

on all of the land in the drainage area, and proportion the assessment on all of this land based on the original assessment. This, as I remember, is certified to the treasurer to be paid as delinquent taxes within one year.

Where a tile has broken near the center of a tile ditch line, some have questioned the right to assess land that lies below the break for the necessary repairs. Viewing the law as a whole, the drainage system is treated as a unit and the surveyor has no right to fix an assessment on part of the land and not on all of it when he makes a repair on a tile ditch. It must be treated as a unit and all lands must be assessed for repairs.

The problem often arises wherein a farmer owns a tract of land that has been assessed for the construction of a certain drain but which is cut off from the proposed drain by a neighbor's land. This law provides that when a man owns real estate that was assessed for the construction of a court ditch and not more than two landowners intervene between his land and the court ditch, they may enter into a compromise, have the surveyor set stakes, fix the amount that each is to be assessed, and go ahead and construct the drain. In the event that any one does not pay his assessment, it becomes the duty of the surveyor to so certify to the auditor and it comes up as delinquent taxes. I believe that under this act any person can complain to the surveyor, then it becomes the duty of the surveyor to run the line, determine the size of tile and the amount each owner is to put in and pay for. When this is done, he must keep a record of the ditch just the same as in the case of a court ditch, and the assessments can be collected as taxes if necessary.

The statute also provides that if a tile ditch tributary is out of repair at any point, the persons above can complain to the surveyor provided the tributary drains 10 acres or more of land. It then becomes the duty of the surveyor to have the same repaired and certify the costs where he thinks they should be placed. On failure to pay, the surveyor shall certify the assessments with his per diem and 10 per cent penalty to the auditor and the same will be collected as delinquent taxes.

METAL-PLATE PIPE AND ARCHES

By J. C. Eckert, Ripley County Surveyor

Only a comparatively few years ago, an engineer contemplating the building of a small bridge would have considered only two materials—stone or timber, or a combination of the two. As years passed, other materials, with their own peculiar merits and advantages, came into use. Among these

newcomers were steel bridges of various types, monolithic concrete (first plain and then reinforced), and, for smaller structures, large-diameter corrugated iron pipe.

Since the latter is the forerunner of the material which is to be discussed in this paper, let us pause and examine it briefly. It was evident from its inception that corrugated iron pipe was light in weight, and that it could be easily transported, quickly installed, and immediately covered. However, assurances of its strength and durability were necessary before its use could become widespread. Successive years of usage, and finally exhaustive research, have proved its strength and durability.

Here, then, was a structure which was strong and durable and which could be quickly installed by common labor. Another advantage which revealed itself, as increased traffic made it necessary to relocate and widen highways, was its salvage value in cases of relocation or extension to meet changing conditions. However, these advantages existed only up to certain sizes of pipe, for it was obvious that there were quite definite size limits imposed by transportation and fabrication facilities. It was also equally obvious that there were limits of safety in the use of light-gauge materials in the larger sizes.

It was apparent that the limitations of fabrication and transportation could be overcome by working out a sectional pipe that could be assembled in the field and that the problem of strength could be solved by the use of heavier metal (plates instead of sheets), which was perfectly feasible with a sectional construction. The use of heavier plates to give greater strength would also give longer life, for repeated tests have shown that, other conditions being equal, the life of a metal is directly proportional to its thickness. It was to widen the scope of the usefulness of corrugated pipe and to secure its advantages for the structures falling in the small bridge class that what has since become known as multi-plate pipe was introduced about three years ago.

It might be said in passing that such a use of metal is not new. There are at present scattered over the state a number of old arches fabricated from smooth black iron plates which have been in service for at least 30 years. There are also a number of the old "bedstead" type bridges with black iron plates for retaining fills which have been in service equally as long.

When first introduced, this material was used as a giant pipe, in diameters up to 150 inches. However, limited headroom often made it impossible to secure the required flow area with a pipe, a fact which limited the use of this material and suggested the use of the same material in arch form. Development along this line has since resulted in arches with a

wide range of sizes which make it possible to provide structures in this material with spans from 5 feet to 25 feet and with drainage openings from 9 to 160 square feet in cross-sectional area.

Another use is in extending existing structures to provide wider and safer roadways. A third use is in repairing existing structures by lining them with either a pipe or an arch as the occasion may require.

For each of the materials that are considered for the construction of a small bridge, there are certain advantages to be gained. In each case the value or the appropriateness of the material is influenced greatly by the conditions to be met and materials that are available locally. In one case, emergency may cause speed of construction to be the end most greatly desired. In another case, foundation conditions may be the deciding factor in favor of one type. In still another case, economy may rule the decision.

DESIRABLE FEATURES

Since the advantages of a type are important in influencing its ultimate selection, the following brief review of the features of multi-plate pipe and arches which may lead to their choice in certain conditions is presented:

1. Strength. Evidences of strength are best found in installations in service under high fills.

2. Durability. Next in importance to strength is the durability of the material. The best criterion for this is the material's service record as a standard corrugated pipe, allowance being made, of course, for the extra thickness of the heavier metal, because as mentioned before, the life of a metal, other conditions being equal, is directly proportional to its thickness.

3. Speed of Construction. The sectional, bolted construction of multi-plate makes possible quick erection by unskilled labor. Even in the larger installations the time required for the erection of the plates is small. The principal items, from the standpoint of time required, are the footings and the headwalls, which in turn depend on the conditions to be met and the material used.

4. Salvage Value. By the term salvage value, I mean adaptability to changing conditions. Changes in drainage structures are necessary for five principal reasons:

(1) Relocation of the stream because of channel straightening work or the natural forces of rushing water which are continually at work changing the courses of streams.

(2) Relocation of roads to improve alignment.

(3) Deepening streams and ditches.

(4) Widening roadways.

(5) Changes in the character of the watershed which require a structure of greater area.

When the stream or the road is relocated, the salvage value of a structure depends on whether or not it can be removed to another location. When this happens, a built-in-place structure is a total loss. A multi-plate arch or pipe can be taken apart and reassembled in a new location where its form or shape is not governed by the original use. For instance, a pipe can be reinstalled as an arch. If it is an arch, the size or shape can be changed by adding or subtracting one or more rows of plates. If it becomes necessary to extend a multi-plate arch or pipe, all that is necessary is to remove the headwalls, add additional plates, and replace the headwall. Where drainage ditches are cleaned and deepened, as is often the case, a multi-plate pipe can be taken up and reinstalled at a lower level.

5. Use in Soft Foundations. Because multi-plate pipe is erected as a single unit with no continuous circumferential joint, and because of its large bearing surface, it is particularly useful in soft unstable soils where the cost of securing an adequate foundation would be prohibitive. Where an arch is used, an equally large bearing surface can be secured by using a metal or timber bottom. Even where concrete footings are used, the difference in the weight of the superstructure permits economy in securing a proper foundation.

6. Skewed Structures. Where the road and the stream do not cross at right angles, there are two possible ways of securing the proper skew for a multi-plate structure. The plates can be cut to the desired skew, or if the degree of skew is not great, the proper fit can be secured by offsetting the plates.

7. Winter Construction. Both multi-plate pipe and arches can be erected during freezing temperatures. Where a footing is required, it can easily be protected because it is usually below the ground level. Where rubble or metal headwalls can be used, the installation can be fully completed in the lowest temperatures. In some cases, headwalls can be eliminated by mitering the ends to conform to the slope of the fill. Otherwise, a temporary headwall can be erected and a concrete headwall built later during warm weather. The erection of an arch with a span of $23\frac{1}{2}$ feet and a cross-sectional area of 140 square feet was completed in a seven-hour working day during zero weather. Since then, temporary rubble headwalls have been built and the arch has been backfilled. The final headwalls will be built next spring. This immunity to even extremely low temperatures makes it possible to complete winter emergency work or to keep regular bridge crews occupied during the winter months.

8. Special Advantages. Special installations in many cases return special advantages. This is true of a lining or threading job where a multi-plate pipe or arch is used to renew a failing structure. In the first place, such a job does

away with the necessity of removing the old structure. Second, parts of the old structure such as headwalls, wing walls, and railings still in good condition can be salvaged. Third, since all of the work, or at least a large portion of it, is carried on below the old structure, there is little if any interference with traffic. Last, a threading or lining job can be completed at from one third to one half the cost of removing the old and building a new structure.

A TYPICAL EXAMPLE

A particular job was completed in Ripley County during the past year, involving an old concrete arch with a span of $28\frac{1}{2}$ feet at the flow line, located near Sunman. Since the arch had been built approximately twenty years ago, deterioration of the barrel of the arch had exposed the reinforcing in a number of places. In one portion of the arch, disintegration had progressed to such an extent that it was necessary to lay planks across the reinforcing steel to retain the fill. It was unsafe, to say the least.

Because of this dangerous condition, we decided to either repair or replace the structure. With several plans under consideration, we finally decided to line the arch with a multi-plate arch of approximately the same size as the old structure. Our reasons for making this choice were as follows: Doing so would give practically a new bridge of strong, durable construction. It would save the expense of removing the old arch, and at the same time make it possible to utilize the spandrel and wing walls of the old structure, which were in fair condition. By choosing an arch of approximately the same size, it would be unnecessary to reduce materially the cross-sectional area of the old structure, a step which would have been very undesirable.

The first step toward the erection of the new arch was the building of footings for it at the base of the old structure. These footings were made wide enough to carry the loads and deep enough to prevent undermining.

When the footings had cured sufficiently, one half (one complete side) of the metal arch was assembled on the stream bed with the bottom edge resting in its proper place on the footing. After the bolts had been thoroughly tightened, this portion of the arch was raised into place and temporarily propped. The same procedure was followed for the other half of the arch, and after the two sections had been bolted together where the plates joined at the top, the props were removed.

When the arch was in place, the space between the old and new structures varied from about 4 inches at the base to 11 inches at the top of the structure. For a distance of 2 feet in from the spandrel walls on each side of the old arch, this space was filled with a stiff mixed concrete which was troweled

to make a smooth joint with the old arch. The space in the center was filled with a wet grout, which was placed through a hole in the top of the old arch. By making the replacement in this way, a practically new structure was secured at less than half the estimated cost of removing the old arch and building a new structure, and with very little inconvenience or delay to traffic.

The foregoing has given you in a somewhat rambling style the history, the many applications, and the possible advantages of multi-plate pipe and arches, the latest material offered by research to the engineer and the road man as an aid in solving his small bridge problems. I have not tried to give you the details or tell you how it is done, for it has been my experience that those can best be worked out for each particular installation in co-operation with the representative of the company supplying the material, who is trained in the use of his material and has the information to help you design a structure that will best meet your needs. He can by the use of tables and graphs give you the size and shape, the pressures for the different loadings, the proper gauge of the material, and other necessary information.

NEW LEGISLATION AFFECTING THE MAINTENANCE AND REPAIR OF INDIANA COUNTY HIGHWAYS

By Charles A. West, Tippecanoe County Attorney

Since the enactment of the law creating county highway systems in each county of the state, there have been many changes made in the laws governing their operation and control. At first, the system was only a makeshift, but experience soon showed that changes must be made from time to time in order to conserve, as far as possible, the money available with which to maintain such highways and to give the traveling public the best highways possible with the least expenditure of money. The legislature of 1933 enacted a new law with the idea in mind of enabling the building and maintenance of a better county highway system in order to give the public the greatest benefits possible with the money available. It is with this law (Chapter 27, Acts of Indiana General Assembly, 1933) that we are now concerned.

Section 1, page 139, provides that the county surveyor shall have general charge of the repair and maintenance of the county highways, and that he shall receive, as compensation for such services, a sum not less than two dollars and not more than three dollars per year for each mile of highway under his supervision, the amount to be fixed by the board of commissioners. This provision should remind all those who have