From liquid lake asphalt to Superpave

The evolution of hot mix asphalt

The history of hot mix asphalt (HMA) has come down a long road of progress. The first road to be paved with asphalt was in Babylon between 625 and 604 B.C. The Romans built an impressive road system in Great Britain during their occupation of the first through fourth centuries, of which many roads have been used as templates for modern British roadways. Sir Walter Raleigh, in his third voyage in 1498, discovered the still-famous pitch lake of asphalt on the Island of Trinidad, the largest natural asphalt lake in the world. It was the first source of asphalt made available in America; the second source was the Bermudez Lake in Venezuela. The complete implementation of asphalt on roads, however, began with a man named John Metcalfe.

Metcalfe was born in Scotland in 1717. Although blind from the age of six, Metcalfe built 180 miles of roads in Yorkshire, England, after the age of 40. He made sure that his roads drained well and were built on a firm foundation. He built them with three layers: the first layer was made up of large stones, the second contained excavated road material, and the third was a layer of gravel. The road was also arched in the center so that water would drain off and down into the ditches built along each side.

Thomas Telford, who was born in Eskdale, Scotland, in 1757, perfected the method of building roads with broken stones. Telford placed the stones at a certain thickness in accordance with the weight and volume of traffic on that road. He also took into consideration road alignment and gradient, which are still important factors for roadbuilders today.

John Loudon McAdam, born in Scotland in 1757, designed roads using broken stones that were laid evenly and tightly so that they covered the soil and formed a hard surface. These “macadam roads,” as

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Photos courtesy of Asphalt Institute.

Asphalt has been improving our roads throughout history. Here’s an example of an asphalt overlay upgrading and renewing a primary road in upper Maryland in October 1966.

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The portable mixing machine was used for macadam road-building and for graded aggregate road mixes.

Rutted mud roads became paving history as macadam penetration modernized 1900s farm-to-market avenues. Washington Ave. in New Jersey was paved using bituminous penetration macadam 3 inches (75 mm) thick.

Macadam roads comprised a layer of large aggregate below a layer of medium-sized aggregate topped with a layer of small gravel. This cross section of a rural penetration macadam road illustrates McAdam's design.
they were called, served the purpose of providing a somewhat stable pathway for pedestrians and horse-drawn traffic. While Telford and McAdam were contemporaries, they each had different ideas of how to build the best road. Telford's designs were more expensive than McAdam's, but some scholars say they were superior in quality.

Early in the 19th century, rock asphalt and natural asphalt were being used as building products. These asphalt products had already been used for the past 7,000 years for waterproofing. Hot tar was used in England as early as 1820 to bind the broken stones together. This type of mix, known as tarmacadam, was patented in 1910 by Warren Brothers in Cambridge, Mass. This company later became APAC, one of the largest asphalt mix companies in the United States.

The highway builders of the late 1800s depended solely on stone, gravel and sand for road construction. Road surfaces could be stabilized by adding water to the surface sand to form a binder, which would support horse-drawn traffic. Mud and dust did not become a major problem until the introduction of the automobile.

Although many coal tar pavements (not asphalt) were built in the 1860s and 1870s, the first recorded

**Prior to asphalt pavements, roads could be treacherous.**

*(top left) This shot of a dirt road in Iowa in 1916 shows what “frost heave” meant to travelers.*

*(top right) In 1919, the Washington-Richmond Road near Dumfries, Va., about 30 miles (48 km) south of Washington, D.C., claimed this car. Mud was a serious problem before asphalt paving.*

*(bottom right) Brightwood Ave. in Washington, D.C., illustrated the problem dust created prior to road oils.*

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asphalt pavement in the United States was a sand mix placed in front of the City Hall in Newark, N.J., in 1870 by Edmund J. DeSmedt, a Belgian chemist who became the inspector of asphalt and cements for the District of Columbia. This asphalt pavement was probably built using the Paris-Perpignan highway in France, which had been built in 1852 with natural asphalt pavement, as an example.

The first bituminous HMA pavements in the United States were built in Washington, D.C., by N.B. Abbott in 1868 and C.E. Evans in 1873. Both projects used coal tar as a binder. In 1876, however, President Grant selected a group of army engineers to study the use of asphalt on roads. This group suggested that Pennsylvania Avenue in Washington, D.C., be paved with sheet asphalt made from Trinidad Lake asphalt. That pavement remained in excellent condition for 11 years, despite the traffic at the White House.

Part of the Pennsylvania Avenue paving contract was awarded to an exporter of Trinidad asphalt named Amzi Alonzo Barber. In 1893, he formed the Barber Asphalt and Paving Co. and hired Captain Francis V. Greene, former assistant paving engineer for the District of Columbia. This, by coincidence, was the first Barber and Greene partnership, not to be confused with the later worldwide known Barber-Greene Co., which was formed in 1916 by Harry M. Barber and William B. Greene to develop asphalt plants and a paving machine that, according to the Asphalt Institute, revolutionized the asphalt industry.

Refined petroleum asphalt made an appearance in the mid-1870s and was shipped in barrels from California, later coming by train. It was originally

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Herbert Spencer, president of the Asphalt Association from 1941 to 1947, rolled up his sleeves and got to work with an early liquid asphalt distributor. According to Asphalt Institute records, Spencer was integral in developing and improving penetration-type macadam pavements.

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used as an additive, or flux, and was mixed with Trinidad asphalt to soften it for handling and placing. This type of product was first used in 1874 in the District of Columbia.

Laboratory testing was unheard of before 1900. Logan Waller Page from Harvard University enrolled in the French lab of Bridges and Roads. On his return to the United States, Page introduced the French testing method. With the advent of the automobile, road engineers needed to find a road that didn’t self-destruct. Road oils and penetration macadam seemed to be the most logical answers, especially since they were most effective in preventing dust and destruction. Some states and independent labs had already experimented with mixing asphalt or road oils with different sized stones. By 1902, Gulf Refining and Texas Refining in Texas, and Sun Oil in Pennsylvania, started producing asphalt. Asphalt producers began making asphalt mixes, such as the “Topeka Mix,” which used a 0.5-inch (10-mm) stone, to be used for building inter-city highways.

By 1910, refined petroleum asphalt had gained its permanent market supremacy over the producers of rock, natural and sheet asphalt. The oil companies could manufacture asphalt superior to that mined from the natural deposits in Trinidad Lake and Bermudez Lake. This supremacy even threatened

The founding fathers of the Asphalt Institute gathered for this photo in the early years of the organization’s history. From left, back row, are Prevost Hubbard, H.B. Pullar and Herbert Spencer. Seated is Bernard Gray.

Officials at the Sheldon G. Hayes award presentation at Purdue’s 58th Road School were (from left) Russell H. Harrell, executive director of Indiana State Highway Commission (ISHC); Ruel W. Steele, chairman, ISHC; Robert G. Hunt, NAPA president; Sheldon G. Hayes; Gus Sieboldt, president of Midwest Construction Materials Inc.; and John Gray, NAPA executive director.

*Photo courtesy of NAPA.*

diplomatic relations between the United States and Venezuela.

After World War I, the soldiers returned home to find that thousands of miles of inter-city roads need-
ed surfacing. Newly formed state highway departments discovered that thousands of pieces of surplus war equipment were adaptable for use on road construction. The automobile was about to become the most sought-after mode of transportation, but roads outside the city limits were too dusty and muddy for travel. As automobile traffic increased, so did the need for asphalt surface treatments, penetration macadam, sheet asphalt and asphalt concrete mixes. Asphalt manufacturers developed grades to meet certain road conditions. The variety of crude oils produced a variety of asphalt mixes. Lab testing, which was not as sophisticated as it is now, did little to determine the use of refined asphalt for pavement surfaces. Therefore, spec limits were added that had no correlation to how asphalt was actually going to be used. The refiner was faced with trying to make a product to fit the growing list of specs.

To bring this issue to the attention of both engineers and the public, the asphalt industry concluded that it needed a representative to speak on its behalf. The Asphalt Association, which would later become known as the Asphalt Institute, was formed in 1919 to fulfill that role. This agency began with J.R. Draney as the first president, J.E. Pennybacker as managing director and Prevost Hubbard as chief chemical engineer. Its intentions were to reduce the number of asphalt specs and unite state and federal road engineers in the belief that asphalt was, and still is, versatile enough for use on heavy-duty highways as well as farm-to-market roads.

The U.S. Corps of Engineers, which had not previously been involved in pavement matters prior to World War II, was charged with military road and runway construction. Faced with the production of larger, heavier airplanes, the Corps needed to come up with pavement thickness design methods for runways that could handle wheel loads greater than 12,500 pounds (5,670 kg). Not

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Back in 1911, contractors were hauling aggregate in Michigan. This is Caterpillar's Holt 60 pulling gravel wagons.

Here's an example of a 12-hp Caterpillar Tractor Co., Peoria, Ill., grader — eight up front and four in the rear. The belt was driven by power from the bull-wheel.

The Super Turtle pavement reclaimer carried a clever logo.
only did they meet the huge military demand for heavy-duty pavements, but they would continue to influence all aspects of asphalt paving long after the war was over.

In 1956, the Federal-Aid Highway Act was established, creating an infrastructure highway program unmatched by any other in the world. President Dwight D. Eisenhower stated that the Interstate System would establish “a grand plan for the rebuilding of our obsolete road and street system.” The basis of the system was a 41,000-mile (65,983-km) highway network connecting major cities in the Unites States. The network design task was given to the U.S. Bureau of Public Roads and the State Highway Departments. While many state highway departments requested asphalt for their part of the interstate system, concrete was also used despite its higher cost of construction.

Besides cost, another feature that
July 24, 1945, found crews using asphalt to pave the dock area of Apra Harbor, Guam, Mariana Islands, shortly after the United States liberated it from the Japanese. A direct result of the Corps of Engineers' successful use of asphalt during World War II, we now have asphalt highways and interstates.

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makes asphalt superior to concrete is flexibility. Maintaining asphalt is also typically less expensive than maintaining concrete. Contractors, government agencies and asphalt industry-related associations — such as the National Asphalt Pavement Association (NAPA), American Association of State Highway and Transportation Officials (AASHTO), Strategic Highway Research Program (SHRP), Federal Highway Administration (FHWA), American Society for Testing and Materials (ASTM) — keep proving the superiority of asphalt pavement over other paving options.

Today, large stone HMA bases, which were common at the beginning of this century, are once again used as a way to deter rutting and provide increased resistance to heavy and high frequency loads. Asphalt additives are used to increase the stability of HMA pavements at high and low temperatures. Superpave, performance grade binders and stone matrix asphalt (SMA), which have enhanced the capabilities of HMA against rutting, provide

A 2-inch (50-mm) Warrenite pavement, the first patented asphalt pavement, was placed on a pcc base in July 1921. Here the crew spreads a mixed seal coat before rolling.

It's never too early to adopt a preventive maintenance program. Even back in 1920 there were potholes to fill. Here an old wagon repair maintenance crew works on a Pennsylvania highway.
excellent drainage with open grade surfaces and long-term durability of the asphalt pavement with what industry leaders call an enormous reduction in maintenance costs.

This new technology, which was brought from Europe in 1990 and perfected in Atlanta for the 1996 Olympics, requires fundamental changes in the aggregate component of the HMA, such as size, shape, texture and gradation. Tennis courts, bicycle paths, running tracks, football fields and playgrounds benefit from the placement of asphalt because of its versatility, low cost and low maintenance, speed of construction, optimum friction and skid resistance, and rapid drainage and drying after rain. All the great pioneers and builders of roads since the Romans have agreed that the three most important factors to building a good road are drainage, drainage and drainage. What has changed over the centuries is how those contractors modified and applied the HMA to achieve not only drainage, but a sound, stable infrastructure.

In 1908, crews handspread asphalt in front of the steam rollers in Florida.

Above, A 12-foot (3.7-m) paver, equipped with an infra-red heater to prevent cold joints, places the 1.5-inch (38-mm) asphalt concrete surface course on Washington National’s 6,875-foot (2,096-m) long main runway. A 10-ton (9.1-Mg) steel-wheeled roller follows immediately behind the paver.

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**Did You Know...**

...The United States has 4,000,000 miles (6,437,376 km) of roads and highways?

...About 2,200,000 miles (3,540,557 km) are paved?

...About 96 percent of those miles are paved with asphalt?

...Between 500,000,000 and 550,000,000 tons (453,500,000 and 498,850,000 Mg) of asphalt are placed every year?

...The Federal Highway Administration has found that nearly 100,000,000 tons (90,700,000 Mg) of asphalt are removed each year during pavement reconstruction and 80 percent, or 80,000,000 tons (72,560,000 Mg), are recycled? No other U.S. industry recycles more of its own product.

...The HMA industry employs over 300,000 people and another 600,000 are employed indirectly?

...The value of HMA placed annually is $15,000,000,000?

...In 1904, there were more than 55,000 automobiles on U.S. roads?

...In 1910, that number had risen by nearly 415,000 for a total of 470,000?