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Where used ?*

Highway Engineering in the United States  
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Differences between the practice of highway engineering in the United States and in other countries are due mainly to three causes: The comparative youth and rapid settlement of the Country; the coincidence of its period of maximum expansion of settlement with the railroad era; and the rapid development and wide utilization of the motor vehicle.

It is only three hundred years since the first settlement was planted on the shores of the Atlantic. For half that period - the colonial era - there was practically no penetration west of the Allegheny Mountains, and to the population that spread along the coast the water courses were the principal highways. Then roads were mere cleared ways through the virgin forest.

After the establishment of the Republic there was instant recognition of the need for roads to link together physically the thirteen colonies that had merged their interests in the common Federal government, and also to open the vast unsettled areas west of the eastern mountains.

For three decades there was a considerable activity in the construction of roads. Hundreds of turnpike companies were chartered, and the building of stone roads began in accordance with the ideas and methods then current in England. The new State of Kentucky, recently carved out of the wilderness of the Ohio River Valley, as one of its first acts, established a department of highways under

engineering control, remarkably like the State departments under which the great advance of recent years has been made. The Federal government itself, embarked ambitiously upon the construction of the National Pike, which was doubtless intended to be only the first of a system of national highways.

Into this situation came the railroad; and effective road building ceased. The Federal government abandoned plans for the surfacing of the western end of the National Pike in the belief that the grade would eventually serve a railroad. It backed the private promotion of rail arteries by prodigal grants of public land. States mortgaged themselves, and exhausted their credit to hasten the building of the new lines of communication. There is no doubt that government and people alike supposed that the railroads would eventually become the universal means of communication, displacing all but the most local of wagon roads. The hundreds of short lines projected, built, and since abandoned prove that.

In the older East towns that had sprung up and grown by virtue of their commanding location on the pioneer wagon roads withered and died because they were not favored by the surveyors of the railroads. In many instances they were moved from their old locations to others in order to benefit by the new order in transportation. The wagon roads remained, and as population thickened their mileage increased. The joining of the roads of each community formed a connected net work the mesh of which became progressively closer as the country grew,

but these roads were viewed as mere neighborhood lanes. For more distant travel each community had or hoped to have a rail connection with all others. The revenues of the turnpike companies dwindled to the vanishing point. One by one they abandoned their unprofitable investments and these main highways as well as the lesser local roads reverted to public control. The Federal and State governments washed their hands of them and they fell under the administration of the authorities of the counties and townships, the smallest of political subdivisions, and under such local administration they all remained for upwards of a half century.

In all that period no effective general effort was made to improve them. Those which had originally been graded and drained and surfaced were allowed to deteriorate until they became practically indistinguishable from the much greater mileage that the engineer had never touched. To this result the natural inability of minor elective officials to cope with an engineering work was only one of the contributing factors. There were also the moderate requirements of local wagon travel; the complacency of a people willing to tolerate small inconvenience of travel within the locality if only the more pressing needs of long-distance travel were finally met by railroad connection; the constant expectation that the deficiencies that were actually felt would soon be rectified by the laying of rails; and above all the very limited revenues available for road purposes. To keep the roads barely passable; to fill the worst mudholes; to cast out

the largest rocks; to reduce slightly the steepest grades; these were all that were or could be done, and all in fact, that were generally

In the Middle West the early situation and the course of development was somewhat different, but the final result was the same. Across the great central area between the Allegheny and the Rocky Mountains, by the Mississippi and its two main tributaries, the Missouri and Ohio, there existed before the coming of the railroads a limited number of made wagon roads in the section east of the Mississippi. Beyond the Father of Waters there were only a few routes of exploration, the tracks marked by the wheels of the prairie schooners of the emigrants as they pushed their toilsome way westward toward the few known passes through the forbidding barriers of the high and rugged western mountain chains lured by the promise of wealth that lay in the furs of Oregon and the gold of California.

East of the Mississippi the pre-railroad situation was more nearly similar to that of the eastern seaboard. Towns already existing, their location determined mainly by the navigable watercourses. West of the great river there was nothing but a vast level plain crossed by the few westward winding trails, along which at long intervals were small rest posts and forts for defense against the Indians.

The first transcontinental railroads promptly occupied the lines of the old trails; and, eased of its greater difficulties, the settlement of the west began in earnest and continued at an unprecedented pace accelerated by the liberal agrarian policy of the Federal government.

The vast, almost level plain, uniformly arable was carved by the government into square - mile rectangular sections, the borders of which were invariably reserved as highway right of ways, and as the land was taken up by settlers most of these right of ways actually came into use as wagon roads, and still remain as public highways, Numerous beyond any reasonable need of the present day, indirect in the extreme for long-distance travel, and a heavy burden upon the public treasuries. But when these roads were laid out there was no intention that they should ever serve a more than local usage. They were intended merely to give access to the rectangular farms; and those who occupied the farms as well as the government that laid them out envisaged the day when the needs of long-distance travel and transportation would be served by railroads yet to come to a degree far more complete has ever been realized.

On a map these section-bordering roads would appear as a vast rectangular highway system, but no one thought of them in that way. On the contrary, they were regarded and used merely as local lanes, and as such they required and received no attention beyond the absolute minimum required to keep them passable - here, as in the East, at the hands of the local authorities.

In the Far West, beyond the Rocky Mountains, the development of roads was more similar to the Eastern growth. Here again, the boundless prairies past, mountain walls hemmed in the spread of population, and watercourses gave it direction. The roads followed. But here, from the beginning, the public attitude was framed with knowledge of the railroad, and not, as in the east, in ignorance

of its coming. Into the more remote and least habitable portions of this great area railroads have never penetrated to this day; the wagon road is the only means of communication, and it is generally a mere trail. Where there was possibility of rail service the road was regarded as in the other sections of the country as of local importance only; and where it was actually the only feasible means of access population has always been so sparse and revenues consequently so limited in proportion to the great distances to be traversed that improvement by the States or localities has been financially impossible.

So it happened, that between 1830 and 1890 the public roads of the United States increased to upwards of two million miles and none outside the immediate vicinity of a few of the larger cities was surfaced or otherwise improved beyond the most essential requirements to preserve passability. In all that period engineers had practically no concern with their construction or even their location except as the latter was entailed by land sub-division or the development and exploitation of natural resources.

The first stirring of a renewed public interest in the condition of the roads appeared when the bicycle came into use. The roads that had sufficed for a half century of plodding use by horse-drawn vehicles were far from conducive to the pleasures of cycling. As nearly every one soon came to bicycle ownership there arose a strong public demand for road improvement, directed first to the local authorities in whom authority was vested. When these were found incapable of adequate response sentiment crystallized in favor of the creation of

State agencies, manned by engineers, capable of advising the local authorities in regard to the best methods of road construction and maintenance, and by grants of State funds to assist in carrying out the advised improvements.

The first of such agencies, the forerunner of the present State highway departments, was established in New Jersey in 1891. Massachusetts followed within a year, and its scientifically-minded commission was instrumental, to a greater extent than that of perhaps any other State, in reviving the art of road construction in the United States and in the training of capable highway engineers.

In 1893 a memorial addressed by the League of American Wheelmen to Congress led that body to authorize the Secretary of Agriculture to make inquiries concerning the best methods of road construction and maintenance and to disseminate the information he obtained. To carry out the duty thus laid upon him the Secretary created within the Department of Agriculture a small Office of Road Inquiry-necessarily small, since the annual appropriation by Congress was only \$10,000-and thus was begun the work of investigation, education, and coordination, which has been continued and is now carried on by the Bureau of Public Roads.

In these three establishments - the highway departments of New Jersey and Massachusetts, and the Federal Office of Road Inquiry - there was the genesis of all that has made the profession of highway engineering what it is today in the United States: The adoption of the principle of State aid, later to be expanded into Federal aid; the inauguration of systematic investigation of methods most applicable to the condition of the country; and the creation of an agency for the prompt spreading

of whatever knowledge might be gained anywhere, from State to State and throughout the country.

In the decade that followed the creation of the first three agencies, State highway departments were organized in eleven other States, their form patterned upon the models of New Jersey and Massachusetts; the art and practice of road building were taken up where they had been laid down by the contemporaries of McAdam; and some tentative efforts were made to adapt the old methods to the conditions of the later day.

Not that conditions had greatly altered; in fact, they were but little changed by the passage of seventy years. The road was still of local importance only, and so far as any one could see it would remain so. The local authorities were still in control. The few State governments which had manifested interest and the Federal government offered advice mainly, supplemented on the part of the States by nominal money aid as an inducement to accept the proffered advice. But there was a new group of road users - principally the cyclists, but also in the later years a sprinkling of venturesome motorists - who wished to use the roads for pleasure; and from this group there was already a complaint of the dustiness of stone and gravel road surfaces, which had started the American highway engineer upon his twenty - year search for new methods of road construction to meet the needs of a changed and changing traffic - a traffic that was to grow at a rate beyond all precedent and the most fantastic prophesy.

Viewing the year 1904 as the beginning of the period of modern highway construction, it will be well to see what was the condition



of roads in the United States at that time. There were then in the entire country 2,151,570 miles of public rural roads. Of this total only 153,662 miles had been surfaced in any way, and the bulk of this surfaced mileage - 114, 899 miles - consisted of roads topped with gravel and less durable materials such as shell, and sand-clay mixtures. Of water-bound macadam roads there were 38,662 miles; and of types of surfaces now considered superior to macadam there were in the whole country just 141 miles.

So, it will be seen that up to 1904 there had been no important change in the methods of road construction which had been employed for a century or more. The major types of surfacing were gravel and macadam, and either was known to give entire satisfaction under the traffic normal to the country roads of the time. Other types had been developed and used in small mileage, such as the shell roads of the tidewater States and the sand-clay roads of the South, but the element of availability was the determining factor in the choice of such materials rather than any difference in the demands of traffic; and the same element, in fact, largely determined the choice of the two major types.

Thus we find that there was a preponderance of gravel roads in Michigan, Indiana, Illinois, Iowa, Wisconsin, Minnesota and the Dakotas where gravel deposits were plentiful; and a preference for stone in Kentucky, West Virginia and others where suitable gravels were scarce. From New Jersey south, the Atlantic and Gulf States

had built considerable mileages of oyster shell roads; and the Southern States, in which there was a scarcity of other materials, had developed the sand-clay type. Even the small mileage of high-type surfaces which had been constructed was doubtless attributable less to traffic demands than to the availability of the materials, for of the total of 141 miles we find that 123 were paved with brick, of which 104 miles were in the two States of Ohio and West Virginia where brick was cheap and perhaps the most available local material.

Viewed broadly, the few types of surface constructed up to this time may all be considered as of one class. In the construction of all the same principles governed; in all a fragmental mass was bound together more or less firmly by a natural cement in the manner made familiar by a century of practice; and all alike depended for their efficiency upon the conic principle of pressure transmission by which they spread the vehicular loads and thus reduced the intensity of pressure borne by the subgrade.

That need was felt for no other kind of construction was due, of course, to the fact that the traffic on all roads was much the same. Even in the more populous States the greater part of the traffic using the roads consisted of relatively light horse-drawn, steel-tired vehicles, to which were added near the cities a bicycle traffic which, though it might attain considerable volume, was never more than a negligible factor in determining the type of surface. This was the normal traffic condition which existed practically up to 1904. What makes that year a turning point in the

highway history of the United States is the fact that about that time there began the great outpouring of motor vehicles from the cities which quickly set the intercity roads apart from others as a class requiring different treatment.

The peculiar effect of the automobile on water-bound macadam roads is so well known as to require no description and the manner in which the road builders met the challenge by substituting tars and asphalts for the weaker mineral binders has been an oft-told tale. First as dust layers then as protective surface coatings, then as binders introduced into roads of the macadam type by penetration, and finally as hot admixtures according to the bituminous-concrete principle, these materials, borrowed from the stock in trade of the city street builder, solved the automobile problem in a manner which was apparently entirely satisfactory.

The effect of this development in the road building art is shown by comparison of the statistics of 1904 and 1914, the dates which, to all intents and purposes, mark the beginning and crest of the wave of early bituminous construction. In 1904, according to the records, there were in the entire country only 18 miles of bituminous rural roads, all in the two States of Massachusetts and Ohio. By 1914 there were 10,500 miles, a mileage which was nearly three-quarters of the aggregate length of all roads of higher type than macadam. This was the first high-water mark in the use of the lower forms of the bituminous types.

Ten years later in 1924 - the mileage of surface-treated and bituminous macadam roads was less than 50 per cent of the mileage of all types better than water-bound macadam, in comparison with the 75 per cent level reached in 1914. This was the trough of the wave. Since 1924 there has been increasing need for the lighter bituminous treatments, and in modified forms adapted to rapid construction with specialized equipment they are now being applied to large mileages of stone, gravel, sand-clay and topsoil surfaces. The reason for this return to favor is not far to seek. Until 1924 or a few years before it was only upon the main intercity roads and roads adjacent to cities that traffic had reached a density sufficient to require and justify bituminous treatment. In that year it was just recognized that the increasing utilization of motor vehicles had given to a very large mileage of lesser roads an automobile traffic of such density as to create upon this greatly increased mileage the same problem of dust alleviation and ravel prevention that twenty years previously had first been met on the main roads. What is being done to meet this situation is a matter for later discussion in detail.

We are concerned now with the development of road types in general; and it is generally recognized that the low types of bituminous construction, which came into use with the development of passenger automobile traffic are especially adapted to that class of traffic. The erstwhile relative decline in their use began when motor trucks in considerable numbers commenced to appear on the principal highways; and coincidentally we find an increasing swing

toward the rigid pavements of concrete and brick and bituminous concrete on a concrete base. The turning point was reached in 1914 or perhaps a year or two earlier.

The first concrete pavement was built at Bellefontaine, Ohio, in 1893, but up to 1909 no more than 5 miles had been constructed on rural highways in the entire country. In that year approximately 4 miles were built; in 1910 about 20 miles were added, the following year 40 miles, and then the first big increase occurred in 1912 when more than 250 miles of rural highways were paved, to be followed in 1913 with 500 and in 1914 with more than 1,500 miles. At the close of the latter year there were in the entire country 2,348 miles; and by 1927 the mileage had increased to 48,350 and construction was proceeding at the rate of more than 6,000 miles a year, a rate approached by no other type better than gravel.

The more extensive use of brick, and the bituminous pavements of the mixed type on concrete base began at about the same time and was due to the same cause - the increased use of motor trucks. In 1914 there were approximately 1,600 miles of brick pavement; in 1927 there were 4,519. In 1914 the mileage of rural highways paved with bituminous concrete or sheet asphalt was still negligible; in 1927 there were more than 11,500 miles of these types.