BRIDGE SURVEYS FOR NEW STRUCTURES

By W. W. Hadley,
Engineer of Bridge Construction, Indiana State Highway Commission.

The importance of the bridge survey is underestimated by many engineers, especially the younger men. Most young engineers, upon graduating from a technical school, wish to start either in the drafting room or on construction and are rather disappointed if you offer them an opening as assistant on a bridge survey party. Work on a bridge survey party, however is a splendid foundation for later experience either in the drafting room or on construction. An incorrect set of survey notes may, and generally does, require a revision of plans during construction that may involve a costly delay and an additional expense in getting the structure completed. It frequently happens that the location of the road depends upon the result of the bridge survey. An ideal chief of survey party is one who has a working knowledge of construction and design, in order that he may know what phases of the survey are most essential.

I well remember my first bridge survey. The old adage is true, "Where ignorance is bliss, 'tis folly to be wise." About the only qualification I had was the ability to run a transit and level. Fortunately, I was working in a small organization with headquarters close to the proposed bridge site and when information not shown in my notes was needed, I was able, without much expense or loss of time, to get the information required. It took several extra trips, however, to get what I could have secured in my first day's work. The total amount of information secured was not nearly as much as I would get now, however, and much was assumed by the designer that should have been investigated. The structure afterwards built has withstood several floods, but I prefer not to discuss the economy of the design or what could have been saved by more time spent in getting ready to start the plans on the bridge.

With small organizations where the responsible head in charge of the bridge work may have an intimate knowledge of the bridge site, the survey need not be as comprehensive as in a large organization. It is advisable to keep the notes in a field book to be filed away when the plans are completed as during construction, questions often arise which make it desirable to know the reasons for certain features of the design. When a copy of the original survey notes are available, such reasons are generally quite evident.

In a large organization, when the designer and estimator do not see and are not familiar with the bridge site, the survey notes must be complete and nothing be left to guess work. It is a great help if the survey notes are accompanied by photographs showing the site at the time the survey was made.

Detailed Procedure

In making the survey proper, the first step should be the establishment of the center line. When the structure is on a new location, the survey notes for the new road are available and this reduces the amount of work necessary by the bridge survey party. If, however, the structure to be built is on an established road, it is necessary to locate the center line of the existing road. We have found from past experience that it is always necessary to continually caution the chief of the survey party to get information as to the alignment and grade of the road from ¼ to ½ mile on each side of the structure, depending, of course, on the topography of the vicinity. Nowadays, the traveling public is very prone to take the existence of good roads and bridges as a matter of course, thinking that somebody should be able to wave a magic wand and say "presto change," and have a new bridge all ready for traffic without any inconvenience whatever. We, of the bridge department, probably know better than anybody else the amount of criticism of traffic detours on account of bridges being out. So we now endeavor, if at all possible, to locate the new structure on a center line that is far enough to one side to permit use of the old structure until the new one is built. In case of complete failure, we are frequently able to build, at small expense, a temporary bridge on the old abutments and piers. However, the approaches to the bridge may be on high embankments and careful consideration should be given to the advantages of utilizing such work in place.

It frequently is advisable to establish a base line to get the topography and leave the final selection of the center line until the notes have been plotted and all phases of the situation considered. After the center line is established, it is very essential that it should be referenced permanently so that the center line of the survey may be exactly reproduced at the time construction starts. During the first year or two of the organization of the bridge department, most of our bridge surveys were made by separate survey parties not in charge of construction. We were continually receiving complaints from construction men that they were unable to find the reference pointts. It was very easy to establish reference points on telegraph poles and then when the pole gang came along and moved the poles these points were of no use to the construction party. The information secured by these parties

not always being accurate, it was a favorite pastime for the construction men to complain of the kind of work done by the survey party. To relieve this condition, we endeavored for a time to have all surveys made in the winter, during the slack construction period by the men who would be responsible for the construction of the new structures. Then, in response to a long distance telephone call from the construction man that he was having difficulty on account of sub-soil conditions not being the same as shown on the test pits, our first question was, "What was the matter with the information secured by you?"

After the center line has been established, the next step is to take, either by cross sections or stadia, enough information so that a complete topographical map may be made showing the bridge site. There should also be taken, if at all possible, a profile of the bed of the stream, 50 ft. or so on each side of the proposed structure.

Subsoil Investigations

Test pits or some other method should be used to determine the subsoil condition at the bridge site. Ordinarily, we ask our field party to put down test pits with shovels as far as possible. We have found by experience that the most effective instrument is a common post-hole auger to which may be screwed lengths of pipe, and the auger turned with two 24 inch Stillson wrenches. In some cases, we have to secure information to depths of 12 or 14 ft. On some of our larger jobs, where it is of vital importance to determine the subsoil condition to an accurate degree as possible, we have gone to the expense of letting a contract to a wash-boring outfit. Our experience with information so obtained has not been altogether satisfactory. On one of our jobs a few feet below ground level, the wash-boring showed the subsoil to be a soft sandy clay. When the contractor got down with his excavation to this level, it was necessary to remove a very hard sandy clay by means of dynamite. By placing some of this clay in water, we got a soft sandy material such as described in our inspector's report. Evidently, the churning of the drill and the water loosened this material so that when it was examined, it was of an entirely different nature than in its undisturbed condition. After going through this hard material for a depth of 4 or 5 ft. and encountering a soft strata, it was necessary for the contractor to drive longer piling than was specified on the plans. A recent article in "The Engineers News Record," shows that other engineers have been having the same experience with wash-boring outfits. In New York City preparatory to the construction of a new building, some extensive explorations were made by wash-boring outfits and the contract for the foundation was made on a

basis calling for approximately 360 cubic yards of hard material. When the top soil was removed, it was found that the wash-borings were in error and the contractor had to be paid for approximately 4500 yards of hard material on his agreement.

The nature of the subsoil condition determines, to a large extent, the kind of equipment that the contractor will place on the job and also the unit price that he bids. Of course, our specifications and contracts require that the contractor make personal inspection of the bridge site, in order to definitely assure himself that the information given on the plans is correct. But we all know that the majority of the contractors do nothing more than make a superficial examination of the bridge site.

It is excellent practice to stake out the foundations as soon as a temporary layout is made and to put down test holes, one on the center line of the bridge and one at each end to check the information as given in the survey notes.

In addition to recording the information from the test holes, the chief of party should note the bearing value of the subsoil that will be directly below the footing. A short excursion should be made up and down stream from the bridge site and a notation made as to the scouring propensities of the stream, and also the material composing its bed.

Waterway Requirements

The survey notes should give the available waterway necessary and this recommendation is in some cases exceedingly difficult to make. It is often very hard to determine the advisability of making the structure large enough to carry a greater flood than has come down the stream in the past. If the road is subject to overflow at a great number of places, and, due to excessive cost, it is not advisable to raise the entire road above the flood stage, then it is foolishness to build a structure that will take care of a maximum flood. If the road is out of use, no one will use the structure.

Care should be taken to place the foundations to such depth that they will not be undermined during the flood condition. The high water elevation should be determined and it is advisable to give the elevation of both the average and maximum high water. This information should be secured from several citizens of the locality, and we wish to emphasize the *several.* The citizens should also be interviewed severally as we have found a wide variance in memories relative to high water.

Other structures up and down stream should be visited and the available waterway measured. Of course, in case the adjacent road is flooded at times, this area under water should be added to that under the bridge, in order to get the effective waterway required. After a check-up has been made of the

existing structures on the same stream, and an allowance made for the difference in the drainage area, we have found it to be advisable to make a check of the number of acres in the drainage area up stream from the proposed new structure, and then by the use of Talbott's formula to determine the necessary amount of waterway required. If, after checking up the size of the adjacent structures, we find that our conclusions are checked by Talbott's formula, we feel safe in making our recommendations. We frequently find, however, that the information given by Talbott's formula does not check at all with the adjacent structures that carry the flood water. This is especially true in flat country in the northern part of the state in the lake area, and also in the southern part of the state where it is hilly with a very rapid run-off.

Recommendations

After this work has been completed and the notes recorded so that an accurate layout sheet may be drawn up, the most important task remains. This is the making of recommendations relative to the new structure. With the knowledge of the site gained by the actual survey work, the chief of party should have in mind the size and type of structure that will best fit the location. Recommendation should be made as to the type of structure, the clear span, the location of the face of abutments, the center line of piers, and the type of wings at each corner of the abutment that will best fit conditions. If it has been impossible to locate the structure so that it will not interfere with the flow of the stream, a recommendation should be made relative to the placing of rip-rap to prevent scour around the wings or piers. A note should be made as to the availability of any material that could be used as rip-rap. If an old structure is being replaced, there will ordinarily be material from the old substructure that can be used to advantage.

One of the questions confronting the designer is whether or not piling will be required. From the investigation of the subsoil condition and the notes made relative to the scouring propensities of the stream, a decision can easily be made as to the use of piling and the proper length required. Piling is frequently necessary where scour may occur, even in soil that has the required bearing value where undisturbed. Information should also be given as to whether or not piles are available locally, and if so at what price. This is for the benefit of the estimator.

A recommendation should be made as to the advisable elevation of the bottom of each footing. If a truss, girder, or arch, is called for, the clearance elevation of the low steel, bottom of girder or intrados at the crown of the arch should be given.

All possible information should be given for the use of the estimator including the nearest shipping point and its distance as an aid in arriving at an estimate of the cost of the new structure.

In most cases the contract for a new structure requires the removal of an old one. The survey party should get the necessary information relative to the old structure so an estimate of the cost of removal may be made. If the old structure is a steel truss, enough dimensions should be taken so that a fairly accurate estimate can be made of the weight. We are now asking the contractors to bid on the old steel superstructure, and if their bid is satisfactory, the old steel is sold to them and can be removed as they see fit. If not, they are required to match-mark the structure and use care in removing it, piling the material within 500 feet of the bridge site for our disposal. Most of the contractors find it to their advantage to buy the old steel and remove it in the easiest possible manner. This saves us the cost of disposal and the liability of having it stolen.

The survey party is requested to recommend a method of caring for traffic during the construction of the new bridge. The length of the available detour is measured and the condition of the detour roads is noted. As stated before, where possible and economical, it is good policy to make a slight relocation so that the old structure may be used until the new one is completed. When this is impractical and a temporary bridge is feasible, the owner of adjacent land is interviewed to see if right of way can be secured for a run-around. If it can, the cost of the temporary bridge is estimated and recorded. In some cases parts of the old structure such as stringers, I-beams, etc., can be utilized so that a temporary bridge need not be expensive. In case such material is not available, native timbers can frequently be secured at small cost for a trestle to serve until the new structure is ready. Where possible without too great cost a temporary bridge and run-around should be provided.

In conclusion, I wish again to emphasize the importance of the bridge survey as an essential factor in the work toward the building of a structure. In any organization, a well kept set of survey notes, giving the information on which the design and location of the structure were based, is a valuable asset which amply pays for all the time spent in keeping the records. If, as sometimes happens, it becomes necessary to defend the design after the structure is completed, they are invaluable.