LOW COST BRIDGES FOR SECONDARY ROADS

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Probably a more appropriate title for this discussion would be "Bridges for Low Traffic Roads." The reason for this observation is that when low cost bridges are considered, the question immediately arises—what is meant by low cost bridges, low initial cost or low ultimate cost? There can be little doubt in anyone's mind that the lowest initial cost bridge is the timber structure supported on timber piles. However, when maintenance costs are considered over a period of years and taking into consideration the load capacity, the more permanent structure of reinforced concrete and structural steel will, in our opinion, ultimately prove more economical.

Although it is recognized that even on secondary roads, larger streams and special conditions may require long spans of a special nature, this discussion will be limited to spans up to about 60 feet. It is felt that even on the larger bridges approach structures constitute a considerable part of the cost and that savings made on the shorter span portion of larger bridges as well as on bridges over smaller streams where only short spans are required is very important. This discussion will also in general refer to bridges having a roadway width of 22 feet from curb to curb and having an H-15 design capacity.

Various studies for low cost bridges have made it apparent that there is little common basis for the comparison of substructure costs. Substructure conditions vary widely in a relatively small area, and there is not much opportunity to effect economies by standardization or new labor saving methods. The bridge superstructure therefore is the portion of the bridge where, in our opinion, costs may be reduced by the methods which will be discussed in detail later.

In approaching the problem we believe that it will be recognized that one of the greatest contributing factors to the relatively high cost of the bridges on secondary roads is that often the location is in a remote section and the available labor even if sufficient, is not skilled in the type of work required. It is necessary to either use the available men at relatively low productivity on a strange job, or to bring in some or all of the skilled workers required, often at a premium as to expenses or hours of work. Under either of these alternates the amount of work for any one trade is usually small and intermittent and the result is
that the total labor costs are high. It is apparent that substantial savings in the cost of the superstructures could be made if a considerable part of the work could be completed in a shop by mass production methods of precasting or prefabrication.

It is recognized that there may not be a sufficient number of bridges built by any one agency in any year, except perhaps by the State Highway Department, to obtain the fullest benefit of mass production but it is reasonable to assume that if the bridge needs of several counties and towns were grouped together at intervals with those of the State and bids taken for the furnishing, at a central point, of a number of identical units, the cost of each unit should be relatively low. Another point pertaining to the cost is that if standardization of design is achieved and maintained, the cost of subsequent units would be considerably less because amortization of plant cost, shop drawings, templates, etc., would be spread over a large number of units. It is entirely conceivable that at slack times units could be prefabricated at lowest cost and stockpiled for future use.

The two principal materials used in bridge construction are structural steel and reinforced concrete. In the field of low cost bridges for secondary roads the Bureau of Public Roads in collaboration with the American Institute of Steel Construction and the American Association of State Highway Officials has given a great deal of study to the reduction in costs by standardization and the elimination of expensive details in shop fabrication. Better understanding by bridge designers of the problems confronting the fabricator will contribute to decreased costs of fabricated structural steel. There is one feature on all bridges which is always troublesome and contributes to increased cost. That is the handrail. Simplification of handrail details particularly those details which provide for the adjustment of height and line is important in helping reduce costs in fabricated structural steel. As one nationally known fabricator stated recently a great deal of time, trouble and expense goes into providing handrail brackets, even on the lowest cost jobs, that provide for the handrail to be adjusted to absolutely straight lines. After it is once erected usually no further attention is paid to it and before any great length of time, the handrail is out of line, bent and twisted and the money that went into the elaborate handrail adjustment bracket has been wasted.

Inasmuch as the proposals for the standardization of steel spans are in competent hands and progress is being made, it is thought that there is no need at this time to discuss them at any great length.

It is more or less by the process of elimination that we arrive at the point where it is evident that if any new substantial savings can be
made in the cost of the smaller bridges they must be made in the superstructure and in the reinforced concrete work. It is my intention, at this point, to bring before you two ideas which, in my opinion, offer a field for exploration with the idea of approaching the goal of low cost bridges for secondary roads. Both of these ideas involve the precasting or the prefabrication of portions of the bridge superstructure. In my opinion the precasting of concrete units for bridge construction represents a great field for progress. There are many advantages in precasting concrete which are not always readily apparent, but which I feel contribute materially to the object of this discussion.

As already pointed out precasting permits better and more economical use of plant and equipment and more particularly precasting contributes to a better finished product for the following reasons:

(1) As the concrete plant can be made semipermanent a much better and more exact control can be exercised over the composition of the concrete itself. Since large amounts of aggregate will be used better control, testing and uniform supply of aggregate can be obtained.

(2) By the use of more permanent forms, either steel or concrete, a denser surface, which reduces the likelihood of any appreciable maintenance being required, is obtained.

As an example of the possibilities of precast spans, on a job under construction at present at Brunswick, Georgia, on which we are consulting engineers, 103-36 foot slab and girder spans of 3 and 4 span continuous units for five bridges were precast at the job yard and barged to the bridge sites. The spans were designed for the A.A.S.H.O. H-15-44 loading. Each section, which weighed about 46 tons, consisted of one-half the 24 foot roadway and one 3 foot wide curb and walk. The handrail rails were precast also and the posts were formed and poured after the erection of the slabs and the placing of the rails. The cost of the superstructure was $5.70 per square foot of roadway surface. This cost compares favorably with the Bureau of Public Roads estimate of $4.00 to $5.00 per square foot for a standardized 40 foot steel span with a 22 foot roadway and no walks. Bids were taken on two alternates - precast and poured in place spans. The bid price on the poured in place spans gave a cost of $6.78 per square foot of roadway surface. Of the five low bidders one bid only on cast in place construction and one bid only on precast construction. Another contractor bid lower on the poured in place alternate, while two bid lower on precast spans.

This is a more or less special case as the handling of 46 ton sections requires the use of heavy expensive equipment but the above figures
give an idea of the savings possible through precasing a large number of identical units. By the use of light weight aggregate such as Haydite, by eliminating the walk and by reducing the roadway to 22 feet, the weight of the sections could be reduced, for a 28 foot span, to about 23 tons. While the weight of these sections would still be large, it is felt that no particular difficulty would be experienced transporting them when it is considered that heavy equipment such as cranes must be transported to the site for use in the construction of the substructure.

For longer spans it might prove economical to precast slab and girder sections using steel beams and shear connectors to provide composite action with a reinforced concrete slab cast directly on the beams. The forming for the slab could be simplified by casting the span upside down and setting the beams directly on the freshly poured slabs. This would require some special consideration of the means of turning the spans over to their final position without damage but this could be worked out without too much trouble. Another possibility is the precasting of concrete girders and slabs separately, the slabs to be placed on the girders in the field.

A number of years ago we were confronted with the problem of placing a new permanent concrete floor on a bridge which, because of lack of funds had been originally decked with timber. In this case it was necessary to replace the floor in the quickest possible time in order that traffic would be inconvenienced as little as possible. In seeking a satisfactory solution we came upon a plan which proved so effective and of such a low cost that we were impressed with the fact that this method could, with certain adaptations, contribute materially to lowered cost of new construction.

As those of you present who are familiar with the individual items of cost will recognize, one of the most costly operations of bridge construction is the forming for the concrete deck and the stripping of forms after the deck is poured. This is particularly true where the span is sufficiently high to require suspended scaffolding for stripping. This is a costly, time consuming and often dangerous portion of the work. Also it is true that where bridge deck slabs are poured in place, the placement of reinforcing is a costly operation and from our experience it has been found that the difficulty of obtaining placement of the reinforcing in the correct position and maintaining it there when concrete crews are working across it is almost impossible. In attempting to find a new and better method of pouring concrete slabs we decided upon the use of precast lightweight concrete channel sections which could be used as a form for concrete and remains as a permanent portion of the deck.
Developing the idea of the precast channels for forms we find many advantages and have evolved a design utilizing these features. Such a design is applicable to various span lengths and it should be recognized that it could be used with either steel beam or girder sections or, in the case of shorted span lengths, could be used with precast concrete beams.

This design is shown in the accompanying drawing. Many of you will recognize that precast channel sections are not new to the building industry and were originally developed as roof slabs for building construction and as such are manufactured by many companies in various parts of the country. The application of channel sections to a bridge floor is a relatively simple matter and in our design we have taken a 22-foot roadway supported by four longitudinal beams. The channel sections are placed transversely across the beams, the two outside sections being 9'-3" long and the center one 6'-6" long. The larger sections, 9'-3" long and 2'-6" wide, would weigh about 420 lbs. or approximately 18 lbs. per square foot. Actual experience has shown that these sections can be quickly and easily handled by manpower being lifted from a truck and placed in their final position without equipment. By the design of the precast form channels, transverse roadway beams are formed at 2'-6" centers and the roadway deck and roadway beams are poured monolithically using the curb as an outside form for the roadway deck. By the use of prefabricated trussed reinforcing, some of the problems of placing and maintaining the reinforcing mentioned previously will be solved. While we have shown the curb as being precast it will be recognized that it could be cast in place at a minimum of cost and time. It will be noted that we have shown the curb as being 14" in height. In our opinion a 14" curb is one of the most effective devices to prevent vehicles from leaving the roadway and decreases the need for extremely heavy guard rail sections.

In the matter of costs manufacturers have advised us that in their opinion the precast channel sections could be furnished in central Kentucky for about $.65 per square foot and if a plant were to be set up in an area to furnish a large number of the sections, this cost could be reduced to about $.58. This, from our experience, would cut the forming costs almost in half. Of course, this does not include the cost savings in the placement of the reinforcing steel.

We estimate that the cost of a bridge superstructure of average span based upon this design could be reduced to approximately $3.78 per square foot for a 30 foot span and to about $4.07 for a 40 foot span. This figure might not be obtained initially but after the contractors be-
come experienced in the manufacture and use of the precast form sections, I feel that this cost would be obtained.

I have presented these two methods making use of precast concrete as illustrations of methods that could be adapted to the field of bridges for low traffic roads. The point I would like to leave with you is that probably only through mass production can appreciable savings in the cost of small bridges be made and of course the prerequisite of mass production is standardization. I feel that if each of you would work toward this end, truly low cost bridges for secondary roads could become a reality in Kentucky.