COST OF GIRDER AND SLAB CONCRETE HIGHWAY BRIDGES.*

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The purpose of this paper is not to discuss the practice of the Illinois Highway Commission in the design of through girder and slab types of concrete highway bridges, but to develop a ready means of ascertaining the approximate number of cubic yards of concrete in a completed structure of a known span, height of abutments and length of wings, as well as to develop a means of making preliminary estimates of the cost of completed structures without calculating the quantities in detail.

The bridge work of the commission requires a personal inspection of the bridge site with the local officials, and at this meeting the necessary data are obtained for the design of the bridge. Almost invariably the officials expect that an estimate of the cost of the proposed work be given them at this time. Consequently, it is desirable to be prepared to give an estimate of the proposed bridge that will closely approximate the one that is made from the detailed drawings. This is usually a somewhat difficult matter unless the time is taken to compute the number of cubic yards that will be in the bridge.

With the increased interest in concrete bridge work the past four or five years, it is needless to say that the commission has been called upon for engineering assistance more frequently each year, until to-day it is almost impossible to meet all the requests. For this reason a system of standards was devised and all computations tabulated. This greatly improved the office efficiency and made it possible to answer a large number of requests.

Again, in our office, it has been necessary to do considerable figuring to determine the best make up for a bridge. Frequently a series of small slabs on piers would sum up much cheaper than the larger spans, and vice versa. It is sometimes advisable to compare a steel bridge for the same site. With curves worked out by Mr. H. E. Bilger on the cost and the number of cubic yards in substructures for steel bridges, we are able to get a very accurate estimate of the cost of a steel bridge complete. It, therefore, became desirable that some ready means be devised for determining the approximate number of cubic yards in concrete slab and girder bridges, for both office and field use.

From the large number of computations we have made of various concrete bridges, it was thought possible that a complete tabulation of quantities or a system of curves could be worked out that would enable one to determine readily the contents of either the slab or the girder type of bridges. It is proposed, therefore, to correlate all computations and data on the flat top type of bridge, and to arrange it in a convenient form for both office and field use in determining the number of cubic yards in ordinary bridges, besides obtaining an approximate estimate of the cost. Before proceeding, however, it may be well first merely to outline in a general way the slab and the girder bridges as designed by the Illinois Highway Commission, and give a few dimensions that you may better understand the types of bridges under consideration.

Slab Bridges.—For reinforced abutments for slab bridges the main wall is made 12 inches thick from top to bottom, the steel reinforcing being placed on the stream side, and the percentage of steel increased as the height increases. The abutments rest on an 18-in. reinforced footing, which is made of sufficient size to allow but 3,000 lb. per square foot bearing on the foundation. When a soft foundation is encountered, this same size footing is usually sufficient to permit the proper spacing of the required number of piles.

The reinforced wings for slab bridges are of the standard cantilever type, the base being 33 per cent. of the total height. The wing wall proper is 12 in. thick for heights up to 16 ft. For greater heights the base of the wall increases in proportion to the height. Nearly all wings for this type of bridge have a drop of 18 in. to 5 ft. at the end to conform to the 2 to 1 slope on the sides of the road. I may say here that the cantilever type of wing for extreme heights has been found much more satisfactory than the buttress type, as the increased thickness at the base and the large percentage of steel does not equal the extra cost of forming necessary for the buttress type.

Reinforced concrete slab bridges are designed with various roadways, ranging from 16-ft. upward. The side rails usually average 8 in. thick and 3½ ft. high. On this type of bridge the slab and the side rails come flush with the back of the abutment walls. The top of the wings comes up along the outside of the rails to catch the side slope on the road. In determining the thickness of the slab, its entire dead load is considered, the load of the cushion wearing surface, and a 24-ton engine live load. Excluding temperature stress, the steel is figured at 12,000 lb. per square inch; the compressoin in the concrete is assumed at 800 lb. per square inch.

Girder Bridges.—For the reinforced abutments for girder bridges, the general type is the same as that for the slab bridges, with the exception that all abutment walls proper are 18 in. thick, and the width of base for the wings is 40 per cent. of the total height. The extra thickness in the abutments is for bearing of the girders. The extra width of base under the wings is for stability, as the wing walls are cut away from the abutment walls proper by a 1-in. partition to allow for expansion of the superstructure. They can, therefore, receive no support from the abutments, as is the case with wings on slab bridges. The wings on this type of bridge also come up on the sides of the girders and drop several feet at the ends to follow the general side slopes on the road.

The reinforced concrete girder superstructures are designed with roadways from 16 to 30 ft. The roadway usually required is 16 to 20 ft. The side girders average from 4 to 16 ft. in height, and 16 to 30 in. wide on the top. On the side girders there are heavy depressed panels to lighten the web and to give the proper appearance to the finished bridge. The floor slab and side girders on this type of bridge also extend to the back side of the abutment wall. The floor slab is designed to carry its own dead load, the cushion wearing surface and a 24-ton engine live load. The side girders are designed to carry the entire dead load of the superstructure, plus a live load of 125 lb. per square foot on the roadway, or a 24-ton engine, whichever gives the greater moment.

Abutment Diagram.—For the purpose of determining offhand the approximate yardage in a pair of reinforced concrete abutments for either slab or girder bridges, Fig. 1 has been prepared, and is applicable within the specific cases used. For abutments of slab bridges, 40 different designs were taken from the files of the commission, and the number of cubic yards in the two abutments of each design was plotted against H (R + 2W), where H is the distance from the finished roadway to the bottom of the footings, R is the clear roadway of the slab bridge, and W is the length of one wing measured on the stream side. R was taken as the clear roadway of the bridge, as this figure is always secured at the preliminary inspection of the bridge site. W, the length of the wing, can always be assumed in the field or

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