

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

Earl B. Lockridge,
Field Engineer of Maintenance,
Indiana State Highway Commission, Indianapolis

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.

The character of grade and alignment obtainable should be looked into thoroughly. Likewise, cost must be taken into account both as to construction and future maintenance. We have learned from experience that to build along the hill-sides of Southern Indiana, later to have slides, and to cross the muck lands of Northern Indiana, with subsequent settlements, means costly maintenance.

To provide properly for stage construction, too much care cannot be taken in furnishing proper grade and alignment, not only for such type of surface as is intended at this time, but for development by successive stages even to the highest type of pavement known to modern engineering.

When only limited finances are available, the first stage of construction may contemplate only grading and structures.

The securing of adequate right-of-way is most important. Right-of-way width should not only be sufficient to complete the type of improvement planned, but some allowance should be made for additional future requirements. The arguments for wide rights-of-way are so many and so convincing that it seems hardly necessary to present them in this paper. I will say, however, that it is a decided advantage to secure in the first place all the right-of-way that may ever be needed. Not only can it be had at a more reasonable price, but any roadside planting that may be done will be back where it can be preserved, the utilities will not have to be disturbed later, and adjacent private improvements can be made with the assurance that they are not to be molested. Mr. Adams, the Chairman of our State Highway Commission, has often and wisely said, "The only really permanent thing about a highway is its right-of-way." That being true, there surely is no justification for unduly limiting the ratio of the cost that the right-of-way may bear to the entire improvement.

No construction should be contemplated without considering how it will adapt itself to future maintenance. Many so-called white elephants have been created because of failure to consider the proposed improvement from this angle. At least an attempt should be made to visualize its future behavior and existing or available means of maintenance. This leads us back again to the matter of plans and specifications.

Of recent years there has been a growing conviction among authorities on highway development that primary and secondary roads or state and county roads, if you please, are integral parts of one road system to be jointly financed and improved, each in proportion to its traffic and social service possibilities. What is the distinguishing difference between a primary and a secondary road? At best the division is a more or less arbitrary one based upon the amount and kind of traffic and modified by the practical consideration of building and maintaining certain through routes to a somewhat

higher standard for the kind of traffic that might be warranted by the volume.

It has been said that any community whose citizens can afford to own motor vehicles can afford all-weather roads. Assuming that the first stage of construction, that of providing proper grade and alignment on adequate right-of-way, has been completed, how are we going to arrive at a decision as to the most practical wearing-course to provide as our next stage? Certainly a traffic census will be considered and some thought given to the amount and kind of traffic to be handled. Perhaps the traffic has not sufficiently developed as yet, because of prevailing conditions, to allow one to determine just what might be expected in the future. This being the case, some inexpensive type of surface will be considered, having in mind its future value as it may become necessary to add successive courses from time to time to meet the requirements of increased quantity and weight of traffic.

SUBGRADE

Recently much study has been given to soils to learn their comparative values as subgrade material or as stabilized surface material. Subgrade character exercises a controlling influence on road condition. Surface design that is adequate for a given traffic on one type of soil may be wholly inadequate for an inferior type. Drainage must be reckoned with and cannot be ignored. One of the advantages of stage construction is to get uniformity of subgrade settlement and stability before investing in the more costly type of surfaces. A relatively thin pavement or wearing-course sufficient to meet a given traffic load can be built and maintained on a subgrade of high support-value more cheaply than a thick pavement or wearing-course can be built and maintained on a hit-and-miss subgrade. It is self-evident that the subgrade finally carries the highway load, regardless of what kind of pavement is placed upon it. Therefore, utilizing subgrade values is essential in design practice. In fact, pavements are merely amplified subgrades.

Availability of suitable local materials should be given consideration in surface design; however, public officials should not be forced to use inferior local materials when it means sacrificing quality of work.

The second stage may be one of the soil-stabilized surfaces or perhaps local plant-run gravel or stone to a compacted depth of about two inches. Successive stages may follow within a few months or possibly not for several years, depending upon traffic requirements and available funds. If the surface is of such character as to require considerable replacement because of wear and if materials are not conveniently available at reasonable cost, it may prove economical

to advance to the next stage quite soon to avoid not only unsatisfactory surface condition, but to get away from high maintenance cost. The third stage may consist of adding metal and binding it with some agency such as calcium chloride or road oil. Succeeding stages may consist of dual bituminous surface treatments, mixed-in-place retreads, or any of the higher type of pavements. Old rigid-type pavements that have become broken and rough-riding, resulting in impact that rapidly destroys them, make excellent bases if patched out in time, and can be given a bituminous mixed or rock asphalt wearing-course at a nominal cost that will prolong their life more or less indefinitely.

Each road project is a special problem requiring a complete knowledge of the strength of the existing pavement and subgrade and careful alternate estimates of different methods of treatment. There are a number of solutions which will serve the purpose, provided the general basic principles are not violated. For instance, a high-type surface should never be used on a weak base. In fact, any low-cost road without sufficient base course will prove to be expensive.

In addition to the progressive stages of surface developments, culverts may be extended and bridges widened as one stage of construction. The grade may be improved by widening berms and easing off slopes of cut and fill sections as another stage. Likewise, beautification of the right-of-way by planting trees and shrubs and sodding surfaces of bare slopes might constitute another stage. This planting should not be gone into extensively until suitable grade and cross-section has been developed.

EARLY LEGISLATION

The first session of the Fourteenth Congress of the United States passed an act, approved April 19, 1816, entitled, "An Act to enable the people of the Indiana Territory to form a Constitution and State Government and for the Admission of such State into the Union on an equal footing with the original States." Paragraph 3, Section 6 of Chapter 57, of this "Enabling Act" provided: "That five per cent, of the net proceeds of the lands lying within the said Territory, and which shall be sold by Congress from and after the first day of December next, after deducting all expenses incident to the same, shall be reserved for making public roads and canals, of which three-fifths shall be applied to those objects within the said State, under the direction of the Legislature thereof, and two-fifths to the making of a road or roads leading to the said State under the direction of Congress." Congress no doubt had in mind the Old National (Cumberland) Road, (now U. S. Highway No. 40) in this act, for shortly thereafter the first stage of its construction was carried out by

clearing the right-of-way and grubbing the stumps on the center portion. Since that date successive stages of improvement have consisted of grading, draining, bridging streams, and surfacing with everything from corduroy and split planks to local gravel and stone and later all of the various materials known in pavement construction. Traffic has constantly increased both in volume and weight, making it ever necessary for authorities in charge to seek better design both as regards ability to carry more weight and ability to carry greater volume. Different sections constructed by our state highway commission since 1920 have had to be replaced entirely or strengthened by adding additional depths of surface material to carry the loads. At present a program is under way to increase the number of traffic lanes throughout the entire length of this heavily traveled highway in order to relieve congestion. So another stage of construction is under way.

One of the early acts of the legislature committing the State of Indiana to stage construction of highways provided for the surveying and marking of what became known as "The Michigan Road" extending from Michigan City on Lake Michigan through Indianapolis to Madison on the Ohio River. Subsequent acts provided for the development of various sections of this road, one of which, passed on January 29, 1830, provided for opening that part of the road lying between Madison and the Wabash River at Logansport, one hundred feet wide, between August, 1830, and the last day of November, 1831, in the following manner: "All parts of the road were to be cleared off, leaving no stump more than than one foot above the level of the earth; and grubbed thirty feet wide in the center of the road as the United States road (Cumberland Road) was grubbed through Indiana."

Of the various subsequent acts of the legislature dealing with highway matters, I dare say that none had more influence on the general improvement and development of a system of highways in the State of Indiana than the so-called Three Mile Gravel Road Law enacted in 1905. I would list as the next major steps the creation of a state highway system by acts of 1917 and 1919, and then, through the acts of the special session of 1932, the placing of all township roads under the jurisdiction of the respective county authorities for maintenance and development.

Not only has the state highway commission developed and improved by stage construction many miles of highway under its supervision, but I personally know of many instances where county officials have done excellent work in grading some of the unimproved roads now under their jurisdiction, using their maintenance equipment as a first stage of construction. Later these roads were surfaced with metal, and others that needed but very little grading were shaped up

and given surface material. The counties have accomplished this through proper conservative handling of their gasoline tax fund. Other instances of stage construction have come about through the efforts of the National Government in its attempt to give relief to the unemployed through made-work projects. Though the results from this source of labor have been very discouraging in many instances, there are also cases where much good has been accomplished, due largely to the quality of leadership of the men in charge. City streets received their share of improvements as a result of Government made-work projects and pavement construction within municipalities.

The state highway commission has been able to do much shoulder widening by the use of federal and state funds, all of which work is stage construction. In addition to the work accomplished by force account, the state highway commission report for its fiscal year ending June 30, 1934, shows that contracts were let as follows on stage construction projects:

- Structure extensions on 338.74 miles of road.
- Grading and structures on 68.51 miles of road.
- Gravel and stone surface on 57.62 miles of road.
- Bituminous retread surface on 6.67 miles of road.
- Bituminous mulch surface on 19.42 miles of road.

A similar table for the fiscal year ending June 30, 1935, shows the following:

- Stabilized material course on 20.20 miles of road.
- Structure extensions and shoulder widening on 324.62 miles of road.
- Grading and structures on 14.33 miles of road.
- Gravel and stone surface on 70.27 miles of road.
- Bituminous retread surface on 1.39 miles of road.
- Bituminous mulch surface on 111.26 miles of road.

In addition to the above-listed contracts, the maintenance department applied oil as a dust palliative on 232 miles of stone and gravel surfaces and stabilized with calcium chloride 25 miles of gravel surface in 1934.

For the fiscal year ending June 30, 1935, the maintenance department applied oil as a dust palliative on 1,028 miles of stone and gravel surfaces, while formal contracts were let for surface-treating with heavier grade of bituminous material on 728 miles of road, much of which work might be classed as stage construction where the quantities of materials used were sufficient to increase the thickness of the wearing surface materially.

It is my belief that the highway authorities consistently adhering to the policy of stage construction will be able to improve the maximum number of miles and give appropriate service to the maximum number of people at the minimum

cost. Let me suggest the following slogan to the supporters of stage construction: "Build highways where needed in the measure needed."

THE USE OF HEAVY EQUIPMENT IN COUNTY ROAD MAINTENANCE

Richard H. Hofmann,
Franklin County Road Supervisor,
Brookville

This topic is worthy of more serious discussion than it has had the good fortune to receive at previous Road Schools. To many people the word "construction" applies almost entirely to projects under the jurisdiction of the state highway commission, while they consider that county highway departments should concern themselves, for the main part, with maintenance work merely.

This idea would be practical, if the state highway commission could be prevailed upon to take over those roads which, by their importance to the traveling public, merit changes in location and type which cannot properly be made under the heading of maintenance. We have found, however, that in our locality the state prefers to take over those roads which, by their condition, require the least cost to make them a part of their secondary road system. This leaves us with the problem of maintaining those roads upon which the burden of ever-increasing traffic demands not only a better type of surface, but, in many cases, the elimination of steep grades, narrow fills, and sharp turns, or, in other words, practically the construction of a new road.

In the past four years, we have found a place in our budget for this type of work without materially crippling the work on our other roads, which consists principally of ditching and maintaining the road surface.

Franklin County lies at the southern edge of the east central section of the state, the county seat, Brookville, being some 40 miles south of the National Road. The east part of the county is level, the roads being laid out on the rectangular system, while the western and southern parts of the county are more or less hilly and typical of all southern Indiana counties.

Our maintenance material consists chiefly of bank and creek gravel. Our county road system comprises some 700 miles of road, and our budget totals approximately \$80,000 per year, derived from the gasoline fund. Our maintenance equipment includes five dump trucks, ranging in size from 1½- to 3½-ton capacity, 1 five-ton Caterpillar, 1 five-ton Allis-Chalmers tractor, several maintainers, drags, and small grad-