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**A CENTURY OF PARQUET PAVEMENTS: WOOD AS A PAVING MATERIAL
IN THE UNITED STATES AND ABROAD, 1840-1940.**

**Part 1, Nineteenth Century Origins**

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**ABSTRACT**

This article investigates the use of wood paving blocks around the world as industrial societies grappled with the high noise levels in growing cities during the decades before pneumatic rubber tires eased the ride and reduced the clatter of steel-wheeled vehicles and iron-shod horses.

*Trees for the construction of the road had been felled in 148 BC. 1   Since the introduction of Gas, no subject of domestic comfort, or of public utility, has been brought under consideration, of equal importance to that of Wood Paving [London, 1841]. 2   Railways, with all their value, and they are of priceless worth to man, are yet the thoroughfare for the citizen away from his home — for the journey, the travel, the tour; but the plank road is for the home use — for the transit which is begun and ended in a day, or its fraction — which gives to him who uses it a double value or occupation for the hours of the day — which increases the happiness and the comfort and profit of the farm, that foundation of all the institutions of society [1851].³   From 1847 to 1853 New Yorkers built more than 3,500 miles of wooden roads.4   James G. McBean, a wood block paving contractor, has offered to pave half of Washington Street, between LaSalle and Clark streets, in Chicago, with cedar blocks [1892].5   A trial is being made in Paris of a new system of wood-paving [1892].6   [Wood paving] is used in the busiest sections of the streets of Melbourne and Sydney [1894].7   Tokio [sic], Japan, is using Douglas fir blocks, creosoted locally, for paving [1923].8*

The human quest for an ideal pavement is nearly as old as the search for the perfect god. Leaving in their trees, primates travelled by water when possible and struggled with land travel otherwise. Nature is rarely kind to adenturers: bogs, rivers, mountains, mud, and dust hazard people, their animals, and their machines — even late-twentieth century high technology could not rescue American hostages from Iranian militants when common sand throttled the sophisticated engines propelling some of the world's most advanced military helicopters. Flying, that wonderful alternative to water and land travel, available for a century, has not alleviated the need for dependable all–weather surface routes, mankind's millennia-long pursuit.

Evidence of early stone roads proves the durability of hard surfaces: streets laid in Mesopotamian cities thousands of years ago testify to the endurance of stone paving. But stone is difficult to move and may provide a rough, if resistant, surface. Where rock and quarry stone were scarce or builders had no capacity for moving it and turned to other materials, wood was a favorite choice. Ancient stone-streets are extant, but wood decays, leaving little trace. There remains, nevertheless, artificial evidence of early wooden roads . Archaeologist Barry Raftery of University College, Dublin, has excavated the remains of a wooden road at Corlea Bog, County Longford, Ireland. The road, dated to 148 BC, facilitated travel over a bog from one point of high ground to another. "In prehistoric times [the boglands] were dangerous, menacing worlds of reeds and rushes with stagnant pools and quaking mosses laying in wait to engulf the unwary traveller. The Irish bogs were vast wet areas, impassable obstacles to travel for much of the year. In winter they must have been grim and foreboding places."9

"The road consisted of two parallel 'runners' extending along its length. Upon these a series of closely-spaced transverse 'sleepers' was laid... The runners were long, straight, specially-selected timbers of stout dimensions... The surface of the road was composed of split oak logs 3-3.50 m in average length ... The majority appear to be half tree-trunks, usually placed on the runners with their flat surfaces upwards ... closely spaced to form a compact, though uneven, surface." The timbers were held together with mortises and pegs. Beneath the road lies yet another trackway, older and likely dating to the Bronze Age.10 Both roadways were "swallowed by the rapidly growing bog, which embalmed the timbers in a covering of living peat. In the anaerobic conditions thus created the prehistory wood survived in a state of almost total preservation until revealed again to human eyes after an interval of some twenty-one centuries."11

Wooden roads are not restricted to ancient history, but played a role in road and street construction into the first half of the twentieth century when ever-larger motorized vehicles forced them into obscurity. Few alive today recall the wooden rails laid over swamps12 or the cedar blocks that cushioned in-town roads, for steel-reinforced concrete and asphalt have become the premier town and country paving materials. The search that led to concrete and asphalt left little untried as anything in abundant supply that could somehow harden and strengthen a road was tested. Americans, rich in forests, accustomed to using wood in building homes, barns, fences, furniture, and anything else the elastic material could be crafted into were naturally drawn to putting wood on their roads and streets.

In 1851 *Hunt's Merchant Magazine and Commercial Review* reported that plank roads had originated in Russia; Lord Sydenham introduced them in Canada, and New Yorkers of Onondaga County, impressed by the Canadian experiment, brought them to the United States. The roads were promoted enthusiastically in communities left behind by railroad and canal construction.13 Where trees were plentiful, a plank road could be built for about $1,900 a mile; macadam would have cost $3,500 per mile. Under the most favorable circumstances both the right-of-way and timber were donated to the road company, leaving the clearing, leveling, cutting, sawing, and plank-laying to be financed by investors. Toll houses were built and collectors paid to man them. Steam-powered saw mills were the only high-technology equipment available for plank road construction. The simple but heavy labor was carried out with hand tools and horse-drawn wagons and sledges. Promoters often championed their projects with estimates of $800 to $1,000 per mile construction costs, unlikely figures under the best of circumstances. Investors were assured of life expectancies of eight to ten years when in fact the surfaces usually had to be replaced after four or five years. Once the planks began to rot and disintegrate, they became more a danger to travellers than an assistance. A joint stock charter for a plank road often required that owners either keep the surface in repair or return it to a dirt road. Plank roads were usually covered with several inches of sand or dirt to ease the wear on the wood. As planks disappeared, less and less of the road had a plank subsurface, something not obvious until wet weather.14

Although a transportation success, the plank road was an economic failure. Wood surfacing improved the speed and dependability of transportation, but plank road companies were unable to capture sufficient returns from their enterprises to make them as profitable as alternative investments. John Majewski, Christopher Baer, and Daniel B. Klein estimate just 40 percent of New York's 1855 plank roads were in operation in 1860 and "only 32 of the original 350 companies submitted new articles at the end of 30 years."15 Wooden streets in cities did not suffer the same setback as plank roads and because they were built and paid for with taxes and did not have to satisfy investors for their continuation. Rural Americans wanted passable roads, but they refused to pay taxes for them. Instead they paid what came to be recognized as a mud tax, a loss of revenue during the wet months when mud made roads impassable. Inaugurated wit the introduction of the modern bicycle in the years immediately following the Civil War, the good roads movement came to fruition when the internal combustion engine available in an automobile affordable by rural residents stimulated a sustained drive for hard-surfaced roads and persuaded taxpayers to underwrite road construction and maintenance.

As rural folk were building plank roads, their urban counterparts were laying wood-block avenues and streets. J. Lee Stevens, a promoter of wood for city streets, published a pamphlet in 1841 to publicize the wood block pavements on the streets of London. Steel-tired wagons and carriages pulled by iron-shod horses amplified a deafening clatter against granite, cobblestones, and brick laid to guarantee all-weather boulevards, the mark of a modern city. The metal shoes and wheels wore away paving in less than a decade, so repaving became an essential municipal function. Stevens and other advocated of replacing harder surfaces with wood blocks championed the sound-absorbing quality of organic over mineral paving while insisting that wood outlasted stone and was less expensive to install and replace: Stevens estimated twenty-year savings of 10 to 30 percent where wood blocks were substituted for granite. "A structure of Wood instead of resisting the pressure or percussion of passing vehicles, like such an incompressible substance as granite, yields to it sufficiently to counteract friction, from its inherent property of elasticity." Advocates of wood block paving, like Stevens, were committed to their product: "Since the introduction of Gas, no subject of domestic comfort, or of public utility, has been brought under consideration, of equal importance to that of Wood Paving."16

Cleanliness was a consideration given city streets in the days of four-legged house-power fueled by hay and oats that appears quaint in a motorized society dependent on fossil fuels. George Frederick Deacon, writing about macadam pavement noted that:

its dirtiness consists, not only in the excessive mud of wet weather, and the excessive and impure dust of dry weather, but also in the facility with which organic impurities [processed and jettisoned hay and oats] are absorbed by it, decomposed within it, and exhaled to the atmosphere. In country, and in some suburban roads the extent of this objection is insignificant ... but in some of the carriageways of the west end of London one would regard it as intolerable, had it not been tolerated so long... To the unsophisticated provincial the manner in which, on a hot July day, fashionable London rolls over her tainted macadam pavements, apparently without even smelling them, is a mystery.17

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**A CENTURY OF PARQUET PAVEMENTS: WOOD AS A PAVING MATERIAL IN THE UNITED STATES AND ABROAD, 1840-1940.**

**Part 2, Twentieth Century Decline: Geography, Technology, History**

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**ABSTRACT**

Part 2 of "A Century of Parquet Pavements" investigates global distribution of wood paving blocks, the changes in technology of wood-block treatment, placement, and improvement, and the reasons for the disappearance of wood as a paving material.

A Century of Parquet Pavements... Twentieth Century Decline: Geography, Technology, History: continues the investigation of wood paving in cities around the world as industrial societies grappled with the high noise levels of growing cities in the turn-of-the century decades when horse-drawn wagons and carriages were giving way to motorized vehicles astride pneumatic rubber tires. Until World War II bituminous asphalt and concrete were merely candidates for the role of major paving material in a world experimenting with a wide range of substances from rubber and cotton to iron and steel. Although few people in the 1990s have first-hand experience with wood block paving, it had a strong corps of advocates in the early years of the twentieth century and did not disappear until the heavy traffic of the war era clarified the demands of a society on wheels mounted on heavy, high-speed machines and demanded a far sturdier surface than wood blocks could deliver.

At the end of the twentieth century wood block paving is a curiosity. At the beginning of the century before inexpensive mass-produced automobiles made paving a high priority for governments of industrialized nations, wood paving materials offered a quiet, resilient, inexpensive, and easily repaired and replaced surface for steel-rimmed wagon and carriage wheels and iron horseshoes. Moreover, animal excrement did not penetrate treated wood blocks but dried to be blown or swept away Heavy traffic and noise were minor problems on country roads where planks were used to speed travel through wet areas and over small bodies of water. The Industrial Revolution introduced cast iron bridges, but wooden structures with their romantic roofs continued to appear over streams and rivers in rural areas unable or unwilling to finance ferrous metal structures. Cities looked to wood-block pavements to reduce the din of horse-pulled vehicles in streets canyoned with buildings.

The idea of pouring a roadway of asphalt or concrete was alien to road builders of the early twentieth century. Gravel and stone were spread over roadbeds but materials for a hard surface were usually laid like pieces to a puzzle. Bricks were popular for city paving, but they were expensive to produce, difficult to lay, nearly impossible to keep level, noisy, and retained odoriferous and insalubrious animal droppings. When asphalt was used for paving it was not softened and poured on the street but cast into blocks to be laid like brick with all the disadvantages except noise. Asphalt block pavements were as quiet as wood but the blocks disintegrated under the pressure of horseshoes and steel tires. Concrete was also used for paving but until trucks were developed to bring the prepared mixture to the paving site concrete was, like asphalt, cast into blocks to be laid like bricks. Concrete and asphalt blocks were less expensive than bricks, but they did not wear as well. Rubber blocks were the quietest of all pavement but they suffered the disadvantage of other blocks, they wandered and did so with greater fervor than other block materials.¹ Cast iron and steel blocks ere durable but they wandered, retained animal excrement, and magnified the clatter of ferrous wheels and shoes.² A century ago the choices for surfacing streets were bricks and other blocks and compared with the alternatives wood blocks were fetching.

As the twentieth century turns into the twenty-first paved streets and highways appear to fall into two easy-to-identify categories: concrete and asphalt. In fact engineers have a vast array of choices for paving. City streets in residential neighborhoods are very different from the interstate connectors that run around the metropolis even though they may all be asphalt or concrete. Foundation, thickness, density, and reinforcement have to be determined for each street and highway and often for separate stretches of the same thoroughfare. At the beginning of the twentieth century paving alternatives were more readily identifiable. Heavily travelled routes required thick granite blocks, heavy bricks, or squares of iron or steel. Lightly used residential streets were paved with thin granite, light bricks, or blocks of asphalt, concrete, iron, or steel.

The use of wood-block paving should be considered in light of the demands of turn-of-the-century streets and highways and not in terms of modern construction materials. Wood-block paving was not a failure, it disappeared because needs changed. Moreover, wood-blocks were not intended as an all-purpose paving material but a special substance for selected streets. City engineers did not envision a city paved with wood. They did consider wood blocks appealing for streets near hospitals, schools, churches, and public buildings like court houses where street noise was especially bothersome and in congested streets with heavy traffic. It is not easy for modern men and women to imagine the noise generated by hundreds of steel-tired wagon wheels and horse shoes on bricks, steel iron, or granite block streets sandwiched between multileveled buildings. A wooden pavement was not small blessing in the horse and wagon society. Wood blocks were also useful in filling gaps around trolley tracks. The flexible wood was less likely to crack, break, or wander from the vibrating iron or steel rails.

Wood-block paving was not a whimsy but solution to a serious urban problem. Wooden streets, like trolleys, are no more because technology offered new alternatives in transportation that eliminated the need for them. Until World War I a debate raged over the future of transportation. Was the motorized vehicle going to replace the horse and buggy? Or would organic fuel win out as people tired of motor car engine and tire failures?³ The was left little doubt that internal combustion engines would easily eclipse horsepower, but technological obstacles had yet to be surmounted before airplanes, cars, and trucks were so productive, dependable, and economical that horses and wagons and trolleys would disappear and railroads would be pushed to the margin of the transportation picture. During that hiatus wood streets were laid. By 1925 wood paving, like electric trolleys, was finished. Trolleys are fondly remembered, a few still operate – trolleys in New Orleans and cable cars in San Francisco, for example, and many cities operate motorized buses built to resemble the rail-bound coaches they turned into museum pieces – but mention of wood-block streets solicits snickers from a world that has forgotten them.

**Geography** – Despite its limited use for streets targeted for special attention, wood-block paving was used around the world. Figure 1, Global Distribution of Wood-Block Pavement by Nations, shows the ten nations whose experiences with wooden streets is discussed in the English language engineering literature.

Figure 1

GLOBAL DISTRIBUTION OF WOOD-BLOCK PAVEMENT BY NATION

|  |  |  |  |
| --- | --- | --- | --- |
| JAPAN |  | CANADAUNITED STATES | FRANCEGERMANYGREAT BRITAINSWITZERLAND |
| BURMA | AUSTRALIA | ARGENTINA |  |

*Argentina* – In 1913, with wood-block paving enjoying the height of its popularity, *Engineering and Contracting* published an extract of a paper presented before the London meeting of the International Road Congress by Claro C. Dassen, Director of Municipal Works, Buenos Aires: "Practice and Experience with Algarrobo Wood Pavements in Buenos Aires, Argentina."

In 1888 a French firm laid imported pine blocks in Buenos Aires with indifferent results. After another failure in 1894 native lumber was tried in 1895 in trials that revealed the merit of algarrobo and karri blocks laid on properly prepared foundations. The first blocks probably failed as much from lack of ground preparation as from faulty timber. After surveying their street, engineers placed granite curbing in a base of portland cement. (Nineteenth century experiments with block paving of all kinds showed pavers the importance of sturdy curbing to reduce the wandering of individual blocks.) The compacted roadbed was spread with six to eight inches of concrete (stone, sand, water, and portland cement) which was in turn smoothed with a thin layer of portland cement, sand, and water.

Dassen included sketches of block arrangements determined to reduce waviness and instruction on how to control wandering and other problems associated with streets laid with wood. "Experience has definitely shown that properly constructed algarrobo pavements last for 10 years in reasonably good condition. For the first six years after construction they hardly require any expenditure on maintenance, later on defects begin to appear."4

*Australia* – Sydney and Melbourne's nineteenth century experiments with wood-block streets generated attention and exaggeration in the engineering press of other English speaking nations. "The life of the pavement is estimated at sixteen years. It is used in the busiest sections of the streets of Melbourne and Sydney, and after eight or ten years of wear it is found to have worn off about one-sixteenth of an inch."5 Australian hardwood blocks found their way to London, New York, and Seattle where they met mixed reviews.6

*Burma* – According to a paper by J. Stirrat published in *Industrial Engineering* in 1898 street builders in Rangoon, Burma experimented with wood paving. In "Notes on Wood Paving vs Macadam in Rangoon," Stirrat reported on experiments with teak and pyinkadoe laid on a concrete foundation.7

*Canada* – Canadians, early users of plank roads, were also pioneer wood-block pavers who put down cedar blocks at least as early as 1888.8 Toronto laid several types of wood in 1895. "In June, 1901, City Engineer Chas. H. Rust reports, these different woods were examined with the following results: Beach, nearly all the blocks were decayed; maple, a few of the blocks were in good condition, but the majority of them had dry rot; rock elm, most of the blocks were in good condition ... soft elm, the blocks were all decaying; hemlock, the majority of the blocks were sound; Norway pine were in fairly food condition ... white pine were in as good condition as the Norway pine ... round cedar blocks were in better condition than any of the other woods."9

At the height of the wood-block paving era Toronto was a leader in a development of wood-block treatment. In "Wood Blocks for Street Paving: Their Treatment and handling," the editors of *Municipal Engineering* drew on Toronto in an effort to establish standards for wood-block treatment: "the Toronto specifications covers all the various classes of oil in use and may help to clarify the situation."10 Block paving was not limited to Toronto, in 1916, Hamilton, Ontario, Canada, laid 2,000 square yards of wood-block paving and Ottawa put down ten times that amount.11 In 1920, near the end of trolleys and wooden streets, Ottawa exhibited an advanced technique of laying wood blocks around city railway tracks to reduce the incidence of wagon and car wheels caught between paving and rails.12 Winnipeg's wooden streets also received attention in the civil engineering literature.13

*France* – Paris was home to innovative street paving of many kinds, rubber, iron, steel, and wood. The French capital was held up as an example of a city that pioneered in construction that benefitted its citizens' comfort and health.14 Nineteenth-century technological advances that kept Paris on the forefront of wood-block paving were continued into the twentieth as other nations looked to the French for solutions to heaving, waving, blistering, bleeding, and wandering.15

"Berlin has probably the finest sheet asphalt paving in the world. Their wood paving is rough and comparatively noisy. About the only thing of especial interest noted in Berlin was that a new wood block plant has been erected where the Rueping process will be used for treating Swedish pine similar to that used in England."16

*Great Britain* – London boasted wood-block streets as early as 1840. Like Paris, the British capital pioneered resourceful paving. "Wood-block paving is [1915] in general use in nearly all of the several hundred boroughs of the United Kingdom whose population is greater than 60,000. Its growing popularity is due to the fact that it shows a longer life under motor-bus traffic than any other smooth pavement that has yet been introduced at an equal expense, to the ease with which repairs may be made, and to the absence of dust and noise.

"There are a few prominent cities, such as Glasgow, Liverpool, Dublin and Belfast where wood-block paving is not used except in front of hospitals and schools. In these cities granite sets are employed and their displacement by wood pavements is delayed because of the practice of shoeing draft horses with sharp calks, which tear up the wood blocks."17

In 1915 Canadians anticipated the end of World War I and sales of Douglas fir, white spruce, jack pine, and red pine for paving British streets. "The supply along the Grand Trunk Railway is unlimited, there being enough still uncut to pave every street, not only in Europe, but in the world ... The extent of this new industry can be realized from the fact that the quantity of timber used by Great Britain for paving in 1913 was approximately 60,000,000 feet."18 Wood is an "esteemed paving material in the English Cities. In ten of the twenty eight boroughs constituting the City of London, and comprising the most thickly populated sections of the city, the total mileage of creosoted wood block in 1912 was 121, and of this total 40 miles was in the city of Westminster, that part of London containing the best retail business streets; the government buildings, theatres, museums, art galleries, etc., the social heart of the city."19

"All the other English cities have adopted wood paving for some of their best streets. Liverpool has approximately 150,000 square yards; Birkenhead, 95,000; Birmingham, Nottingham, Bristol, in fact all English cities over 50,000 population have wood block streets, and in the majority of cases these are the principal thoroughfares of the town."20

*Japan* – In 1923, *American City* reported that Tokyo, Japan was paving with creosoted Douglas fir blocks "laid on a concrete foundation which has been covered by a layer of mortar ... No covering or top dressing is used. This method of laying the block is probably the reason why there has been some complaint about a portion of the wood block paving which was put down about a year ago. If these blocks had been thoroughly treated and laid as they are in Europe and America, the pavement would probably have lasted for then years.

"A very rough estimate of the percentage of various kinds of paving planned for Tokio [sic] to be carried out prior to the end of 1926 is as follows: present completed wood block paving, 1 percent; future wood b lock paving, 10 percent; and asphalt macadam, 32 percent."21

*Switzerland* – In 1900 *U.S. Consumer Reports* noted experiments with wood-block paving in Basle, Switzerland. Included in the Swiss project was pitch pine from the United States.22

*United States* – Figure 2 depicts the distribution of wood-block paving across the United States by region. Wood-block paving projects in twenty-nine states and the District of Columbia were reported in newspapers and engineering journals. Some eighty American cities (not including Washington, D.C.) were involved. States and cities included may have laid wood block pavements, but they were not mentioned in major English-language newspapers or engineering magazines. *Municipal Engineering* reported in 1915 "150 cities using the wood block pavement, the amount so far laid being fully 10,000,000 square yards."21 Figure 3 lists the American cities that used wood-block paving.

**Figure 2  DISTRIBUTION OF WOOD-BLOCK PAVEMENT IN THE UNITED STATES BY STATE AND REGION**

|  |  |  |  |
| --- | --- | --- | --- |
| **NORTH WEST**WashingtonOregon | **MID WEST**North DakotaSouth DakotaIowaMontanaNebraska | **NORTH CENTRAL**IllinoisIndianaMichiganMinnesota OhioWisconsin | **NORTHEAST**ConnecticutMassachusettsNew YorkNew JerseyPennsylvaniaWest Virginia |
| **SOUTH WEST**California | **MID SOUTH**Texas | **SOUTH CENTRAL**TennesseeAlabamaArkansasLouisiana Missouri | **SOUTH EAST**MarylandWashington, DCSouth CarolinaGeorgia |

**Figure 3  U.S. STATES AND CITIES WITH WOOD-BLOCK PAVING**

|  |  |  |  |
| --- | --- | --- | --- |
| **ALABAMA** | Birmingham24 | Mobile25 |  |
| **ARKANSAS** | Hot Springs11 | Little Rock26 |  |
| **CALIFORNIA** | Holtville27 | Oakland28 | San Francisco29 |
| **CONNECTICUT** | Bridgeport30 |  |  |
| **GEORGIA** | Americus24 | Atlanta31 |  |
| **ILLINOIS** | Chicago32 | Granite City11 | Pontiac11 |
| **INDIANA** | Gary11 | Indianapolis33 | Logansport11 |
|  | South Bend43 |  |  |
| **IOWA** | Burlinghton11 | Centerville11 | Des Moines34 |
| **LOUISIANA** | New Orleans35 | Shreveport25 |  |
| **MARYLAND** | Baltimore36 |  |  |
| **MASSACHUSETTS** | Boston37 | Manchester11 |  |
| **MICHIGAN** | Detroit11 | Monroe11 |  |
| **MINNESOTA** | Albert Lee11 | Duluth38 | Minneapolis39 |
|  | St. Cloud11 | St. Paul11 | Virginia11 |
| **MISSOURI** | Joplin40 | Kansas City41 | St. Louis42 |
| **MONTANA** | Bute43 |  |  |
| **NEBRASKA** | Omaha44 |  |  |
| **NEW JERSEY** | Jersey City45 | Newark46 |  |
| **NEW YORK** | Buffalo11 | New York47 | Plattsburg11 |
|  | Syracuse48 | Watertown11 |  |
| **NORTH DAKOTA** | Fargo11 | Grand Forks49 | Minot11 |
| **OHIO** | Cincinnati50 | Cleveland51 | Dayton11 |
|  | Findlay52 | Lakewood53 | Norwood |
|  | Toledo54 |  |  |
| **OREGON** | Astoria11 | Eugene11 |  |
| **PENNSYLVANIA** | Philadelphia24 |  |  |
| **SOUTH CAROLINA** | Charleston24 |  |  |
| **SOUTH DAKOTA** | Huron11 |  |  |
| **TENNESSEE** | Memphis55 | Nashville56 |  |
| **TEXAS** | Austin25 | Beumont25 | Dallas25 |
|  | Fort Worth25 | Galveston57 | Greenville25 |
|  | Houston58 | Longview59 | San Angelo25 |
|  | San Antonio25 | Waxahachie25 | Wichita Falls25 |
| **WISCONSIN** | Chippewa Falls11 | Madison11 | Milwaukee60 |
|  | West Allis11 |  |  |
| **WASHINGTON** | Wenatchee61 |  |  |
| **Washington, D.C.24** |  |  |  |
| **WEST VIRGINIA** | Charleston62 |  |  |

***Technology***

The central theme of the engineering literature dealing with wooden roads is the performance of oils for treating the wood blocks. In *Journal of the Association of Engineers Society* (1892) T. J. Caldwell and T. D. Miller discuss St. Louis's treatment of blocks with tannin and zinc-gypsum. In 1902 *Municipal Engineering* reported on the plants used to treat wood blocks with kreodone oil for longer wear; P. C. Reilly, noted that kreodone also made wood blocks impervious to water, dryness, cold, and heat. "Wood Preservation with Asphaltic Material," relates "the success of the Santa Fe Railroad in treating ties with natural asphaltic oils from California and Mexico to prevent decay," and *Engineering News* published Clark R. Mandingo's "Creosoted Wood-Block Paving Specifications to Prevent Bleeding and Bulging". In 1915 *Municipal Engineering* set forth the history of treated wood block pavements in the United States, reporting that "one of the first creosoted wood pavements in Chicago was a section of long-leaf pine blocks laid in front of the auditorium hotel in 1900," and "nearly thirty miles of the most heavily traveled streets in Manhattan Boro, New York, are paved with treated wood blocks". In 1915, Hermann von Schrenk, in a presentation before the American Society of Municipal Improvements meeting in Dayton, Ohio, called for specifications for creosoting oil – "straight coal-tar creosote, additions of refined coal-tar to creosote, water-gas tars, etc." P.C. Reilly warned against the use of tars in creosote oil: "The serious results that follow the use of wood paving blocks, which have been treated with creosote oil mixed with tar, are well known to almost every paving engineer, chemist and contractor". And, in 1919, K. M. Waddell presented a paper that is available for treating wood blocks for paving.

Wood preservatives were widely used for paving materials and other wood products:
"statistics compiled by the National Wood Preservers' Association ... show that during 1913
the consumption of wood preservatives by the 93 treating plants reporting amounted to
10-8,373,351 gallons creosote oil, 26, 466,803 pounds dry zinc chloride, 3,883,738 gallons miscellaneous liquid preservatives" increases over 1912 of 29.5, 27.5, and 26.46 percent.63

After oil treatments to preserve wood paving b locks the topic attracting the most attention from engineers was foundation preparation. Nineteenth century wood-block streets sustained light loads on a dirt or sand foundation. Buckling, heaving, warping, and other problems were mitigated by undemanding traffic and shoddy construction. The blocks were put down on a poorly prepared surface without curbing. If loads exceeded the capacity of the blocks the paving shifted toward the sides of the road and the traffic was carried by the original dirt surface. Twentieth-century engineers carefully designed roadbeds and corralled their blocks with stone curbing that forced overburdened blocks to buckle or break under heavy burdens. remedies included oil treatment for blocks, to make them stronger and resilient, and improved foundations. It became common twentieth-century practice to carefully grade the roadbed, lay several inches of concrete–portland cement mixed with stone, sand, and water; until highway engineers learned to reinforced concrete with steel wire and wire and rods, that surface crumbled too easily to serve as a highway or street – then cover the concrete with few inches of mortar. The treated wood blocks were carefully placed on the dry mortar and wedged between permanent curbing.

In 1917, Walter Buehler, wood preservation and paving engineer employed with the Barret Company of New York, wrote in *Engineering News-Record* that hardened pitch was an improvement over dry mortar. "Possibly the general opinion as to the costliness of laying wood block on a pitch slayer has arisen from lack of actual experience with this type of construction, and perhaps also because of the erroneous idea that it is necessary to give the concrete base a 'side-walk' finish." Buehler directed pavers to allow the base to firm up before painting it with a think coat of pitch. Blocks could then be laid over the dried pitch and "rolled with a tandem-roller, which will be found sufficient to set the blocks in the pitch so that they will adhere firmly to it."65 In 1920, Hermann Von Schrenk, in another presentation before the American Society of Municipal Improvements, reinforced Buehler's arguments for a base of pitch beneath wood blocks.66 Ellis R. Dutton, a city engineer in Minneapolis, developed a technique for smoothing the concrete base before the pitch and covering wood blocks were added.67

Lambert T. Ericson, contracting engineer, Jennison Wright Company, Toledo, Ohio, and Midland Creosoting Company, Granite City, Illinois; C. H. Teesdale of the Forest Products Laboratory, Madison, Wisconsin; and James A. McElroy, city engineer, Bridgeport, Connecticut addressed the treatment of wood-blocks already in place. McElroy writes, "A few years ago I suggested to one of the wood-block companies that they might devise some method of treating old blocks on the street. The cheapest scheme they should suggest was to take up the clocks and relay them with another type of cushion. They estimated the cost at $1 to $1.25 per square yard, exclusive of the cost of new blocks.

"It was then decided to seal the old wood-block pavements by giving them a surface treatment of hot road oil ... After a few days under traffic the treated blocks had the appearance of a new pavement, and although considerable wet weather has been had since the work was done, the blocks have shown no signs of buckling. This treatment cost $.10 a square yard for 5,000 sq. yd."68

Slipperiness of wood-block paving was often offered as an argument against its use. Opponents of the blocks insisted that horses were unsteady on wood, especially in wet weather. In 1915, a Philadelphia firm began marketing a special block to increase traction on wooden streets. "The insertion of a bar of steel in a groove at the bottom of a channel in the surface of a creosoted wood block is the basis of the patent on a safety wood block made by the National Safety Wood Paving Company ... about half the blocks in a pavement are fitted with the grids and the combination of channel and grid gives the horse a chance for a footing, which is a great help in drawing heavy loads. Skidding of automobiles is also prevented in large measure. The grid blocks may be laid in several patterns. Probably the most popular will be with every other block a safety block."69

One 1917 technological advance comprised the corrugated wood paving block. "Each of these blocks is corrugated at one side and one end, by grooves running parallel to the grain of the wood." Grooves would press a flat side of a neighboring block, they were not cut into the exposed surface of the block. The grooves were designed to permit expansion and contraction without buckling and to be avenues into the pavement for sealing oils.70 Another innovation combined wood blocks with granite blocks or bricks to create a permanent surface between railway tracks laid in streets.71

In 1920 W. W. Horner, chief engineer, sewers and paving, St. Louis, Missouri, reported in *Engineering News-Record* on his success with jackscrews to tighten wood-block pavements. "Faced with the probability of having to take up 7,500 sq. yd. of loose wood block at an estimated cost of about $10,000 there has been developed this year, in St. Louis, a successful method of tightening pavement without removing and relaying the block ... the task was accomplished by cutting into the pavement at intervals, and tightening up the block on each side of the cut with jackscrews."72

Perhaps the most impressive technological advances in wood-block paving are found in the machinery to cut and lay blocks. As early as 1903 *Scientific American* reported on a portable gasoline-powered trimming machine that permitted Parisian maintenance crews to trim worn or damaged blocks and refit them into the pavement upside down thereby greatly reducing the time and cost of repairing wood-block streets. *Scientific American* reported on yet another wood-block cutting machine in 1908, a device "100 feet long, which divides each plank into 16 blocks by means of 17 circular saws ... [the] machine can saw 25 planks per minute. As each plank furnishes 16 blocks, the theoretical output of the machine in a day of 10 hours is 25 x 16 x 60 x 10 = 240,000 blocks."73

The ultimate technological advance in wood-block paving is an apparatus that anticipated the continuous paving machines used for asphalt and concrete highways and streets at the end of the twentieth century. The device will "level, smooth and compact a sand or wet concrete base and lay automatically consecutive rows of brick or other paving blocks, closing the joints, rolling the paved surface and leaving it ready for the joint-filling operation.

"The machine travel on rails, laid carefully to a correct grade, on both sides of the strip to be paved ... straight stretches of uniform width of paving. If the machine is motor operated, the only manual labor necessary, other than that required of the operator, is the feeding of the blocks in V-shaped troughs on the sides of the machine."74

***History***

Articles on wood-block paving disappeared from the engineering literature after 1925. One explanation is increasing traffic.

**400 Per Cent Increase in Tonnage Moved Over Highways.** – At the conference Sept. 17-19 [1918] of the Highways Transport Committee of the Council of National Defense, reports made by the regional chairmen showed tonnage moved over the highways increasing at a tremendous rate, in some states as much as 400 per cent increase over last year being show. The Cleveland-Akron-Canton area reported 61 per cent as much freight being moved by motor express now as the railroads are carrying.75

The 22 million registered motor vehicles of 1926 were overshadowed by the nearly 35 million of 1941–24,000 busses increased to nearly 120,000, 2.9 million trucks to almost 5.2 million and 19 million automobiles to nearly 30 million. The estimated 141 trillion vehicle miles traveled by motor vehicle in 1926 to 334 trillion in 1941.76

Had wood paving not given way to materials and processes that produced highways for high-traffic loads and heavy vehicles, the cost of wood-blocks might have become prohibitively expensive. "Ten million square yards of wood block pavement means that we have used up for this purpose practically 400,000,000 feet of merchantable lumber. At least 50,000,000 feet of lumber will be used up in wood block pavements during 1915. This brings us face to face with the great problem of to-day: The conservation of our timber."77

As important as the need for sturdier pavement and the supply of timber as explanations for the demise of wood-block paving is the demand for a wooden street surface. The leading quality of wood for paving was its capacity to muffle iron and steel-tired vehicles and horseshoes. Automobiles dispensed with the clattering of horse hooves and more and more horse-drawn vehicles were mounted on rubber tires as the twentieth century progressed. Wood-block pavement to lower noise levels in cities was no longer necessary.

The streets of Westminster are important thorofares. The traffic is, however, very largely rubber-tired [in 1914]. In fact, the percentage of iron-tired traffic, if known, would probably be suprisingly low. There are a few exceptions, such as the Strand, where there is considerable mixed traffic, but, on the whole, the streets of Westminster and those of purely residential boroughs ... which together contribute ninety miles to the total of London wood paving, carry a traffic comprising a tremendous number of vehicles, but of a very nondestructive character to pavement.78 As early as 148 BC a wooden road at Corlea Bog, County Longford, Ireland facilitated travel over a bog from one point of high ground to another. Two thousand years later highway engineers in California used redwood logs as a fill for the Redwood Highway in northern California.79 The two-millennia history of wood paving is complete. Wood will be used in road building only under exceptional circumstances. When historians review obsolete modes of land travel – horses, buggies and wagons, steam trains, and trolleys – they should recall the equally remote yet engaging materials that paved the way for ancient travel equipment: iron, steel, rubber, cotton, and wood.

**NOTES**

1. David O. Whitten, “Rollin' on Rubber: 120 Years of Rubber Roads,” *Essays in Economic and Business History*, 414-27.

2. David O. Whitten, "Rusty Roads: Ferrous Metal Paving Materials," *Essays in Economic and Business History*, 14(1995), 249-66.

3. My late mother recalled her assignment to defend the horse and wagon in a 1930 high school debate. "Everyone knew that horses and wagons were finished, that automobiles were the future, yet I had to make the affirmative in 'The Horse and Wagon Will Win the Race with the Motor Car.' I marshalled the potent arguments against motorcars and in favor of horses and buggies and won that debate!" As late as 1930 there was much to be said in favor of horses and carriages. The race was lost but the horse was still on the track.

4. Claro C. Dassen, "Practice and Experience with Algarrobo Wood Pavements in Buenos Aires, Argentina," *Engineering and Contracting* 40 (August 20, 1913)8, 198-99.

5. "Australian Wood Pavement," *Municipal Engineering*, 6(1894), 271

6. Walter Alexander Smith, "Advantages of Australian Hardwood for Paving," *Engineering Record* (November 24, 1894); Sir Edward H. Wittenoom, "A Defence of Australian Hardwood Pavements," *Engineering News* (August 23, 1900); R. W. Richards, "Hardwood Pavements in Sydney, New South Wales," *Engineering News* (March 18, 1897).

7. J. Stirrat, "Notes on Wood Paving vs Macadam in Rangoon," *Industrial Engineering* (September 10, 1898).

8. Alan MacDougal, "Cedar Block Carriage Ways," *Transactions of the Canadian Society of Civil Engineers* 2(1888), 185.

9. "Wood Pavement Tried in Toronto," *Engineering Record* 45(February 8, 1902)16, 137.

10. "Wood Blocks for Street Paving: Their Treatment and Handling," *Municipal Engineering* 50(1916), 183-84: "Treated Wood Block Paving: Investigations Made by the Forest Products Laboratories of Canada," *Canadian Engineering* (June 17, 1915).

11. "Wood Block," *Municipal Engineering* 50(1916), 150.

12. Andrew F. Macallum, "Wood Block Paving Between Street Railway Tracks," *American City* (City Edition) 22(March 1920) 3, 237-38.

13. "Winnipeg's Pavements," *Canadian Engineering* (January 19, 1911).

14. "Wooden Pavement and Public Health in Paris," *Sanitation Record* (June 11, 1897).

15. See part 1; M. P. Toulon, "A Metallic Plug for Wood-Block Pavements (Un Tamp métallique pour le Pavage en Bois)," *Bulletin of the Society of d'Encour* (March 1920).

16. S. R. Church, "Wood Paving in Europe: Soft Wood Universally Used and Method of Laying," *Engineering Magazine* 47(April 1914) 1,103.

17. See part 1; "Popularity of Wood-Block Paving in Great Britain," *Scientific American* 113(November 20, 1915), 449.

18. "Canadian Wood Blocks for Paving in Great Britain," *Municipal Engineering* 49(1915), 225.

19. S. R. Church, "Laying Wood Paving in London," *Municipal Engineering* 46(1914), 448.

20. "Wood Paving in Europe."

21. "Wood Block Pavements in Japan," *American City* 28(February 1923), 121.

22. "Wood Pavements in Switzerland," *U.S. Consumer Reports*, No. 772(July 5, 1900).

23. E. W. Church, "The Wonderful Growth in Wood Block Paving," *Municipal Engineering* 49(1915), 156.

24. "Treated Wood Block Pavements: Their History in the United States," *Municipal Engineering* 48(1915), 94-100.

25. "Wood-Block Pavement Failures of Southern Cities Analyzed," *Engineering News Record* 80(February 14, 1918) 7, 307-310.

26. B. Woods, "Wood-Block Paving in Little Rock, Arkansas," *American City* 22(May 1920), 459-61.

27. "Plank Road Laid Across Shifting Desert Sands—Near Holtville, CA," *Engineering Review* (July 29, 1916).

28. M. K. Miller, "Redwood Block Paving with Asphalt Carpeting, at Oakland, California," *Engineering News* (July 20, 1899); Walter C. Howe, "Modern Street Work in the West," *California Journal of Technology* (August 1908).

29. "Wood Block Pavement in San Francisco," *Municipal Engineering* 13(1897), 99-100; Ernest McCullough, "California Redwood for Street Pavements," *Municipal Engineering* (June 1897).

30. J. A. McElroy, "Wood-block Pavements Restored by Seal Coat," *Engineering News* 90(March 22, 1923): 531.

31. "Wood Block Pavements in Atlanta," *Engineering Record* (January 1, 1898); "Creosote Block in Atlanta, Ga.," *Municipal Engineering* 44(1913), 39-40.

32. See part 1; William W. Marr, "Repaving the 'Loop' District in Chicago with Creosoted Wood Block," *Engineering News* 41(December 29, 1910) 26, 718; Harry G. Davis, "Creosoted Block Paving in Chicago," *Engineering and Contracting* 36(September 13, 1911)11, 276-77; John Ericson, "Creosoted Block Paving in Chicago," Municipal Engineering 44(1913), 17-20; Louis A. Dumond, "Wood Block Pavements in Chicago," *Municipal Engineering* 45(1913), 51-52; "Repair and Maintenance of Various Kinds of Pavement, Chicago, IL," *Engineering News* 70(December 4, 1913(23, 1137-38; Walter Buehler, "Economical Value of Wood Block Paving," *Journal of Western Society of Engineers* 25(February 5, 1920)3, 73-92.

33. See part 1; P. C. Reilly, "The Development of the Kreodone Block Pavement," *Municipal Engineering* 38(January 1910)1, 42.

34. "Street Paving in Des Moines, Iowa," *Municipal Engineering* 47(1914), 304-05.

35. R. S. Manley, "The Construction of Creosoted Wood Block Pavements," *Municipal Engineering* 46(1914), 152-53; "From Ancient Granite to Modern Wood Block," *Municipal Engineering* 50(1916), 69; Lambert T. Ericson, "Recommended Procedure in the Construction of Wood Block Pavements," *Municipal Engineering* 54(1918), 139-40; Walter E. Rosengarten, "Pavement Guarantees: Prevailing Requirements in Principal Cities as Shown in Study by the Asphalt Association," *Engineering and Contracting* 64(October 7, 1925)4, 785-88.

36. "The Detailed Cost of Constructing 19,067 Square Yards of Belgian Block Pavements at Baltimore, Maryland," *Engineering and Contraction* (September 22, 1909).

37. B. T. Wheeler, "Recent Experience with Wood Pavements," *Engineering Record* 44(October 5, 1901)14, 324-5; James H. Sullivan, "Creosoted Wood Block Pavements in Boston," *Municipal Engineering* 45(1913), 2456-58; Rosengarten, "Pavement Guarantees."

38. John Wilson, "Creosoted Wood Block Pavement in Duluth," *Municipal Engineering* 45(1913), 481,82.

39. D. M. Avery, "Wooden Block Pavement Tests in Minneapolis, Minn.," *Municipal Engineering* 39(October 1910)4, 265-70; B. H. Durham, "Nine Years' Experience with Creosoted Wood Block Pavement in Minneapolis," *Engineering and Contracting* 35(April 19, 1911)16, 450-53; "Wood Block Paving in Minneapolis," *Municipal Engineering* 43(December 1912)6, 376079; Ellis R. Dutton, "Method Employed in Minneapolis in Constructing Smooth Surfaced Concrete Base for Wood Block Paving," *Municipal Engineering* 57(1919), 51-53; J. D. MacLean, "Minneapolis Experimental Wood Block Pavement After 15 Years' Service," *Engineering and Contracting* 56(November 2, 1921)18, 417-17.

40. H. L. Collier, "Expansion and Contraction in Wooden Blocks," *Municipal Engineering* 41(September 1911) 3, 294, 95.

41. See part 1.

41. T. J. Caldwell and T. D. Miller, "Treatment of Wood for Paving," *Journal of the Association of Engineers Society* 4, 232; "Wood Block Paving in St. Louis," *Municipal Engineering* 43(October 1912)4, 265-68; W.W. Horner, "Jackscrews Tighten Wood Block Pavement in Place," *Engineering News-Record* 85(October 7, 1920)15, 686-89; W.W. Horner, "Contraction of Wood Block Pavement through Contraction and Floatation," *Engineering News-Record* 84(April 1920)22, 814-17.

43. L. R. W. Allison, "Wood-Block Street Paving in Butte, Montana," *American City* 15(July 1916), 54-55.

44. "Brick and Wood-Block Pavements in Omaha," *Municipal Engineering* 8(1895), 257; Collier, "Expansion and Contraction in Wooden Blocks."

45. "Creosoted Wood Block Paving in Jersey City," *Municipal Engineering* 46(1914), 492; "Wood Block," *Municipal Engineering* 50(1916), 150.

46. William A. Howell, "Wood Block Pavement in Newark; Features of Recent Construction," *Municipal Journal* October 29, 1914); William A. Howell, "Repairs to Wood Block Pavement in Newark, New Jersey," *Public Works* 50(June 18, 1921)25, 515-18.

47. See part 1; Frederic Arnold Kummer, "Wood Paving Specifications in Greater New York," *Municipal Engineering* 25(November 1903)5, 328-32; George W. Tillson, "Development of Wood Bock Specifications," *Municipal Journal & Engineering* (March 15, 1911); "Creosoted Block Pavements in the Boroughs of the Bronx and Brooklyn, City of New York," *Municipal Engineering* 44(1913), 346; Rosengarten, "Pavement Guarantees."

48. S. M. Feinberg, "Suggested Composite Standard Specifications for Exterior Wood Block Paving," *Municipal Engineering* 60(1921), 236-46.

49. J. J. Smith, "Method of Constructing Creosoted Wood Block Pavement at Grand Forks, North Dakota," *Engineering and Contracting* 32(October 27,1907)17, 352-53.

50. H. M. Waite, "Creosoted Wood Block in Cincinnati," *Municipal Engineering* 45(1913), 157-59; Ericson, "Recommended Procedure."

51. Ericson, "Recommended Procedure" Rosengarten, "Pavement Guarantees."

52. "Cost of Wood Block Paving in Findlay, Ohio," *Municipal Engineering* 49(1915), 195-96.

52. "Construction Procedure in Repaving Detroit Avenue, Lakewood, Ohio, with Granite and Wood Block," *Municipal Engineering* 55(1918), 201-202.

54. "Creosoted Wooden Block Bridge Pavement in Toledo," *Municipal Engineering* 20(1901), 96; Raymond Pierce, "Procedure in Constructing an Open Joint Wood Block Pavement at Toledo, Ohio," *Municipal Engineering* 56(1919), 174-75.

55. Niles Meriwether, "Pavements: Brick, Cedar Blocks, Granite Blocks, Telford and Macadam...Memphis, Tennessee," *City Engineer* (January 1, 1893).

56. "Lug Wood Block in Nashville," *Municipal Journal* (September 3, 1914).

57. J. W. Byrnes, "Creosoted Wood Pavement in Galveston, Texas," *Municipal Engineering* 8(1895), 206-207; Hetherington, "The Creosoted Wood Block Pavements; Wood-Block Pavement Failures."

58. "Creosoted yellow Pine for Pavements," *Municipal Engineering* 42(April 1912)4,341.

59. P. E. Green, "Creosoted Wood Block Pavement in Longview, Texas," *Municipal Engineering* 45(1913); 363-64; "Wood-Block Pavement Failures."

60. Ericson, “Recommended Procedure;” Rosengarten, "Pavement Guarantees."

61. F. J. Sharkey, “Wood Block Pavement in Wenatchee, Washington,” *Engineering and Contracting* 44(October 20, 1915) 16, 300-302.

62. “Wood Fiber and Asphalt as Paving Materials,"”*Municipal Engineering* (May 1915).

63. T.J. Caldwell and T. D. Miller, “Treatment of Wood Paving,” *Municipal Engineering* (May 1915). *Association of Engineers Society* 4(1892), 232; “Plants for Treating Wooden Blocks," *Municipal Engineering* 22(1902), 88; Frank W. Moulton, “Kreodone Wood-Block Pavements,” *Municipal Journal and Engineering* 24(March 1903)3, 232-34; “The Durability of Kreodone Wood-Block Pavements,” *Municipal Engineering* 24(April 1903)4, 314; Reilly, “The Development of the Kreodone Block Pavement;” “Wood Preservation with Asphaltic Material,” *Municipal Engineering* 44(1913), 192; Clark R. Mandigo, "”reosoted Wood-Block Paving Specifications to Prevent Bleeding and Bulging,” *Engineering News* 72(November 5, 1914)19, 946; “Treated Wood Block pavements ... United States;” “Specification of Oil for Creosoting Wood Paving Blocks,” *Municipal Engineering* 49(1915), 233-34; “Specifications for Creosoted Wood Block Paving,” *Better Roads & Strets* 7(March 1917)3, 110-11, 135-36; P.C. Reilly, “Destruction of Wood Block Pavement Due to Use of Tar in the Creosote Oil,” *Municipal Engineering* 54(1918), 183-84; K. M. Waddell, “Proper Grade of Creosote Oil for Wood Paving Blocks,” *Municipal Engineering* 57(1919), 269-72.

64. “Consumption of Wood Preservatives in 1913,” *Municipal Engineering* 47 (1914),65.

65. Walter Buehler, “Creosoted Block Can Be Laid on Hardened Pitch Cheaper Than on Dry Mortar,” *Engineering News-Record* 79 (December 20, 1917) 25, 165-67.

66. Herman von Schrenk, “Recent Experiences with Wood Block Pavements,” *Municipal Engineering* 59 (1920), 159-611.

67. Ellis R. Dutton, “Method Employed in Minneapolis in Constructing Smooth Surfaced Concrete Base for Wood Block Paving,” *Municipal Engineering* 57(1919): 51-53; Ellis R. Dutton, “Method of Constructing Smooth Top Concrete Base for Wood Block Paving,” *Engineering and Contracting* 51 (February 5, 1919), 141.

68. Lambert T. Ericson, “Proper Method of Application of Bituminous Filler for Creosoted Wood Block Pavements and Floors,” *Engineering and Contracting* 50 (October 2, 1918) 14, 320-21; “Wood-Block Pavement Failures;” McElroy, “Wood-block Pavements.”

69. “To Overcome Slipperiness in Wood Block Pavements,” *Municipal Engineering* 44 (1913), 377; “Lug Wood Block in Nashville;” “A Non-Slip Wood Paving Block,” *Municipal Engineering* 48 (1915), 148-49.

70. “Corrugated Wood Paving Block,” *Municipal Engineering* 53(1917), 103.

71. “Combining Brick or Granite Block with Wood Paving Blocks,” *Municipal Engineering* 53 (1917), 181.

72. Horner, “Jackscrews Tighten Wood Block Pavement in Place.”

73. “Wood Paving in Paris,” *Scientific American* 62 (January 3, 1903) 11; Jacques Boyer,
“A Machine That Saws 240,000 Wooden Blocks a Day,” *Scientific American* 98 (April 18, 1908), 273-4.

74. William Bayley, “A Machine for Laying Brick or Block Pavements,” *Engineering News* 72 (July 9, 1914) 2, 74-76.

75. *Engineering and Contracting* 50 (October 2, 1918) 14, 321.

76. U.S. Bureau of the Census, *Historical Statistics of the United States, Colonial Times to 1957* (Washington, DC: GPO, 1960), ser. Q314-317 & 322, 463.

77. Church, “The Wonderful Growth in Wood Block Paving.”

78. Church, “Laying Wood Paving in London.”

79. “Redwood Logs Used for Fills on California Highway,” *Engineering News Record* 113 (October 18, 1934), 16.