

# Roads and highways: New paving materials

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When urban street paving became widespread in the latter half of the 19th century, the common paving materials were hoof-sized stone blocks, similarly sized wooden blocks, bricks, McAdam's broken stones, and occasionally asphalt and concrete. McAdam's broken stone provided the cheapest pavement, but its unbound surface was difficult to maintain and was usually either slimy or dusty as a consequence of water, weather, and copious amounts of horse excrement. Thus, roads at the turn of the 20th century were largely inadequate for the demands about to be placed on them by the automobile and truck. As vehicle speeds increased rapidly, the available friction between road and tire became critical for accelerating, braking, and cornering. In addition, numerous pavement failures made it obvious that much stronger and tougher materials were required. The result was an ongoing search for a better pavement. Asphalt and concrete both offered promise.

Asphalt is a mixture of bitumen and stone, and concrete is a mixture of cement and stone. Asphalt footpaths were first laid in Paris in 1810, but the method was not perfected until after 1835. The first road use of asphalt occurred in 1824, when asphalt blocks were placed on the Champs-Élysées in Paris, but the first successful major application was made in 1858 on the nearby rue Saint-Honoré. The first successful concrete pavement was built in Inverness, Scotland in 1865. Neither technology, however, advanced far without the pressures of the car, and they both required the availability of powerful stone-crushing, mixing, and spreading equipment.

The impetus for the development of modern road asphalt came from the United States which had few deposits of natural bitumen to draw upon and where engineers were therefore forced to study the principles behind the behavior of this material. The first steps came in the 1860s, with the work of Belgian immigrant Edward de Smedt at Columbia University in New York City. De Smedt conducted his first tests in New Jersey in 1870 and by 1872 was producing the equivalent of a modern "well-graded" maximum-density asphalt. The first applications were in Battery Park and on Fifth Avenue in New York City in 1872. De Smedt went to Washington, D.C. in 1876 as part of President Ulysses S. Grant's desire to make that town "a Capital City worthy of a great Nation". Grant had appointed a commission to oversee road making, and it conducted its first trials on Pennsylvania Avenue in 1877. Sixty percent of the trials used de Smedt's new product and were great successes.

In 1887 de Smedt was followed as inspector of asphalts and cements by Clifford Richardson, who set about the task of codifying the specifications for asphalt mixes. Richardson basically developed two forms of asphalt: asphaltic concrete, which was strong and stiff and thus provided structural strength; and hot-rolled asphalt, which contained more bitumen and thus produced a far smoother and better surface for the car and bicycle.

One of the great convenient coincidences of asphalt development was that the automobile ran on gasoline, which at that time was simply a by-product of the distillation of kerosene from petroleum. Another by-product was bitumen. Until that time, most manufacturers had used coal tar (a by-product of the making of gas from coal) as the binder for road asphalt. As the demand for automobile fuel increased, however, so did the availability of bitumen and, hence, of good asphalt designed to the standards of de Smedt and Richardson. This gave U.S. road builders a major advantage over their European counterparts, who were still wedded to the virtues of the various natural asphalts, such as those from Neuchatel, Switzerland, and the island of Trinidad.

Richardson published a standard textbook on asphalt paving in 1905, and the practice did not change greatly thereafter. The biggest change was in the machinery available to produce, place, and finish material rather than in the product itself. Toward the end of the century, there were major movements toward the use of recycled asphalt, chemical modifiers for improving bitumen properties, and small fibres for improving crack resistance, in addition, developments in testing and structural analysis made it possible to design an asphalt pavement as a sophisticated structural composite,

The first modern concrete roads were produced by Joseph Mitchell, a follower of Telford, who conducted three successful trials in England and Scotland in 1865-66. Like asphalt technology, concrete road building was largely developed by the turn of the 20<sup>th</sup> century and was restricted more by the available machinery than by the material. Problems were also encountered in producing a surface that could match the performance of the surface produced almost accidentally by hot-rolled asphalt. For the following century the two materials remained in intense competition, both offering a similar product at a similar cost, and there was little evidence that one would move far ahead of the other as they continued on their paths of gradual improvement (The principles of modern pavement design are described in the modern road: Road engineering: Road design: Pavement)