

fill in a short time in order that a high-type surface can be constructed, the use of controlled moisture contents in grading operations would be economically possible. This optimum moisture content method will continue to be used on mixtures of soils and aggregates for base purposes. The next step will be the combination of natural materials and cheap binders in order to provide a stable, splatterless surface throughout the year for intermediate-type roads. It will be an easy procedure then to construct the relatively thin wearing courses which are common today and secure a high-type highway. The engineer has progressed more rapidly in designing and constructing surfaces than he has in designing and constructing subgrades and bases. However, the two are now rapidly coming to the point of equilibrium.

THE CONSTRUCTION OF SMALL TREATED-TIMBER BRIDGES IN DUBOIS COUNTY, INDIANA

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The Indiana State Legislature at a special session in 1932 transferred all the township-maintained roads from the jurisdiction of the township trustees to the county highway systems. In the southern part of the state this resulted in a considerably larger undertaking than was originally anticipated, because in many counties the unimproved township-road mileage was larger than the improved county highway system.

In Dubois County, which is a typical example of many of the southern counties, there were three miles of unimproved roads for each mile of improved roads after the change. In the 755 miles which made up the new highway system were approximately 3,500 drainage structures. The maintenance of these structures and the construction of new structures to replace ones that had failed proved to be one of the problems in proportioning the revenue available for highway use, which amounted to approximately \$85,000 annually.

After the making out of a tentative budget, since it was apparent that it would be impossible to build permanent structures, it was decided to build timber structures wherever the drainage area required something larger than could be taken care of with corrugated pipe.

The advantages of timber constructions were that they could be constructed rapidly, that they could be taken down and moved or have their roadway increased if they did not fit in with the future surfacing of the unimproved roads, that the entire expenditures could be kept in the county to help the farmers and the local unemployment situation if native oak timber was used, and, most important of all, that their

immediate cost would be about one-third of the cost of permanent construction.

In our investigation of several timber bridges to determine the useful life which could be expected from them, records of two bridges were found which had been constructed by a township road supervisor. These bridges were approximately fifty feet in span and made up of three spans each. Both of these bridges were constructed of native oak lumber, and one of them had been given a treatment of coal-tar creosote applied with a brush. The life of this bridge which had been given a light treatment of creosote was approximately double that of the untreated structure. Records kept and published by several railroad companies show that pressure-treated railroad ties will last from two to four times longer than untreated ties.

For these reasons it was decided to give the bridge timbers a dip treatment in a tank filled with hot creosote. The tank, with a capacity of about 150 gallons of creosote, was so arranged that a fire could be kept under it to heat the creosote and the cover for the tank could be used as a drain rack for the treated timber. This treatment gave the timbers a light skin-coating and filled the cracks and checks, thereby preventing decay and destruction by termites.

Approximately 200,000 board feet of treated native oak timber have been used during the past two years in the construction of approximately sixty bridges and the reflooring of numerous light steel-truss spans. All timbers were framed before treating, and only seasoned timbers were used.

Table 1 shows the itemized and total costs of several typical structures. The average cost of the timber used, including the cost of the creosote treatment, was \$35.00 per M.F.B.M. If commercially creosoted timber had been used, the cost would have been about \$60.00 per M.F.B.M.

TABLE 1
COST ANALYSIS OF TIMBER STRUCTURES

Span	Roadway	Height*	Lumber†	I-Beams	Hardware Paint, etc.	Labor and Trucking	Total Cost
10'	18'	6' 0"	\$69.65	\$1.10	\$41.45	\$112.20
12'	18'	7' 0"	65.03	1.50	50.35	116.88
14'	18'	7' 0"	77.22	\$60.70	2.50	52.90	193.32
16'	18'	6' 0"	65.83	62.40	6.00	58.00	192.23
18'	18'	7' 6"	124.20	86.23	8.50	90.60	309.53
20'	18'	7' 0"	89.25	87.75	9.40	56.00	242.45

*The figures under the heading "Height" show the distance from the bottom of the footing to the top of the floor.

†The quantity of lumber used varied greatly because of the sizes of the wings used with the various structures.

These bridges were framed and erected by a county bridge crew working under the supervision of the county surveyor, who also served as a highway supervisor. The bridge crew consisted of a foreman, a carpenter, a truck driver, and from one to three common laborers. They removed the old structure, constructed the new one, and made all approach fills necessary to complete the structure in from two to five days time, the time depending on the size of the structure.

I-beams were used for stringers on all structures having a span of fourteen feet or over, and the three-inch flooring was fastened to the I-beams with cleats which locked the individual planks to the stringers and to each other. The roadway was determined by the type of road on which the structure was built, and all structures on improved roads or roads which would be improved soon were constructed with not less than eighteen feet of roadway.

These structures have proved very satisfactory and the construction of similar ones will be continued in the future. Their life is estimated, on the basis of the life of several old structures in the county, at a minimum of fifteen years when native oak lumber treated with creosote as described in this article is used. Many of the southern and western states use pressure-creosoted timber structures in their state highway systems and find them very satisfactory.

STAGE CONSTRUCTION AS IT APPLIES TO INDIANA ROADS

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Taken in its broadest sense, this subject covers the entire field of highway activities. By this I mean that good, first-class maintenance borders so closely upon stage construction that it is frequently difficult to distinguish between them or to draw a line setting out where maintenance leaves off and construction begins. In fact, stage construction is of such character that it lends itself in the earlier steps to being carried on by maintenance organizations and equipment.

Just what is meant by stage construction? I imagine that most of us think only in terms of road surfaces as they are developed progressively from the loose or traffic-bound gravel and stone to the more costly high-type pavements. It is obvious that there are necessarily many things to be arranged for and accomplished before the actual assembling of physical materials into a road surface. For the purpose of this discussion I am going to define stage construction of roads as their progressive improvement by successive betterment operations.