“WELDED SHOP FABRICATED NEW CLAYS FERRY BRIDGE”

C. G. Cook
Bridge Designer
Kentucky Department of Highways

For the past twenty years, the Kentucky Department of Highways has been the proud owner of the highest highway bridge east of the Mississippi river. In the near future it will be able to claim the two highest highway bridges east of the Mississippi. Side by side will stand the highest riveted truss flanked by the highest welded truss. The two bridges will give the appearance of being twin structures at first glance, but this will be a deceiving appearance because they will be quite different. Whenever the new bridge has been discussed, the point of greatest interest has been as to how the new compares with the old. Therefore, this discussion shall attempt to give the comparison between the proposed and the existing.

Preliminary Design

When it was decided that the existing Clay’s Ferry bridge would be incorporated into Kentucky’s Interstate system to carry Interstate 175 over the Kentucky river, there was quite a bit of thought of locating the new bridge some distance away from the old one due to the rock fault that was discovered during excavation for the old bridge. But after extensive studies were made and soundings taken, it was decided that the new structure would be located parallel to the existing one since the soundings showed that a good solid rock foundation could be anticipated and the location was the most economical site.

When the preliminary work began, the designers were aware that the existing bridge had been architecturally designed as well as structurally. It was felt that the graceful lines of symmetry that had been employed in the geometrics of the old bridge should also be incorporated in the new one. Therefore, every effort has been made to maintain the qualities of symmetry, harmony, simplicity, proportion and conformity with environment that are so necessary to create a beautiful bridge.

The new bridge will have close to the same overall length and the truss spans will employ the same geometrics as the old structure. Obviously, in order to save a tremendous amount of valuable engineering time if at all possible, the first study made was to determine whether the existing structure design and details could be used for the new bridge. The new bridge has a 30 ft. roadway while the existing was designed for a 26 ft. roadway. A few calculations showed that the old truss members would not carry the heavier load, thereby meaning that an entirely new design had to be made. As previously stated, the designers hoped to create a new structure giving a like appearance to the old. However, for economies sake, preliminary estimates were made for several structure types, including a redesigned riveted truss, a double webbed welded plate girder, a concrete arch and the welded truss which proved to be the most economical structure and also allowed the aesthetic qualities that the design engineers were endeavoring to maintain.

Welded Fabrication

Welded fabrication of girders and beams has become a fairly well accepted practice in many states in recent years. Kentucky has completed several welded shop fabricated steel girder bridges and at present has several more either under construction or ready to go to contract, among these the twin continuous welded
plate girder structures that will soon be erected over the Kentucky river at Frankfort. This has involved the use of thousands of tons of welded steel girder construction using A7, A373, and A242 steels. These structures have all been fabricated and erected in a most satisfactory and efficient manner and the welded designs have shown a definite economy through the savings of many tons of structural steel.

The very satisfactory results that had been obtained from the designs of the welded girders combined with the fact that the state of California had recently employed welded design for the Carquinez bridge led to the conviction that welded design could be used on the new Clay’s Ferry truss with equally satisfactory and economical results.

Extending welded fabrication to the design and construction of major truss spans offers many advantages: (1) It indicates considerable savings in the amount of structural steel used; (2) It gives the designer greater leeway in choosing the member make-up and greatly simplifies design details all of which make for savings in engineering time (3) Fabrication time should be reduced due to the simple member make-up and the elimination of thousands of drilled holes and shop driven rivets.

In order to achieve the utmost satisfactory results in its welded bridges, the Kentucky Department of Highways maintains strict inspection of all shop work by contracting the services of a welding specialist firm and no fabrication can be done unless the inspectors are present. All butt welds are inspected by the Radiographic process and the magnetic particle method is used for the fillet welds. Any weld that proves to be defective must be removed and rewelded.

Comparison of New and Old

It would be erroneous to compare the new bridge with the old as it exists. As stated earlier the two bridges are supporting different loads. Therefore, the comparison will be between the new welded bridge and the old riveted truss redesigned to carry the heavier loads.

Figure I shows the location plan of the proposed and the existing bridges. The new structure will be located on the downstream side with the center lines of the bridges being 84 ft. apart. This picture certainly illustrates the changing times. Note the old U.S. 25 with its steep grades and hairpin curves crossing the river with an old wrought iron bridge which was built in 1869. In the early 1940’s the present Clay’s Ferry bridge was erected virtually eliminating all these grades and curves and providing U.S. 25 as it is today. As can be seen, the new Interstate I75 will add the new bridge structure plus straightening out the highway still further.

Figure 1A shows an elevation view of the new bridge. It consists of the main three span continuous Warren type truss with a 448 ft. center span and 320 ft. side spans. In addition there will be two 192 ft. simple Warren deck truss spans, 100 ft. and 120 ft. simple welded plate girder spans giving a total bridge length out to abutments of 1710.5 ft. The 100 ft. welded plate girder replaces two 50 ft. R. C. Deck Girders and the 120 ft. welded plate girder replaces two 50 ft. and one 40 ft. R. C. Deck Girders which are part of the existing bridge. This eliminated three piers from the substructure. The plate girder spans will be suspended from the simple truss spans thereby eliminating the split-level piers as are employed in the old structure. The bridge will be constructed on a three percent grade which is the same as the old and the roadway just as the old will be approximately 250 ft. above normal pool stage.

Figure 2 shows a cross section through the main truss at midspan. The continuous truss is 30 ft. deep at midspan and 60 ft. deep at the piers. The trusses are spaced on 22 ft. 6 in. centers. 33WF130 floor beams are spaced on top of the trusses at 32 ft. intervals which in turn carry 27WF94 stringers spaced on 6 ft. 6 in. centers. The deck is composed of a 7 inch reinforced concrete slab,
two, 2 ft. 6 in. sidewalks with a two rail reinforced concrete handrail which matches the railing on the old bridge. A continuous stringer design was made but due to the long span between floor beams and the slab supports required with a continuous stringer, the continuous system proved to be about as expensive as the simple stringer system. Also it was felt that a continuous stringer system placed on top of the floor beams which in turn are on top of the trusses would create too much of a stacked appearance. This would also have required the exterior sidewalk stringer to be the same height as the interior roadway stringers.

Light weight wide-flanged sections were used for the cross bracing in both the continuous and the simple trusses. The old bridge employs heavy angles and lacing bars for all its secondary members. The use of perforated plates in the struts and lateral systems of the trusses proved to be as economical as lacing bars with very little difference in weights of materials.

A typical box section used for the truss members is shown in figure 3. The section consists simply of two flange plates which vary in thickness and depth and two one-half inch perforated plates with four three-eighths fillet welds. The 18 inch width is constant throughout. The top and bottom chord members are 24 in. deep, the diagonals vary from 12 to 20 in. deep and the posts and hangers are 10 in. deep. All members have ¾ in. diaphragms spaced at approximately 8 ft. centers. These diaphragms are welded to the flange plates before the perforated plates are welded on. By allowing ¼ in. minimum bearing and ½ in. for the fillet weld, the minimum thickness plate was set at ¾ in. The thickest flange plate used was under two inches thereby eliminating a lot of preheating which is required for welding plates over two inches thick. The greatest amount of savings in materials was realized in tension members by simply increasing the thickness of the flange plates at the joints to make up for loss in section due to the connecting bolt holes. This was done by butt welding short lengths of thicker plates to the thinner flange plates of the member at a point approximately 9 inches from the edge of the joint gusset plates. The gusset plates on the new truss are thicker than those on the old truss since they are acting as splice plates for the chord members.

In figure 4 is shown the comparison between the new and the old. Section to the left is for member U9U11 of the old riveted structure redesigned to carry the same load as the new member. Section to the rights is for the same member in the new welded truss. The old member is made up of 10 component parts not including the double lacing bars requiring the punching or drilling of over 4,600 holes and the driving of over 1,600 shop rivets. The new member is made up of only four component parts fastened together with 256 ft. of ¾½ fillet weld. The new member make-up gave very low secondary stresses which did not affect the design of the members. The new member weighs 320 lbs. per ft. compared with 495 lbs. per ft. for the old member giving a weight reduction of 35 percent. The new section presents a much easier surface to clean, paint and maintain.

The new continuous truss unit will contain some three and one-half million pounds of A7 and A373 structural carbon steel. This represents 107 lbs. per square foot of roadway compared with 123 lbs. per square foot in the old bridge or a weight reduction of fifteen percent overall.

**High Strength Steel Bolts**

All field connections will be made using high strength steel bolts. The contractor will have the option of using either rivets or bolts for the shop joints. If the shop chooses to use high strength bolts for the few shop joints this would provide a completely rivetless structure.

High strength bolts have been used for field connections on all of Kentucky's steel bridges for several years and have proved completely satisfactory in every respect. While the cost of the bolts to furnish is slightly higher than rivets, a
great deal of erection time and therefore cost can be saved by using bolted field connections. On most heavy truss work where riveting is required it is frequently necessary to completely bolt up a joint before riveting is started. This is necessary in order to obtain a tight joint prior to riveting. It has been estimated that a two-man bolting crew can easily keep pace with a four man riveting crew. It is believed by using high strength bolts, the bolting crews will be able to keep pace with erection which it is felt would not be possible with riveted joints.

Conclusions

As a result of the design of the welded shop fabricated new Clay’s Ferry bridge, the following conclusions can be drawn:

1. Welding of bridge truss members can be satisfactorily accomplished with a savings of materials of up to thirty-five percent for heavy tension members and therefore welded fabrication should show overall economy.

2. Simplified design details and member make-up makes for savings in design time and engineering costs.

3. The smooth surfaces resulting from welded fabrication presents fewer sharp edges and absence of rivet heads making for a longer life of the paint surfaces. In addition, the members will be much easier to clean, paint and maintain.

4. The simple member make-up of both truss and bracing members tends to greatly improve the aesthetic qualities of the structure.

5. The use of high strength steel bolts for field connections should save considerable time in erection and show overall economy.

Thus soon there will stand along side of the present Clay’s Ferry bridge a structure designed and fabricated in a manner unheard of when the present bridge came into being. What changes will the future bring? Only time will tell.
DETAIL A -

Conslan[...]

Diaphra[...]

8'-0" ± C-C

DETAIL A

TYPICAL BOX SECTION

FIGURE 3

Angl[...]

A7. STEEL
495#/PER FT.

OLD

A373 STEEL
320#/PER FT.

NEW

FIGURE 4.

75