Proper Installation of Corrugated Metal Structures

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Grading of an embankment and installation of drainage structures are closely related. Generally there are two methods of installing a culvert, depending on the distance it projects into the fill above the original ground line.

Where the invert is well below the original ground line, it is common practice to excavate to flow line grade, place the culvert and backfill, completing the fill above it in the normal way. In such cases, there would be a well defined ditch in which the culvert is placed; but where nearly all of the culvert will be above the normal ground line and most of it will project into the new fill, it has become common practice to build the fill to an elevation equal to, or above, the top of the culvert. Then, a trench is excavated for placement of the structure.

In recent years the method of placing and backfilling a drainage structure has become more important for three reasons: (1) larger diameters of culvert pipe are being used; (2) higher fills are being built; and (3) most important is the weight and speed of modern grading equipment.

If the inspector and construction foreman understand the purpose of the various details of installation, they can get the remainder of the crew to produce a more serviceable structure. Proper installation of any engineering structure pays off in longer, more efficient service. Good installation is just as important as good design.

Corrugated metal structures, because of their light weight and resistance to fracturing, can be installed easily and without expensive equipment. Yet they should be handled with reasonable care. The same is true of all types of culvert pipe.

First comes the proper location of a culvert with respect to the roadway and the stream. A culvert is a substitute for an open stream where it meets a roadway embankment. Therefore, a good alignment of the structure gives the water a direct entrance and a direct exit.
Here are some suggested ways of securing correct culvert alignment.

A skewed alignment calls for a greater length of culvert, but it is usually justified by improving flow conditions and protecting the roadway from overtopping.

Channel changes can improve culvert alignment.

A stream should pass under the road at the first opportunity. If it is necessary to change the direction of a stream, it should be done on the downstream side of the embankment in order to prevent washing out of the toe-of-slope on the upstream side.

When large drainage structures are placed on a skew, it is sometimes desirable to use cut ends. When this is done, it is necessary to specify the direction of flow as well as the angle of skew.

The ideal grade line is one that produces neither silting in the invert of a culvert nor excessive velocities or scour at the outlet end. Ideally the grade line should follow the grade of the present stream bed.

Silting can be prevented in several ways. If the flow line of the culvert is below the natural stream bed, sedimentation can be expected. It is all too common to see the outlet of a culvert partly filled with sediment.

Hillside grades that would cause erosion can be corrected. It is important to protect the embankment from erosion, especially on the outfall side by placing riprap, sod, or paving the slope. A cantilevered pipe will carry the water beyond the fill, but some riprap may be required at the outlet to prevent erosion.

When a culvert is placed under a high fill, more settlement can be expected under the center of the embankment than at the ends. This can be anticipated and provided for, by placing the pipe on a cambered or arched grade line.

So much for culvert location. Now for the actual installation. First, of course, is the excavation.

Trenches should be as narrow as possible, but wide enough to permit proper tamping of the backfill. Wide trenches not only require more excavation and backfill, but they increase the load on the structure. It is recommended that a string line be used to maintain correct grade.

Preparation of the base or foundation is important and should be based on careful investigation, especially for large structures. A drainage structure should be placed on a firm foundation in order to distribute the load evenly along its full length. Never install a structure on sod, frozen earth, large boulders or rock.
All uneven areas in the foundation should be excavated below grade and replaced with uniform material, well tamped in place. The best material for this purpose is sandy gravel, crushed rock or other material suitable for a fill.

The width of the base should be at least twice the diameter of the pipe and as deep as conditions require, from 12 in. to as much as 3 ft. If a spring or seepage is encountered a subdrain may be needed to stabilize the base and the backfill.

Corrugated metal structures that are to support a fill should not be placed directly on pile bents or concrete cradles. If such supports must be used, they should have a flat top and be covered with an earth cushion, which permits the flexible structure to develop side support. Corrugated metal pipe should not be encased in concrete. Some rigid types of culverts may be placed on concrete cradles where the foundation conditions are extremely bad.

Rock foundations are not good for flexible or rigid structures, especially if irregular in contour. The rock should be excavated at least eight in. below grade and backfilled with a cushion of earth.

All pipe culverts and sewers should be installed with the lower quarter firmly supported. Some specifications require the bedding to be done by shaping the foundation soil. This takes careful workmanship. Corrugated metal structures can be satisfactorily bedded by excavating to a flat surface and then tamping the fill thoroughly under the haunches.

The next step is placing and assembling the structure.

Although corrugated metal will withstand rough handling without breaking, it deserves reasonable care. It is better to lift or roll it to prevent damage to the galvanizing or bituminous coating. It is poor practice to drag any type of culvert pipe.

The usual method of joining sections of corrugated metal pipe or pipe arches is with corrugated connecting bands or couplings.

There is no overlapping of the ends of the pipe sections. Instead, there is a gap of $\frac{3}{4}$ to 1 in. This permits the corrugations of the band to mash with those of the pipe, as designed. For every band used there is a gain of one corrugation or $2\frac{1}{3}$ in. over the nominal length.

Dirt or gravel should be kept from between the pipe and the band so that the band will fit snugly. Merely tightening the bolts at the lugs will not produce a tight joint, but by tapping with a mallet and by using a cinching device a good joint can be secured.
On large pipes, the band may come in two pieces, requiring bolting on each side. For bituminous coated pipe the connecting band as well as the end of the pipe should be lubricated with fuel oil or some other solvent in order to make the band fit snugly. This is particularly true when the surfaces are cold.

Instructions for assembling structural plate are provided for each structure. The structure may be assembled on the bank or in its final position. The corrugated plates are shipped to the job with the proper curvature so that when fitted together in the right manner they will form the diameter of pipe or span and rise of pipe arch that is required.

The rings of plates should be assembled with a minimum of bolts until all plates, or several rings, are in position. Three or four bolts near the center of each plate along all the seams is sufficient. After all plates or several rings are assembled, the remaining bolts can be inserted and tightened progressively. It is important that the bolts be well tightened.

Where large structural plate sections, like 16½ foot diameter ones for a tunnel under a canal of the St. Lawrence Seaway, are assembled on the bank and sledded into place, they can be maneuvered if separated by one plate length; then the intermediate plates are installed to join the pipe sections.

It has become common practice to assemble this type of structure in a maintenance yard and haul it to the site on a low-boy. Several plates may be sub-assembled near the site and lifted into place for final assembly.

Erection of structural plate can be speeded by the use of structural wrenches, socket wrenches, lining bars or drift pins, and handling hooks. When power wrenches are used, the nuts should be checked with a structural wrench or socket wrench to insure proper tightness.

Structural plate arches are generally erected on concrete foundations. The groove or channel in which the arch rests must be accurately built to line and grade for easy assembly of the plates and to insure good even bearing.

When two or more structures are laid parallel they should be placed far enough apart to give enough space for tamping the backfill between them. For pipes under 24 in. diameter, the minimum distance between them should be 12 in., for pipes 24 in. to 72 in. diameter, this distance should be half the diameter. When the diameter
is more than 72 in., the space between the pipes should be a minimum of three ft. Similar distances should be maintained between pipe arches.

The principal reason why corrugated metal drainage structures will withstand tremendous loads and high fills is their flexible design. Even after the backfilling has been properly placed and the load is increased by building up the fill, vertical deflection will usually occur thus causing the sides of the pipe to move outward and build up side support from the backfill. Such deflection allows the pressure to become evenly distributed around the periphery of the pipe.

By elongating the vertical diameter of the pipe before backfilling, additional side support can be built up, and the load-carrying capacity of the structure increased. This can be done by shop strutting with wires or rods or by placing timber struts for larger diameters in the field. However, the most economical way is to have the pipe elongated in the shop before it is shipped. In such cases, the vertical diameter is elongated five per cent of the nominal diameter.

If timber struts are placed in the field, it is important to permit the pipe to deflect slowly as the fill is built up, because there is danger of the pipe bending sharply at each side of the timber struts. In order to avoid this, a soft wood compression cap must be placed between the posts and the top sill.

After the fill in the embankment has consolidated, all struts should be removed. However, when there is danger of floods, the struts may have to be removed before the fill has settled completely.

Now we come to the last operation, backfilling. The importance of proper backfilling cannot be over-emphasized. In order to obtain maximum strength and resistance to washouts and undue settlement, it is necessary that the backfill be made of good material, properly placed and carefully compacted. Selected, drainable backfill material is preferred. However, most local fill material can be used if carefully placed and compacted.

What not to do! Large rocks and hard lumps, larger than three inches, should be kept away from the pipe. Do not use frozen soil, sod, cinders, or earth containing a high percentage of organic material.

The recommended practice is to place fill material under the haunches and around the structure in six inch layers alternately on both sides, tamping each layer thoroughly. The same is true of pipe arches, keeping the fill at the same level on both sides; but again, the
need to thoroughly compact the fill under the haunches should be emphasized.

End dumping of fill from one side should not be done. Tamping should be done with pneumatic tampers or vibrating compactors or with tamping rollers if the site will permit. Compaction of the backfill by puddling or jetting is not recommended except for sand or sandy-gravel which can drain well. Puddling in clayey soils tends to produce a permanently unstable condition in the backfill.

When there is sufficient room between or alongside the structures, it is possible to spread the backfill with tractors, scoops and bulldozers. Compaction can also be done with sheepsfoot rollers but close to the structure, pneumatic tampers should be used.

With modern equipment, more than normal fill is needed over the pipe to protect it during construction. This construction loading is often greater than the heaviest live load of road traffic. Always be sure that the structure is adequately covered before heavy equipment is allowed to pass over it.

Completing the fill over the structure should be done with the same thoroughness as along the sides. It should be compacted in six in. layers to a depth equal to the height of the structure, or the entire fill if it is shallow. This is good standard practice. Beveling the ends of the pipe to fit the slope is economical.

Erosion protection can be added with riprap or with bags filled with dry sand-cement mixture. Other types of standard headwalls, or even half-height end anchors may also be added as an end protection.

The jacking method of installing a conduit avoids interference with traffic and tearing up existing surface installations. Costly detours may also be eliminated by this method.

The installation practices discussed here are generally accepted. Individual locations may require special methods and special precautions.

To summarize: good installation practice is as important as good design. Proper location as to line and grade, providing a firm foundation, taking reasonable care in handling, placing and connecting the structure, and surrounding it with suitable backfill material, properly placed, are the elements of good installation. It pays off in longer service with less maintenance. In addition, such a job will bring maximum credit to the engineer and construction crew.