batch plants are stationary plants that blend and discharge mix in batches of approximately 2 to 5 megagrams each. A megagram is equal to 1.1 tons. Drum plants are portable and work with a continuous feed of aggregates into the drum, where they are dried and asphalt is applied.
- Trucks for hauling hot mix to the project. Belly dump trucks are usually used on larger projects when the paver is equipped with a windrow pickup machine. End dumping trucks are used for smaller projects where the mix is dumped directly into the paver.
- Surface preparation equipment may include a water truck and power broom for overlays, a rotomill (planer) for rut rehabilitation, and all supporting construction equipment to build a structural section.
- Distributor truck for prime and/or tack coat application. Prime coat may be applied to the base course prior to paving. Tack coat is applied to existing pavement and along edges of an asphalt concrete pavement overlays.
- Paver includes receiving bin or pick-up machines and lay-down equipment. The screed drags along the back of the paver, providing initial compaction. The screed height determines the depth or thickness of the asphalt concrete pavement.
- Rollers usually include double steel-wheeled and one rubber-tired (pneumatic) roller for compaction of the mix.
- Nuclear gauges are used to monitor and check compaction levels of the mix.
- Coring machines are used to remove core samples of the completed mix, which are tested to measure the level of compaction for acceptance.
- Traffic control equipment and personnel

14.2.3 Proper Applications of Asphalt Concrete Pavement

Asphalt concrete pavement is applicable to areas of high and/or heavy traffic and stable foundations, preferably with a permanent plant nearby. A life cycle cost study in the Yukon Territory found that asphalt surface treatments were more effective than asphalt concrete on roadways with less than 2000 ADT (average daily traffic) and permafrost areas. On roadways with ADT greater than 10,000 and high usage of studded tires (>40 percent), asphalt concrete pavement may not provide sufficient wear resistance. Use of Stone Mastic Asphalt, described later, may be considered to provide better wear resistance.

Paving should not be done on wet surfaces or in the rain, or at temperatures below approximately 5° C (40° F). The mix cools too rapidly and proper compaction is hard to obtain, especially with thin paving lifts.

New construction of asphalt concrete pavement requires providing for drainage, preparation of the foundation (stripping, digging out unsuitable materials, blasting rock, surcharging, etc.), and construction of appropriate thicknesses of granular supporting layers, including subbases and base courses. The appropriate thickness of asphalt concrete
Pavement used is a function of predicted future traffic loading, foundation support, and the quality of materials available for base course and subbase. Pavement designs provide for limited frost protection using an appropriate thickness of non-frost susceptible material.

**Overlays** are a means of rehabilitation of distressed existing asphalt concrete pavement. They are most appropriately applied before the existing pavement has become too rough, cracked, and rutted. An application of emulsified asphalt tack coat is applied on the existing pavement prior to the overlay. Existing cracks may be expected to reflect up through the new overlay within one to three years. Existing rutting or roughness is usually assumed to be 75 percent corrected per lift of overlay. Therefore, more than one lift of overlay or pre-leveling may be required to thoroughly correct problems. The thickness requirement for the overlay is a function of the structural condition of the existing pavement and the predicted future traffic loading.

**Reclaim existing pavement and overlay:** This rehabilitation process is used when the existing pavement has become very rough and cracked, and is usually less than 100 mm (4”) thick. The existing pavement is ground up and mixed with a nominal thickness of the existing base. Emulsified asphalt may be applied into the mixture of broken old pavement and base course in situations where there are frost-susceptible materials or when additional support is required. The resulting blend is graded, compacted, and then overlaid with new asphalt concrete pavement. A tack coat is not required since the overlay will be on basically granular or recently treated material. See the section on reclaimed or recycled asphalt pavement for more information.

**Plane surface and overlay:** Roadways that have become rough, rutted, cracked, and have greater than 100 mm thickness of existing pavement are candidates for this type of rehabilitation. Areas with curb and gutters may require this type of rehabilitation to avoid complete removal or overlaying gutters. A rotomill or pavement planer is used to remove surface irregularities. Any large cracks may be filled with an acceptable crack sealer/filler following planing. The area to be overlaid is tack coated and paved over with the appropriate thickness of pavement.

A falling weight deflectometer (FWD) is used for structural analysis of existing structural sections, including paved and unpaved. It is a trailer mounted, nondestructive testing device with computer data logging. The FWD drops a weight on a rubber-backed circular plate that is mechanically lowered onto the surface being tested. This action is used to simulate the dynamic loading of the design vehicle. There are four possible levels of weight drops. Drop stress and maximum pavement deflections at seven locations, including the center, are monitored and recorded to computer screen, disk, and a printer. These data are used to back-calculate the modulus of each structural section layer, such as pavement, base course, subbase course, and subgrade. Using elastic theory, stresses and strains within the structural section are predicted and limiting criteria are applied. The limiting criteria are used to determine the structural capacity of the section in terms of numbers of equivalent single-axle loads (ESALs) to failure. If the predicted number of ESALs to failure is less than what is expected in the design life, work must be done to improve the structure.

### 14.3. Crack Sealing and Filling

#### 14.3.1 Background and Materials Used

Cracks in pavements appear in many forms and they are caused by several internal and external factors associated with the roads. They may be caused by:

- Thermal shrinkage of the pavement
- Differential frost heave
- Differential settlement of subgrade materials
- Poor construction of joints in the pavement
- Slope stability problems
- Fatigue of pavement layer under traffic loading due to loss of support

Cracks are sealed to prevent the intrusion of water into the underlying pavement layers. Once water gets into the supporting layers of the pavement, further cracking may be due to its affecting the differential, stability, and support problems mentioned above. Crack sealing is more critical in wetter climates. The cracks must be wider than approximately 6mm (1/4”) for crack sealing to be effective.

Crack sealants typically used are hot-applied, low-modulus, modified asphalt materials that retain flexibility down to -40°C. Modifiers used include rubber extender oils, reinforcing fillers, and polymers. Some typical brands used consist of Crafco Roadsaver 231 and Koch Flex 270-ME. Sometimes hot AC-5 or
Emulsions may be used temporarily. However, these do not have the low-temperature flexibility that Crafco and Koch-type materials have.

Cleaning, routing, and heating the crack edges is done prior to applying crack sealers. Wider cracks may not require routing. Sealant is heated and pumped through a hose to a wand for application. The top of the sealant is then leveled and flattened with a squeegee. Sometimes the back edge of the wand may have a squeegee edge.

On the wider cracks and potholes, crack filling is usually done with a CRS-2 emulsion and chips. The chips are necessary to help fill and provide support. Very wide cracks and potholes may require filling and smoothing with cold- or hot-mixed asphalt concrete.

### 14.3.2 Equipment Requirements for Crack Sealing and Filling

- **Joint preparation equipment** consists of tools designed to blow out, heat up, or rout out cracks.
- A double boiler heater with agitator and pump that is thermostatically controlled
- **Application equipment** such as a wand or other device
- **Traffic control equipment and personnel**

### 14.3.3 Proper Applications for Crack Sealing or Filling

Crack sealing and filling are generally maintenance operations, though they are sometimes done in conjunction with pavement rehabilitation projects. Most maintenance crack sealing is done on the narrow cracks, but over 6 mm (¼") in width, that appear within the first three years after construction.

Crack filling is done when cracks get wider than 25 mm. Crack filling usually involves placing and compacting cold- or hot-mix asphalt. Sometimes the bottom of a crack may be filled with fine aggregates, then emulsified asphalt, then more aggregates, then squeegeed smooth.

### 14.4. Chip Seal (Single-Shot Asphalt Surface Treatment)

#### 14.4.1 Materials Used

A chip seal or single-shot asphalt surface treatment is the spraying of emulsified asphalt material followed immediately by a thin (one-sized stone) cover. This is rolled as quickly as possible to create adherence between the asphalt and the aggregate cover. The chips (or stones) range from 19 mm aggregates to sand and are predominantly one size. Sand seals are less costly and appropriate for use in areas with low-volume traffic. As the expected traffic volume increases, the size of the aggregate is usually increased.

Typically, 12.5 mm maximum size aggregates or “E Chips” are used. The aggregates are required to be highly fractured, have high resistance to degradation in moist conditions, and have low susceptibility to chemical loss. The aggregates must be clean, having less than 1 percent dust, for the combination of emulsion and aggregate to work properly.

Use CRS-2, cationic rapid-setting, high-viscosity emulsion, for chip seals. A latex modified CRS-2P is recommended for use in higher traffic areas and/or warmer climates. These emulsions will break within minutes of the time of application, so it is important to apply chips very soon after it is sprayed.

### 14.4.2 Construction Equipment Requirements for Chip Seals

- **Pit development and extraction equipment**: This will include any necessary equipment to prepare a material site, and extract and haul aggregates to a crushing plant.
- **Crushing plant** includes crushers, conveyor belts, screens, loader, and controls. Washing over screens may be required to clean chips.
- **Trucks** for hauling materials to the crushing plant and chips to the project are also required.
- **Surface preparation equipment** may include a water truck and power broom pavement applications, a grader and compactor for gravel applications, and all supporting construction equipment to build a structural section for new construction. Leveling and patching may be done with either cold-mix or hot-mix asphalt.
- **Emulsion distributor** is used to contain, heat, and evenly apply CRS-2. Newer models are computer controlled and provide more accurate distribution of the desired amount of emulsion applied. It is very important to have even and proper distribution of emulsion for a good chip seal.
- **Chip spreader** is used to receive from trucks and evenly spread chips. The newer and better models are computer controlled and have augers in the front spreader bar to evenly distribute the chips and avoid segregation. Even and accurate spreading of the chips is very important to the
success of a chip seal operation.

- Rollers usually include two rubber-tired (pneumatic) rollers for compaction of the treatment.
- Traffic control equipment, pilot car and personnel

### 14.4.3 Proper Applications of Single-Shot Chip Seals

Primary applications of single-shot chip seals extend the life of existing asphalt concrete pavements or rehabilitate older emulsified asphalt surface treatments. When fine cracks are too extensive to make crack sealing operations effective, chip seal may be used to seal the cracks. A chip seal applied to a rough, aged pavement is not expected to stop progressive distress. Chip seals are often done as a maintenance operation. They may also be used to improve skid resistance on paved surfaces. They are relatively inexpensive to construct and do not require the large expenditures for purchase and mobilization of an asphalt plant.

A good chip seal application is for existing pavements that have become aged, as indicated by whitish color and narrow cracking without excessive roughness or rutting. When cracking densities are such that normal crack sealing operations are not cost effective, consider chip seals. Chip seals are generally used where the volume of traffic is less than 10,000 ADT. A properly applied chip seal may extend the life of the pavement for five years or more.

Chip seals could be applied to a prepared base course or on recycled in-place asphalt material. However, since they are relatively thin, the use of a double-shot asphalt surface treatment or high-float surface treatment will give longer life and are worth serious consideration.

Chip seals are not used when existing pavements have wide cracks or deep ruts, or are very rough. If these problems are localized, they may be patched or repaired by other means and then chip sealed. Chip seals also not recommended for heavy-traffic urban areas or roadways with greater than 6 percent or 8 percent grade.

The minimum temperature for construction is about 10° C. (50° F.) and it should not be placed during or prior to expected rainfall. The asphalt emulsion will break too slowly at low temperatures. Rainy conditions may cause the emulsion to run off into inappropriate areas. Therefore, the timing of construction is carefully planned and flexible.

Cured asphalt emulsion will coat approximately two-thirds of the thickness of the larger aggregates in the final product. Since the emulsion is approximately 40 percent water, this means that during construction, it must coat to the top of the larger aggregates. It is better to err in using too much emulsion than not enough. You can always add more aggregates or blotter to an over-asphalted chip seal, but you cannot add more emulsion once the chips are placed.

### 14.5. Bituminous Surface Treatment (BST) or Double-Shot Asphalt Surface Treatment

#### 14.5.1 Materials Used

A BST is a double application chip seal similar to the single-shot chip seal with a choke stone application. These are often referred to as bituminous surface treatments, or BSTs. However, our neighbors in the Yukon Territory call a high-float surface treatment a BST. The pay item name we use to contract this work is “asphalt surface treatment.” Thus, the double-shot asphalt surface treatment term is used here.

On a prepared surface, CRS-2 is applied, immediately followed by chips. A modified CRS-2P is recommended for application in high-speed and heavy traffic areas. Modified emulsions provide superior adhesion to chips and are less likely to become soft at warmer temperatures. They may also reduce thermal cracking. The chips are required to be predominantly one sized and clean. The first chip application may be twice as large as the second application. The idea is that the second chip application will fit into voids left in the first. Often, 25 mm or 19 mm maximum size chips will be applied in the first application. The treatment is rolled and left to cure for a few days.

The surface of the first treatment is prepared by sweeping. The second layer will then be placed with another application of CRS-2 and then using 12.5 mm or 9.5 mm (3/8”) maximum size chips, which are to fit in and make a tight surface. However, when various sized chips are not available, a double application of same-sized chips may be used.

#### 14.5.2 Construction Equipment

**Requirements for Double-Shot Asphalt Surface Treatments**

Same as for chip seals.
14.5.3 Proper Applications for Double-Shot Asphalt Surface Treatments

A double-shot asphalt surface treatment may be used any place a single-shot chip seal could be applied. Due to using two applications, they might be applied to surfaces that have too much cracking and raveling to use a single-shot chip seal. If there are problems with a single-shot chip seal application, it may be desirable to apply a section shot. Since it takes approximately twice the time and materials as a single-shot chip seal, it is probably not cost effective for simply extending the life of the pavement.

They are more suitable for construction on prepared gravel surfaces since the second application makes a tighter and thicker layer. The total thickness of the treatment will be from 19 mm to 25 mm. They are used for surfacing and maintenance repairs in unstable foundation areas.

On stable foundations, the design structural section is calculated to be the same as would be suitable for a 50 mm (2") asphalt concrete pavement. The crushed aggregate base course is then the primary structural member, so it must not be under-designed. We recommend using a minimum of 150 mm (6") crushed aggregate base course for asphalt surface treatments. If the base course is treated with asphalt emulsion, this thickness may be reduced.

Asphalt surface treatments are often used to upgrade existing gravel roads, control dust and reduce maintenance costs. They may be placed on frost-susceptible materials (containing greater than 6 percent silt). However, frost-susceptible materials directly under the proposed surface treatment should be treated with calcium chloride first. Calcium chloride tends to bind up the fines and suppresses the freezing point, making frost susceptibility less of a problem. Calcium chloride treatment is often done a year ahead of the surface treatment.

Emulsified asphalt surface treatments on unbound gravel support are not recommended for parking areas. At warmer temperatures, parked vehicles tend to sink into the surface treatment and the rubber tires may stick to the emulsion, causing it to pick up when the vehicle is moved. They are not typically used on existing pavements that are very rough, or that have wide cracks or deep ruts. If these problems are localized, they may be patched or repaired by other means and then surfaced. Emulsified asphalt surface treatments are not recommended for heavy traffic urban areas or places with greater than 6 percent or 8 percent profile grade.

The minimum temperature for construction is about 10° C and it should not be placed during rainfall. Therefore, the timing of construction must be carefully planned and flexible. Emulsion application amount for double-shot asphalt surface treatments are the same as for chip seals, that is, final product with two-thirds aggregate embedment into the cured asphalt.

High-float surface treatments are cheaper and should be considered along with this treatment. A main justification for a double-shot asphalt surface treatment is when available equipment is not capable of placing the much larger quantities used on high-float surface treatments.

14.6. High-Float Emulsion Asphalt Surface Treatment

14.6.1 Materials Used

High-float emulsion’s name was derived from the asphalt residue test from distillation it must satisfy: a minimum float test in water 60° C (140° F.). High-float emulsion has the capability of wicking up into the fine materials, unlike CRS-2 that basically only allows embedment of clean aggregate.

In Alaska, typically HFMS-2s grade emulsion is most often used. That is, high-float, medium setting, high viscosity with solvent emulsion. It is considered an anionic emulsion. An HFMS-2s is a specific type of emulsion that may contain up to 7 percent oil distillates, which can result in a softer residue that is less sensitive to low-temperature construction than CRS-2. The emulsion tends to develop a weak gel structure immediately after spraying, which creates a greater resistance to flow on banked and crowned surfaces. It is important to place cover coat material in the emulsion soon after it is sprayed, but not as critical as with CRS-2, since HFMS-2s is a medium setting emulsion. Crushed pit run material may be used, without having to wash, as is sometimes necessary for chip sealing. Cover coat material is simply a crushed aggregate base course, usually screened so that 100 percent passes the 19 mm sieve. A minimum amount of silt-sized material is desirable, with up to 5 percent or 8 percent being allowed. The moisture content of the cover coat is limited to somewhat less (usually half) of the optimum moisture content of the cover coat in order to provide for proper flow through the
Segregation of aggregates often occurs when too wet a cover coat is used.

Application rates are approximately double that of a single-shot chip seal. Thus, high-float surface treatments provide the possibility of constructing a surface similar to a double-shot asphalt surface treatment, except in one pass of the equipment.

**14.6.2 Construction Equipment Requirements for High-Float Surface Treatments**

The requirements are basically the same as for chip seals, except the crushing plant may not be required to wash fines out of the aggregates. Also, some of the older, smaller chip spreaders are not capable of laying down the high quantities needed in high-float operations. Similar considerations must be taken for distributors, which must spray double volumes of emulsion. Newer, computer-controlled chip spreaders and distributors are recommended for use with high-float surface treatments to accurately provide for the large quantities needed. Chip spreader bars equipped with augers to keep the material moving and avoid segregation are recommended.

**14.6.3 Proper Applications for High-Float Surface Treatments**

See the text under double-shot asphalt surface treatments. High-float surface treatments are cheaper to construct than double-shot chip seals since they require only one application of emulsion and cover coat. The cover coat is usually less expensive to produce since it may be simply crushed, screened, pit-run material rather than needing the washing and wasting that is done in chip production. However, high-float surface treatments appear to work best in dry climate areas where cover coats can be kept dryer to avoid segregation.

Use of emulsified asphalt surface treatments on unbound gravel support is not usually recommended for parking areas. At warmer temperatures, parked vehicles tend to sink into the surface treatment and the rubber tires may stick to the emulsion, causing it to pick up when the vehicle is moved. They are not generally used on existing pavements with wide cracks or deep ruts, or that are very rough. If these problems are localized, they may be patched or repaired by other means and then surfaced. Emulsified asphalt surface treatments are not recommended for high traffic urban areas or areas with grades steeper than 6 percent to 8 percent.

High-float surface treatments may be placed at temperatures down to approximately 5° C (40° F) and rising, making them better candidates for cooler areas. Still, avoid placement during or immediately following rainfall. These surfaces initially may be very dusty and are swept after three to seven days of curing. The dust actually helps control traffic speeding, but makes it hard to stripe the first year. Usually the centerline is temporarily striped the first year. Then the centerline and fog lines are restriped the second year.

**14.7. Reclaimed and Recycled Asphalt Pavement**

**14.7.1 Background and Materials Used**

Reclaimed asphalt pavement (RAP) is the removed and/or processed material containing crushed asphalt pavement. It may be used in the construction of stabilized base course or recycled asphalt pavement. Depending on the asphalt plant used and the expected application, between 15 percent and 50 percent RAP may be added when constructing recycled asphalt pavement. With batch plants, RAP is added to the hot aggregate in the pugmill. Batch plants can take up to approximately 15 percent RAP before cooling compromises the product. Continuous asphalt plants can take higher percentages of RAP since it is input to the drum and heated. Many states have standard asphalt concrete pavement specifications indicating an allowable maximum percentage of RAP.

Base course may be constructed using pure RAP, or by mixing it with crushed aggregates. An asphalt emulsion, such as CSS-1 (cationic slow setting), may be added for further stabilization.

**14.7.2 Equipment Requirements for RAP**

If used for pavement, use the same equipment listed for asphalt concrete pavement with provisions for adding RAP. The crushing plant must be set up to crush old pavement into sizes that can be fed into the plant. Otherwise, you can use millings left from pavement planing. Batch plants must be equipped with a feeder, conveyors, and all its appurtenances for adding RAP to the pugmill. Continuous plants must have a feeder, conveyor, and a RAP inlet.
There are many other treatments that can be applied to crushed granular materials. Portland cement is rarely used since its import is expensive. Small amounts of Portland cement (about 5 percent) are sometimes used in emulsified asphalt and sand mixtures to aid in breaking.

Some other stabilizing agents/dust palliatives, such as PermazymeR, use tree resins as a binding agent. They are added to water and sprayed on the surface prior to grading and compaction. These agents work best when treated material contains clay. Most of the soil deposits in Alaska contain little clay, so the application of these stabilizers is limited.

Calcium chloride is often used for dust control on gravel roads. It is a salt that, along with proper amounts of moisture, binds silty aggregates and controls dust. The material is either applied dry in flake form and then wetted, or mixed with water and sprayed on. Dust control operations require annual or biannual applications since the materials tend to leach out.

Calcium chloride is sometimes used to treat base course materials that are to be paved in order to limit frost susceptibility. It depresses the freezing point and its binding properties limit capillary action.

Calcium chloride is a demulsifier of emulsified asphalt. This means it will make the emulsified asphalt break quicker. Therefore, it is not normally used to treat roads that are to have an asphalt surface treatment applied in the near future.

One purpose of any treated base is to provide improved structural support for paving. When asphalt treated base course is used, a portion of its thickness may be substituted for the thickness of asphalt concrete pavement required by structural design.

14.8. Treated Base Course

14.8.1 Background and Materials Used

This section introduces many of the treatments that may be used as stabilizers and dust palliatives on gravel surfaces. The focus, however, is on the asphalt treated varieties, which are dealt with in more depth.

Independent of the RAP base course applications described earlier, asphalt treated bases may be divided into two categories: 1) hot asphalt treated, and 2) emulsified asphalt treated. These two categories may be further subdivided into dense graded and open graded (permeable) bases. Dense graded bases are the materials typically specified for highway construction. Open graded bases require special considerations.
Density of open-grade asphalt treated base is only 60 percent to 70 percent of dense graded base or asphalt concrete pavement. This material is suited for areas with drainage problems that cause weakening of the base.

Dense graded emulsified asphalt treated bases are produced by any means available to combine the emulsified asphalt and crushed aggregates. Some mixing methods include using a pugmill, using a mixing plant, and road mixing. Slow-setting CSS-1 or medium-setting CMS-2 emulsified asphalt is used in production. The CSS-1 grade is the most forgiving, allowing more time to grade and shape before it breaks.

Open-graded emulsified asphalt treated bases are rarely, if ever, used in Alaska. They have been successfully used in Washington and Oregon. Consult Regional or Statewide Materials for further information.

**14.8.2 Equipment Requirements for Treated Base Course**

Construction of hot asphalt treated base course requires virtually the same equipment as is needed for asphalt concrete pavement. Any base course material will have to be crushed, necessitating use of a crushing plant, loader, and hauling equipment.

Emulsified asphalt treated materials require various pieces of equipment, depending on the method of mixing that is used. The simplest road mixing process will only require distributors, graders, and rollers. Pugmill operations require emulsion storage, heating, and pumping facilities.

Sometimes emulsified asphalt treated is placed using conventional paving equipment. It is often placed using belly dump trucks, bladed into place with a grader, and compacted using steel wheeled rollers.

Dust control operations use spray trucks equipped with stirring mechanisms and graders. If applied dry, a truck with feeding and distribution equipment for the particular material is needed.

Traffic control equipment and personnel are necessary for a safe operation.

**14.8.3 Proper Applications for Treated Bases**

The base course is a primary structural member in a paved section. It is therefore of great importance to provide proper materials. When crushed aggregate base course meeting standard quality requirements is not available, treatment is considered. If the treatment is cheaper than hauling standard materials, it is used.

Dense graded asphalt treated and emulsified asphalt treated bases are used in areas where the structural design indicates excessive thickness requirements of asphalt concrete pavement. They provide for decreasing the pavement thickness requirements. Treated base courses may also be used to “lock up” fines in materials with excess silt sized particles or materials that tend to degrade.

When a road is to be rehabilitated and shows signs of base failure, you may choose to look at treating it. Signs of base course problems are premature fatigue cracking, premature rutting, potholes, and breakouts. Rutting referred to here is from permanent deformation in supporting layers of the pavement – not the mix.

Open-graded asphalt treated base may be used in situations with poor drainage where embankments are frost-susceptible and tend to saturate in the spring. It may be used as a substitute for crushed aggregate base course in areas, which have marginally degradable materials. The asphalt treatment is then used to coat the aggregates and protect them from degradation.

There does not appear to be a large cost savings between asphalt treated base courses and asphalt concrete pavement. Therefore, the main justification for its use is not to save money on asphalt concrete pavement.

Emulsified asphalt treated bases are slightly cheaper, but there are problems getting enough asphalt into the base. Recall that asphalt emulsions contain approximately 40 percent water. Optimum moisture contents for crushed aggregate base course range around 4.5 percent. Added asphalt emulsion acts as moisture during the mixing and placing phases of construction. Therefore, even if the crushed aggregate base course was bone dry and you added 4.5 percent of emulsion, the residual asphalt content would only be approximately 2.7 percent, which is barely enough to coat the aggregate. In reality, the crushed material used will always have moisture. If you add emulsion percentages to make the total of moisture and emulsion much higher than the optimum, it will be saturated and a mess.
14.9. Stone Mastic (Matrix) Asphalt Pavement (SMA)

14.9.1 Background and Materials
SMA is a product that is relatively new in America. It was developed by contractors in central Europe who are subject to giving warranties for their work against rutting. SMA optimizes stone-on-stone contact in the mix. It is a gap graded, hot-mix asphalt with a large proportion of coarse aggregates with amounts retained above 2-mm (0.08”) size at approximately 80 percent, and a rich asphalt cement/filler mastic. The coarse aggregates form a strong structural matrix. Asphalt cement, fine aggregate, filler, and stabilization additive form a mastic that binds the structural matrix together. The coarse aggregates form a strong structural matrix. Filler may be silt. The coarse aggregates are highly fractured and roughly cubical stone. Relatively high asphalt contents (about 6.5 percent of the total mix) provide for a durable pavement. A stabilizing additive, usually 0.3 percent cellulose from ground newspapers, is included in SMA to prevent hot asphalt cement from draining down during hauls.

The Scandinavians found that SMA pavements resist studded tire wear better than dense graded pavements. They found that the major factor in studded tire wear resistance of SMA is the quality of coarse aggregate. Several new tests have been developed to test aggregate and mix for studded tire wear resistance. The Materials laboratories in Anchorage and Juneau have Ball-Mill testers that apply impact loading to coarse aggregates under aqueous conditions to rate the wear resistance.

14.9.2 Equipment Requirements for SMA
Requirements are basically the same as for asphalt concrete pavement with a few differences.

No rubber-tired rollers are used since they tend to stick to the mix. However, three steel-wheel rollers are recommended, using two for breakdown and one for finish rolling. Often a release agent, such as dish soap, must be added to the water that is sprayed on the drums of the steel-wheeled rollers. This helps to avoid their picking up of the mix.

Injection equipment for adding stabilizing agent in the plant must be included in SMA production. In batch plants, the stabilizing additive is mixed with the aggregates in the pugmill, just prior to adding the asphalt. In drum plants, stabilizing additive is blown into the asphalt spray.

A separate bin for mineral filler is also included in the plant.

14.9.3 Proper Applications for SMA
The rotomill and overlay option, described in the asphalt concrete pavement section, substituting SMA for the overlay, is used in rehabilitation of worn and rutted pavements. SMA is always placed as an overlay on a dense graded pavement surface. Since it is very coarse, it is not desirable to place it as base (bottom lift) paving where it may prematurely fatigue.

SMA is recommended for use in areas of high traffic flow where there is a high usage of studded tires and frequent winter thaw periods. In Anchorage, routes with ADT greater approximately 10,000 are subject to accelerated studded tire wear and rutting. Because SMA is expensive, it is not recommended for use in low-traffic, rural, or residential areas.

14.10. Superpave Asphalt Concrete Pavement

14.10.1 Background and Materials
The term Superpave stands for Superior Performing Asphalt Pavements. This refers to a relatively new product line that was developed by the Strategic Highway Research Program (SHRP), in which the mix design methods are dictated by the predicted traffic loading and the climate in the project area. It is a related asphalt mixture and binder specification that facilitates the selecting and combining of asphalt binders, aggregates, and any necessary modifiers to acquire the level of pavement performance required.

Superpave uses a completely new system for testing, specifying, and selecting asphalt binders. The binders are called performance grades (PG max. temp.-min. temp.). There, binders are graded according to the maximum and minimum design temperatures expected in the project area. The maximum design temperature is supposed to be maximum design seven-day average pavement temperature. The minimum design temperature, according to the current procedure, is the minimum air temperature expected on the project. Different percentile confidence limits may be used depending on the design needs. In Alaska, a designer may use PG52-34 grade asphalt binder. The high-temperature grade is supposed to help the mix resist plastic deformation up to the...
design temperature under loads. The low-temperature grade is supposed to help the mix resist thermal cracking. Unfortunately, in order to obtain a reasonably high confidence of thermal cracking resistance in many areas of Alaska, it would require low-temperature PG grades below that which is physically impossible to make. Research is continuing to find asphalt modifiers that may help us.

The Superpave design process uses a gyratory compactor to compact mixes. A gyratory compactor uses a rotating flat steel plate that is forced down on the mix contained in a steel cylinder. The number of gyrations required for a mix design is determined from the expected equivalent single-axle truck loads (ESALs) and the design seven-day maximum air temperature. The mix must meet voids criteria, in terms of percentage of air voids, percentage of voids in the mineral aggregate, and percentage of void filled with asphalt at three gyration levels. The goal of the process is to provide for a mix that has a strong aggregate skeleton that will not be tender and will resist rutting. Superpave mixes are not as coarse as SMA.

The Superpave mix design process differs most significantly from the Marshall mix design process in that it requires the designer to try various gradations in order to determine the one(s) that will meet the voids criteria at all three gyration levels. This process requires a minimum of three stockpiles to work up assorted blends with different gradations. It is geared for a contractor mix design. However, the current system used in Alaska calls for mix designs to be done by the state. Therefore, this process calls for closely working with a contractor to develop the mix design.

The above is just a brief overview of the Superpave methodology. For further information, contact your regional or statewide Materials sections.

**14.10.2 Equipment Requirements for Superpave Asphalt Concrete Pavement**

See list for asphalt concrete pavement. Due to the possibly more bony nature caused by design of a strong aggregate skeleton, the Superpave mix may be more difficult to compact than standard dense graded mixes. Therefore, pay special attention to providing appropriate compaction equipment.

**14.10.3 Proper Applications for Superpave Asphalt Concrete Pavement**

Since low-temperature PG grades have not been found that will resist thermal cracking in the coldest regions of Alaska, this is just another, more complex method of asphalt grading. However, it can help us understand what to expect from whatever grade is used. It can help us understand the effects of asphalt modification and the cost of any benefits.

The Superpave mix design process targets pavement rutting. This is not an appreciable problem in Alaska, except mostly in heavy-traffic urban intersections.

Superpave mixes, being of a coarse nature than dense graded mixes, are expected to be better at resisting studded tire wear. However, they are finer than stone mastic asphalt mixes, so may not resist studded tire wear as well. The gradation requirements indicate that Superpave mixes will cost somewhere between stone mastic asphalt and typical dense graded mixes. Their application would then be in areas subject to moderate studded tire wear or intersections with heavy truck traffic. Superpave mixes have been called “poor man’s SMA.”

**14.11. Relative Costs**

Table 1 gives estimates of relative costs in dollars for application of the alternatives listed above that apply to the surface treatments. Alternatives for base course are shown in Table 2. The costs include only design, construction, traffic control, and striping, if applicable. These estimates are costs to the buyer, in this case, the Alaska DOT&PF. For this presentation, a 50-mm overlay of standard asphalt concrete pavement is set at $1. This information is not intended for use in specific project estimating where particular details must be accounted for. These costs are intended to give the reader a general comparison.

Notice the asphalt surface treatments (ASTs) are the cheapest options. That does not mean they will always apply to the given situation. However, they are always worth serious consideration. In proper applications, they can extend the life of pavement by five years or more.

High-float or an AST may be used as the surfacing on a structural section. When properly designed and constructed, they can last more than ten years, which is similar to the life of asphalt concrete pavement. These treatments are especially applicable to unstable foundation areas since they are very flexible and
reasonably easy to rehabilitate. It is more complicated and expensive to rehabilitate asphalt concrete pavement placed on an unstable foundation.

Applications of stone mastic asphalt are currently limited to high-traffic urban areas in Anchorage. It is cost effective to use if it will last approximately 40 percent or more longer than standard asphalt concrete pavement.

Using RAP in asphalt concrete pavement has no benefit since it costs approximately the same as standard mix yet it is not desirable for use as a wearing course. However, allowing its use in lower lifts of paving has the environmental benefit of cleaning up waste piles. If contractors are given standard specifications that allow for its use as they can best figure out, it may become cheaper.

Superpave-designed asphalt concrete pavement has only been used in Southeast Alaska as of this writing.

Table 14-2 shows estimates for relative costs of base course alternatives. In this presentation, the relative cost of standard crushed aggregate base course is set at $1. That is not the same $1 as used in Table 16-1. The costs are for volumetric measure. The lower density of open graded base course, making greater coverage per unit weight, is accounted for. The other materials are assumed to have similar densities.

### Table 14-1

**Estimated Relative Costs for Surface Repair and Rehabilitation Alternatives**

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Relative Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 mm (2&quot;) asphalt concrete pavement overlay</td>
<td>$1.00*</td>
</tr>
<tr>
<td>Reclaim existing pavement + 50 mm asphalt concrete pavement overlay</td>
<td>$1.20</td>
</tr>
<tr>
<td>Plane existing pavement + 50 mm asphalt concrete pavement overlay</td>
<td>$1.50</td>
</tr>
<tr>
<td>Crack sealing</td>
<td>$0.02</td>
</tr>
<tr>
<td>Chip seal (single shot AST)</td>
<td>$0.35</td>
</tr>
<tr>
<td>Double-shot AST</td>
<td>$0.60</td>
</tr>
<tr>
<td>High-float surface treatment</td>
<td>$0.40</td>
</tr>
<tr>
<td>50 mm asphalt concrete pavement overlay using RAP</td>
<td>$1.00</td>
</tr>
<tr>
<td>50 mm stone mastic asphalt overlay</td>
<td>$1.50</td>
</tr>
<tr>
<td>Plane/rotomill existing pavement + 50 mm Stone Mastic Asphalt overlay</td>
<td>$2.00</td>
</tr>
<tr>
<td>50 mm Superpave Asphalt Concrete Pavement overlay</td>
<td>$1.35</td>
</tr>
</tbody>
</table>

* Set at $1.00 for this presentation.
Table 14-2
Estimated Relative Costs for Base Course Alternatives

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Relative Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>150 mm (6”) crushed aggregate base course</td>
<td>$1.00</td>
</tr>
<tr>
<td>150 mm Recycled/crushed asphalt pavement as base course (untreated)</td>
<td>$1.00</td>
</tr>
<tr>
<td>Calcium chloride, per application</td>
<td>$0.05</td>
</tr>
<tr>
<td>100 mm (4”) crushed aggregate base course treated with 3% asphalt emulsion</td>
<td>$2.10</td>
</tr>
<tr>
<td>100 mm crushed aggregate base course treated with 4% asphalt cement</td>
<td>$2.20</td>
</tr>
<tr>
<td>100 mm open-graded base course treated with 3% asphalt cement</td>
<td>$1.85</td>
</tr>
</tbody>
</table>

Most applications will call for only the standard crushed aggregate base course materials to be used. Recycled/crushed asphalt pavement is often substituted for crushed aggregate base course. The direct substitution is provided for in the special provisions for most paving projects. That is why the cost is shown equal in Table 16-2. If it is proposed to be used for a project, the cost will increase, depending on availability. The addition of even crushed asphalt materials in base course increases its stiffness and decreases its compressibility in moist conditions.

Dust control agents are applied only when the gravel surface is to be operated on for an extended period of time. They should not be expected to last more than one year per application of the dust control agent.

Asphalt treatment of base course materials creates stiffer support and decreases the required thickness of asphalt concrete pavement, other things being equal. There is a serious cost for this, as shown above. The emulsified asphalt treated base course is nearly as expensive as asphalt cement treatment. This is because emulsion is approximately twice as expensive as asphalt cement. Emulsified base course is easier to work with, since it can be bladed into place. Asphalt cement treated bases require paving machines.

Open-graded asphalt treated base course shows up as the cheapest of the asphalt treated base courses. It has not seen much use in Alaska as of this writing, but the projects where it was used demonstrate superior performance. It provides structural support similar to other asphalt treated bases and also allows for drainage in springtime and other wet conditions.

14.12. Life Cycle Cost Analysis

This discussion is meant only as a simplistic introduction to concepts used in economic analysis of engineering alternatives. A formal recommended procedure is yet to be developed.

When different materials are being considered during the design of roadways, we recommend determining the life cycle cost of the alternatives. That is, determining the present cost of each alternative if done or repeated over a period of time (analysis period). The analysis period is at least as long as the design life plus one reconstruction of the longest lasting alternative. The present value is the sum of all the expected costs incurred within the analysis period for each alternative. The present value of costs computation must take into account inflation. The equation to use for determining the present value of costs (PVC) for action \( a \), in an analysis period of \( n \) years, based on current prices is:

\[
PVC = (\text{Cost of action } a) \times \frac{1}{(1+I)^n}
\]

Where: \( I \) = inflation rate (decimal)
\( n \) = years

For example, consider an asphalt concrete pavement overlay that presently costs $100,000 per lane kilometer (mile) to construct. Each overlay is expected to have a design life of 15 years and the analysis period is 30 years. The inflation rate is 4 percent. Then present values are:

1st overlay at year 0 costs:
$100,000*(1/(1.04^0)) =$100,000

2nd overlay at year 15 costs:
$100,000*(1/(1.04^{15})) =$55,526

3rd overlay at year 30 costs:
$100,000*(1/(1.04^{30})) =$30,832

Life cycle cost of overlays (Sum) $186,358

This process is used for other alternatives with different costs and design lives for the same analysis period. The alternative with the least expensive life cycle cost is recommended as most cost effective.
Other costs such as maintenance and user costs may be considered. The present values of these are estimated using basic engineering economy principals with gradient cost functions. The present values of these costs are added to the life cycle cost of the alternative, and the totals compared again. In some situations there may be benefits or salvage values to consider. These would be subtracted from the life cycle cost and the final results compared. Be careful not to skew results with unrealistic assumptions.

14.13. Conclusions

1. We must be aware of practical surfacing/rehabilitation alternatives for projects.

2. Provisions for surface and subsurface drainage have the greatest effect on the life of any alternative. Better drainage of water away from the pavement structure directly translates to longer life of the project.

3. Always consider asphalt surface treatment (AST) in areas with less than 2,000 average daily traffic (ADT) unless profile grades are greater than 6 percent to 8 percent.

4. An AST is considered for areas with less than 10,000 ADT.

5. Areas with unstable foundations should have AST applied when gravel surfacing is not acceptable.

6. ASTs are used for the first upgrade of a roadway from gravel.

7. Try to stick with one system or the other on a given project. That is, use either an asphalt concrete or AST throughout your project. This will save contractors from having to mobilize two spreads of equipment and personnel.

8. Calcium chloride treatment of gravel depresses the freezing point and helps bind the materials. In these ways, it helps decrease frost susceptibility.

9. Calcium chloride treatment of gravel roads should take place at least one year prior to placement of an AST. The presence of concentrations of calcium chloride next to asphalt emulsions will make the emulsion break prematurely.

10. Asphalt concrete pavement should be considered for areas with over 2,000 ADT.

11. Asphalt treated base course materials provide the benefit of reducing the thickness required for a wearing course if more than 50 mm (2") thick. However, they greatly increase the cost of the base course.

12. Stone mastic or matrix asphalt (SMA) is used to rehabilitate areas with premature rutting failure due to studded tire wear. These are generally in urban areas with greater than 10,000 ADT. It is used only as an overlay on previously laid asphalt concrete pavement.

13. Applications for Superpave for needs somewhere between using asphalt concrete pavement and SMA.

14. Life cycle cost analysis at the design level will provide an estimate of the most cost effective alternative to construct.

15. Use common sense!