A SunCam online continuing education course

An Introduction to Asphalt Pavement Construction

by

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Getting Started

The material and work associated with placing what will be termed as "Asphalt Paving" goes by many other names. "Hot mix", "Bituminous Asphalt", "Bituminous Concrete Pavement", or just plain "mix" are some of the more common. Asphalt paving is classified as a flexible pavement for design purposes.

There are also relatively new buzzwords in Asphalt pavement, mostly lead by the word "Super pave". Super pave is the federal government's attempt to improve and "nationalize" the performance of Asphalt pavement. Costs have increased drastically in order to manufacture and place this mix and the long term results are still being evaluated, but

generally, it is looked upon as beneficial and will be discussed further in other parts of this course.

When we talk about Asphalt pavements, there are many different test procedures used to determine acceptability, involving among other things, measurement for air voids and compaction. The typical unit of measurement for payment is the Ton or SY. These subjects are covered further as the course proceeds.

Asphalt pavement sections are placed in multiple lifts. They are usually classified by the purpose they serve, being surface, binder or base. Super pave terminology has changed that some. It lists size of aggregate in mm in the pavement description, and depending on that number, with some owners, you distinguish the location of placement. As an example, 19 mm paving is commonly used as a surface mix.

Asphalt plants are a **LOT** harder to get permits for than concrete plants. Things like Stack Tests and other technical testing will have to be performed by independent testing labs. When planning to set up a portable Hot Mix plant for a specific project, it is imperative to confirm with local and state authorities that permits are available, and the approximate time frame it will take to issue them. Some areas have even set a moratorium on issuing any permits at all for new or temporary Asphalt plants.


(asphalt drum plant)


(asphalt batch plant)

Why do Owners choose Asphalt Pavements?

There are several reasons Owners choose Asphalt, the most obvious answer is it is less expensive in the short term than the concrete pavement alternative. But there is more to it than just cost.

A big consideration is traffic. An asphalt paved roadway can have traffic on it within hours, as opposed to 14 to 28 days with concrete. This isn't as much of a factor with new construction but it can be critical with rehabilitation and reconstruction work.

Asphalt also provides for a smoother, quieter riding surface. Even with the new technologies for profiling and micro-grinding new concrete pavements (which has greatly improved concrete pavement rideability), the multiple, thinner lifts of the asphalt placement process allow for corrections to be made several times if needed, rather than at the top of a deep section as is the case with concrete.

Another significant reason is the riding surface can be milled and replaced at reasonable costs. This allows the road surface to be renewed more frequently.

Types of Asphalt Paving

Asphalt pavements are distinguished and categorized one of three ways:

- By where they go and what they do (Surface, Binder, Base, Open Graded, Patch, etc.)

- By the type of liquid asphalt that is used to make the mix (AC-20, PG-64-22, etc.)

- By maximum nominal size aggregate (1", 19 mm, etc.)

Generally, you can tell if the mix is classified as a super pave or not by the description. Any performance grade asphalt (PG) or any metric size aggregate (19 mm) designations are usually super pave mixes.

Surface Mix — The riding layer of pavement, also referred to as the “wearing course", usually contains aggregates no larger than nominal 3/4"stone. Surface mix in most states has a "friction factor rating" or similar worded requirement that restricts course aggregate to a maximum LA abrasion value of no more than 30 +/-. Many states now require the use of a material transfer device to place the surface mix.

Binder Mix - Is an intermediate layer mix between surface and base.

Base Mix - Usually the first course of mix to be placed on a graded/prepared subgrade or subbase material. Although total depth can be 12" or more, usually lifts are restricted to no more than 6" for compaction requirements for density.

Super Pave- (Short for Superior Performing Asphalt Pavement) A performance based method of preparing Mix designs for HMA. The method takes into account, among other things, the project's climate and design traffic count. (ESAL-Equivalent Single Axle Loads)

Open-graded Mix— Has a dual role. First, as an intermediate layer mix that consists primarily of gap-graded course aggregate and liquid asphalt. Used as a drainage layer, typically under concrete pavement, this type mix openly flows water away from the roadway to the shoulder or under drain system provided. Second, as a surface mix, which provides excellent drainage qualities, and is very skid resistance. Known as "Popcorn Mix" it is very unstable and is effective for only 2-5 years. It almost always must be replaced within 10 years.

FAA - A specialty mix used for airport runway paving. Consistency of production and compaction densities are much harder to obtain than with roadway mixes.

Cold Patch — a special mixture of emulsified asphalt and aggregates, which is typically mixed in a central mix plant, but can be mixed in place. It is typically used for wintertime repair of potholes.

Chip Seal Coat (single pass or multiple pass) - is simply liquid asphalt applied to the roadway with a distributor truck, followed closely behind by an application of 3/8" stone.

HMA — (Hot Mix Asphalt) a general term for all hot mix asphalt pavements

SMA (Stone Matrix Asphalt) - Is a premium-wearing course adapted from European technology that uses a predominance of one-size course aggregate, with little fine aggregate. Coupled with a high asphalt binder, mineral filler content, and fibers to induce stabilization, the design creates a mix that is rut resistant and durable. Some states have used this mix on their major interstate projects since the early 90's with consistent success. Other states have developed test sections, with some states adapting the mix and others still evaluating.

(asphalt plant pictured above shows aggregate storage piles, silos, recycled asphalt piles, plant, baghouse, drum, control house, QC lab trailer, and truck haul route layout.)

Ingredients

Liquid Asphalt- as it applies to the paving industry, is a black thermoplastic material consisting mostly of bitumen hydrocarbons. As it is heated it becomes a liquid, enabling it to coat solid aggregate. As the asphalt cools, it hardens and provides cohesion for the coated aggregates. Since virtually all asphalt is produced at a refinery, different grades of asphalt can have different properties. All asphalt is waterproof, and resistant to many chemicals, including acids.

Cutbacks- a term used to describe a number of diluted forms of liquid asphalt. The most common forms and the diluents used are listed:

Rapid Cure (RC)	naphtha or gasoline	high volatility
Medium Cure (MC)	kerosene	medium volatility
Slow Cure (SC)	oils	low volatility

Anti-Strip- A liquid additive that improves the adhesion of the binder material to the aggregates. It also helps makes the mix resistance to moisture damage. Anti-strip can be blended into the liquid asphalt at one of several locations. It can be added as the liquid asphalt is being loaded into the delivery truck, or as the material is being pumped into the storage tanks. Most commonly it is added as an in-line blend as the liquid asphalt is being introduced to the plant as the mix is produced.

Asphalt Emulsions- A combination of liquid asphalt, water and an emulsifying agent. Since the two main ingredients don't mix well, the globules of asphalt stay suspended in the water. Emulsions are either anionic or cationic in nature.

RAP- (Recycled Asphalt Pavement) the asphalt and stone material which is removed from an existing roadway by mill or other methods, to be recycled into new mix to save money. The RAP needs to be crushed to aggregate size before being introduced into the plant dryer. It is then mixed with the other aggregates and coasted with liquid asphalt to produce the new mix. The amount of RAP that can be used depends on type of plant and type of mix being produced. Usually 15% -20% RAP is all that can be incorporated into the new mix using a batch plant for surface course. However, for base course in a drum dryer, up to 40% can be used in most circumstances.

Aggregates — A hard, inert material such as sand, gravel, crushed stone or slag, used as a fill material for pavement applications. For asphalt, the # 8 sieve is the divide between coarse and fine aggregate, whereas in Concrete the # 4 sieve is that dividing size.

Mix Design

With HMA there are four criteria that influence design. They are:

- Mix Density
- Air Voids
- Voids in the mineral Aggregate
- Asphalt Content

Mix Density. High-density mix in the finished pavement is considered essential for a long lasting, well performing mix. Density is expressed in pounds or kilograms per cubic foot or cubic meter, and is calculated by multiplying the bulk specific gravity for the in-place mix by the density of water. Densities are obtained by establishing certain rolling patterns that maximize compactive effort.

(a nuclear density gauge (shown above) emits radioactive particles and measures the number of particles that pass through a substance in a given period of time to determine the density of the in place material)

Air voids in the in-place mix allow for thermal expansion during seasonal temperature variations and to allow for slight compaction and movement of

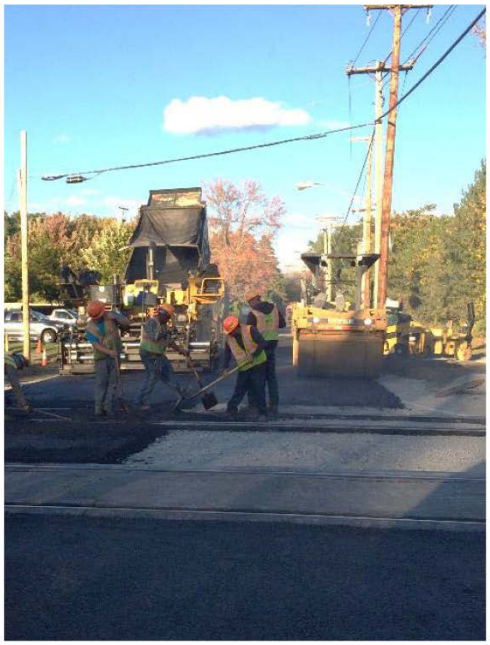
the mix under traffic loading. An allowable range for these voids, between coated particles, usually ranges between 3% to 5%. A mix that has an air void content too low will "bleed", one with a high air void content provides passage for potentially damaging air and water into the layer. Density and air voids are directly related; the higher the density the lower the air void content and vice versa. Lower air void contents provide for a more durable mix.

Voids in the Mineral Aggregate also known as VMA is the void space available between and in aggregate particles in a compacted mix. This space is available to be filled with liquid asphalt, but also contains air voids. VMA is expressed as a percentage of the total bulk volume of the compacted mix, and is the sum of the voids filled with asphalt (VFA) and the air void measurements. The more VMA in the dry aggregate, the more opportunity for all aggregate to be coated by asphalt, hence a more durable mix. If the density of the gradation of the compacted hot mix provides for a below minimum VMA value, the mix will tend to be less durable.

Optimum Asphalt Content is directly related to aggregate gradation. The finer the mix, the larger the total aggregate surface is available to be coated with asphalt, therefore increasing the need to increase the amount of asphalt to be added to the mix design. Aggregate absorption must be determined in the mix design procedure in order to optimize asphalt content. Asphalt content is expressed two ways in HMA terminology: total asphalt content and effective asphalt content. The first is the total amount added to the mix, the second is all that is not absorbed by the aggregates. That gives a good indication of the bonding value of the asphalt to the aggregate.

Applications and Uses

HMA can be used in a variety of ways ranging from a 3/8" overlay of existing pavements (either concrete or hot mix), to a level-up course, to a full depth pavement section.



The single most important factor in the placement of asphalt pavements, other than handwork, is to provide "uniformity in a continual operation". The smoothness of the pavement suffers whenever the paver stops. Therefore, the speed of the paver and plant production/delivery must be coordinated to maximize production and minimize stops. This is not to say that maintaining good rolling patterns and ensuring required and consistent densities aren't also very important.

HMA can be placed using several grade control methods, depending on the owner's specification. It can be placed in a constant lift, say 4", which just follows the line and grade of the existing roadway. It can be placed using a "ski" which is a 30' long aluminum bar that skids along the existing pavement next to the paver. The ski takes the bumps out of the ride and directs the screed to a smooth transition attainable over the 30' length. It can be placed by setting the screed to a particular depth and cross slope, or it can be laid by means automated grade control. GPS survey receivers, robotic survey lasers, or string line control sensors from the paver are examples of grade control automation.

Types of Joints

Most joints in asphalt pavement, whether longitudinal or transverse, are

butt to butt and are vertical. Some states allow a new "wedge joint", for a longitudinal joint. It actually is a sloped 45° degree tapering of the joint to be matched against the next lane. The overlap from the paving of the next lane then completes the required pavement thickness. This approach, allows for better compaction of the **HMA** at the joint.

Longitudinal joints of successive layers need to be staggered so that they do not rest on top of each other (similar to the bonded layers of bricks in a wall). Usually alternating each lift 6" each side of the previous layer will effectively avoid problems. Additionally bonding agents are applied to the joints to help seal and bond the fresh asphalt to the old or previously placed joint material.

Joints need special attention to insure they are constructed to the same density as the rest of the mat. They are a source of constant

maintenance as the roadway ages, and typically lead to the source of pavement deterioration that necessitates the pavement to be replaced.

Method of Placement

Hot Mix Pavements

Temperature is very critical in the placement of asphalt pavements, much more so than it is to the placement of concrete pavements.lthough different mixes are manufactured and placed at different temperatures, most are manufactured above 275 ° degrees F and must be placed above 225° degrees F. This is due to the fact Hot Mix must be rolled (compacted) in stages throughout its cooling period. If hot mix is not rolled when it attains the proper temperature, the desired densities at completion will not be achieved. As a guide, all HMA should be completely rolled before it cools below 180 °degrees.

Rolling hot mix asphalt is an art and should never be overlooked in its overall importance in providing a quality asphalt placement. Different owners have different sequences of rollers and different roller patterns that they believe give them the best results. Some owners use two rollers, some use three to complete their rolling sequence.

Roller Operators must be skilled in reading the pavement, knowing when the pavement is ready for the next rolling makes a difference in the ultimate density obtained.

Most Owners require a "knockdown" rolling. This is usually one or two passes by a double drum vibratory roller. The knock down pass is right behind the paver, so the mix is still quite hot.

The second rolling is usually a pneumatic tire roller. Known for their many - wheeled front and back axles, these rollers simulate tire pressure from vehicles, and knit the pavement together.

Following the pneumatic tire roller is a static rolling. Again, a double drum steel wheel roller, without any vibration, would perform this work.

Ultimately, pavement densities are taken by a nuclear density meter or similar machine, and correlated to lab results by taking in-place cores. Density requirements vary from agency to agency, but typically are between 95% -100% of the lab established density.

Equipment Needs

Asphalt Pavers

Asphalt pavers, like it's concrete counterparts, come in many different shapes and sizes. They can track driven or ruber tired.

Cat AP-1050 Track Mounted Asphalt Paver

Although there are several manufacturers of paving equipment, there are typically two styles; Wheel and Track. Both have their advantages and disadvantages, and although they have specific advantages to placing certain types of mixes, either can be used in most situations, depending on availability. However, track pavers are typically used for thicker layers that take more tons/lf of roadway, hence a slower travel speed, and for base course HMA where placement is on stone or gravel. Rubber tire pavers are more frequently used for thinner lifts of binder or surface courses than are placed on top of other lifts of HMA. Rubber tire pavers can travel much faster than a track machine, and are more maneuverable when pullbacks in the paving operation are required.

Material Transfer Devices (MTD) are becoming more popular and are indeed required by many state DOT specifications. Used to store up to several loads of hot mix, these vehicles proceed in front of the paver, and feed the paver in a more continuous manner than the starting and stopping required sometimes with direct truck delivery into the paver. It also helps cycle time of the trucks since they do not have to wait to dump into the paver. Additionally, the storage capacity helps maintain consistency and temperature for the delivered mix.

Asphalt Rollers

Rollers also come in many makes and models. Rollers for hot mix differ from rollers for soil or stone compaction. Hot Mix Rollers should not be

used for any other type of rolling, since other materials can damage the rollers and may affect its performance on the mix.

Typically four styles of rollers are used:

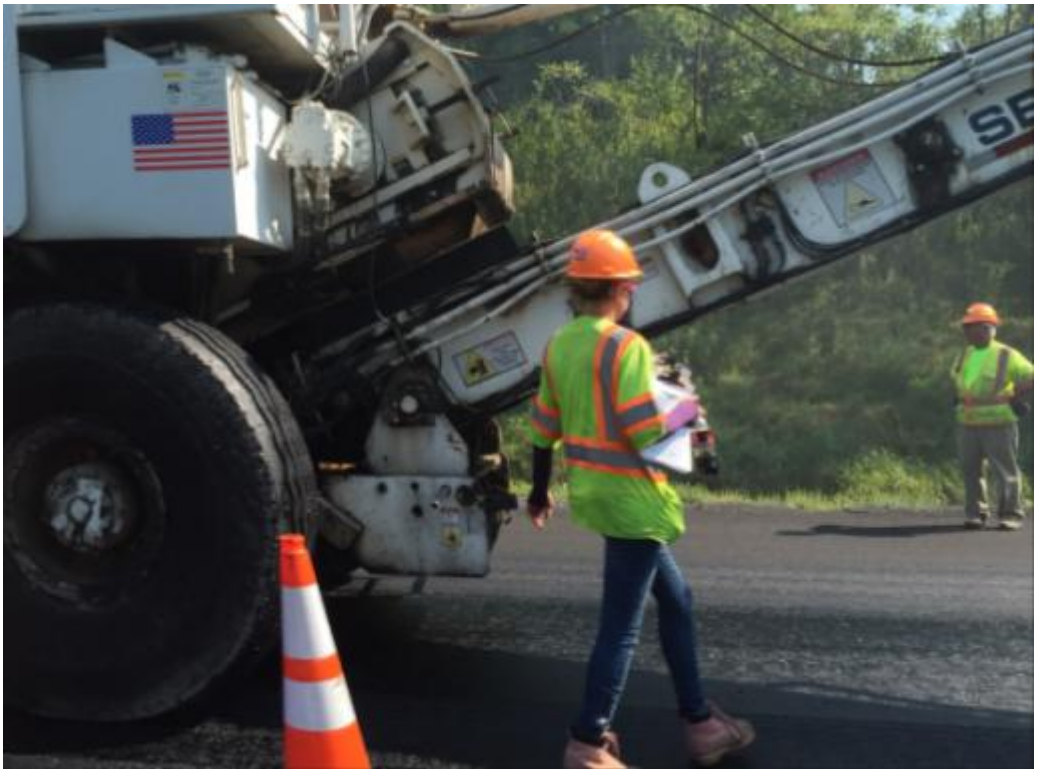
- Static Steel Wheel
- Vibrator Steel Wheel
- Pneumatic Rubber Tire
- Walk behind for handwork

Refer to the placement section for the use of each style.

Distributor Truck

The liquid asphalt placed directly on the roadway to be used for prime, tack or chip seal is placed by use of a distributor truck. Depending on the size of tank desired, (2,500 gal size is standard) the distributor truck consists of the desired tank mounted on a ten-wheel truck frame (although some are mounted on a six wheel frame) with rear mounted spray bar and pumping and metering equipment. The truck is capable of spraying a 15' +1- roadway with the desired application rate of product. A hand wand is attached to do small or irregular sections. Usually MC asphalt is used for this purpose. CAUTION shall be taken when changing liquids in the truck. If MC asphalt is desired to be used after an emulsion, all the water MUST be out of the tank before putting the MC material in.

The Construction Engineer's Role



The engineer's role in hot mix paving is crucial.

The plant engineer is responsible for:

- Preparing Asphalt Pavement mix designs
- Assuring a testing lab/Quality Control is in place
- Preparing grade sheets or 3D Models for paving profile grading.
- Monitoring raw material stockpiles for need, costs, and yield rates
- Assuring all raw material contracts with the major suppliers are fully executed, and that each supplier has a letter advising them of schedule, total quantity needs, and for delivery rates and times.
- Ordering #2 fuel for the plant operation. Increasingly, projects are using waste oil to help mitigate plant-operating costs.
- Assuring contracts for truckers are in place, including delivery of the liquid asphalt.

The field paving engineer is responsible for:

➢ Recording quantities and calculate yields. With liquid asphalt, it is imperative that the engineer account for any escalators provided for in the contract by the owner. The liquid asphalt can be paid as a separate item, or its cost can be incidental to the mix. Particularly with the super pave items; there will be multiple types of liquid asphalts needed and records of each quantity must be kept separately.

➢ Assuring that all quantity control is being performed as required by the specification, including but not limited to Marshall tests, cores, extraction testing, density testing etc.

➢ Smoothness testing of final riding surface.

➢ Ensuring that the distribution truck is scheduled as may be needed.

➢ Scheduling hauling units

Both Field and Plant Engineers will have a role in estimating and pricing, quotes and proposals for bid work.

Lastly, asphalt pavement can be used for LEED (Leadership in Energy and Environmental Design) construction. Permeable asphalt helps control pavement run-off, provides root space and irrigation for trees and plantings, and controls surface transported pollutants. Asphalt pavement is a highly re-useable product by itself. Milling and crushing existing asphalt pavement allows it to be introduced into new asphalt product up to 40% recycled. Additionally many of the ingredients can be made from recycled products, The asphalt material can be extracted from used roofing shingle materials, and the aggregate and filler materials can be made from ground recycled glass and slag products.

ASPHALT FUN FACTS FROM VARIOUS INTERNET SOURCES

Asphalt pavements are the most recycled materials (80 million tons annually) in the United States—more than glass, metal, tires, paper or any other material. We crush and recycle the reclaimed asphalt pavement (RAP) right back into our mixes every day, making asphalt pavements a truly sustainable product.

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Liquid asphalt was used by ancient Egyptians to embalm mummies, as they recognized the lasting qualities of asphalt.
The Phoenicians caulked the seams of their merchant ships with liquid asphalt, the best waterproofing material available.

The United States has 2.6 million miles of paved roads, and about 94% of them are surfaced with asphalt pavement. Asphalt pavements are, and continue to be, America's pavement of choice

The first road use of asphalt occurred in 1824, when asphalt blocks were placed on the Champs-Élysées in Paris, France.