CONCRETE-LINED CORRUGATED METAL PIPE

MANUFACTURING METHOD

Concrete-Lined Corrugated Metal Pipe (CLCMP) is fabricated by applying a concrete lining to a conventional, corrugated metal pipe. Typical metal pipes are galvanized corrugated steel pipe in accordance with ASTM M 218 and AASHTO M 36 (ASTM A 760); aluminized (Type 2) corrugated steel pipe in accordance with AASHTO M 274 and AASHTO M 36; or type A bituminous coated, galvanized corrugated steel pipe in accordance with AASHTO M 190. Diameters range from 24 to 120 inches and metal thicknesses range from 0.064 inch (16 gage) to 0.168 inch (8 gage). Standard corrugations are 2-2/3 by 1/2 inch, 3 by 1 inch and 5 by 1 inch.

The concrete lining is plant applied, typically by a revolving spray head moving inside a stationary metal pipe followed immediately by mechanical trowels. Lining thicknesses are usually specified to be 3/8 inch above the crest of the corrugations with a tolerance of ± 1/4 inch. For galvanized or aluminized metal pipes, a bituminous bonding coat is normally applied to the inside surface of the pipe prior to applying the concrete.

The concrete lining is composed of cement, fine aggregate and water. The mixture typically contains 564 lbs. (6 sack equivalent) of Portland Cement per cubic yard of concrete.

QUALITY CONTROL

Quality control of the base metal pipes is discussed in our Information Series 203 on Corrugated Metal Pipes.

ASTM Specification A 849 includes concrete lined corrugated steel pipe, but does not specifically address limits on cracking of the concrete liner, methods of repairing cracks, bonding criteria, minimum concrete strength, concrete testing procedures, or finish characteristics.

The absence of specific guides has allowed wide variations in acceptable quality levels.

Typical quality problems have included cracking in excess of 1/8 inch, separation of the concrete lining from the corrugated steel pipe and surface characteristics not equivalent to other smooth wall pipes. Cracks or spalls appearing in the manufacturing plant are normally caused by shrinkage or handling.

STRUCTURAL ASPECTS

CLCMP is designed and installed the same as conventional metal pipes without a concrete liner. The concrete liner is considered by most manufacturers to be simply a liner with no structural significance.

Like conventional metal pipes and other flexible conduits, CLCMP has comparatively little inherent strength. It must rely significantly on lateral support to structurally perform. As load is applied, the CLCMP must deflect until side fill forces increase to a point that equilibrium is developed. Because of the rigid nature of the concrete liner, it must necessarily crack.

In order to minimize cracking and its possible effects, such as separation and spalling, deflection should be limited when designing the base metal pipe. The AWWA Manual M11 entitled "Steel Pipe - A Guide for Design and Installation," states that an often accepted deflection limit for steel pipe with a mortar lining is three percent of the pipe diameter.

Some producers of cement mortar lined steel pipe products limit the design deflection to 1% for 24 inch diameter, varying to 3% for 72 inch diameter.

A leading manufacturer of CLCMP has acknowledged in one of its promotional presentations that, "The larger the diameter and lighter the gage, the more cracking we'll have."

FIELD DEPENDENT FACTORS

As with other conventional corrugated metal pipes, CLCMP is very dependent on proper compaction of the backfill materials. With the need to control cracking of the lining, this is even more critical. Therefore, the contractor's installation methods, type of backfill material and adequacy of field inspection are important factors.

Struts have been used to control deflection. Cement enriched slurry backfill has been used to assure adequate consolidation, particularly in the haunch area.

HYDRAULIC FACTORS

One CLCMP manufacturer recommends using the same "n" factor as for concrete pipe. However, a major specifier of CLCMP requires a 6 inch diameter increase for CLCMP as compared to concrete pipe. The reason for this is that existing installations appear to be relatively rougher than RCP and the durability of the lining has not been verified.

DURABILITY, ABRASION AND CORROSION

Durability and corrosion of the base metal pipes are discussed in our Information Series 203 on Corrugated Metal Pipes.

A leading manufacturer of CLCMP has stated in one of its promotional presentations that, "The lining is only a hydraulic improvement", and goes on to state that durability comes from the base metal pipe and its coatings. There is evidence bare metal is typically exposed at the location of cracks in bituminous coated and concrete-lined galvanized steel pipe. At locations of concrete spalling, it has been shown in several cases that the bituminous coating does pull off of the base metal.

Therefore, CLCMP should be designed for the required project life, assuming that neither the bituminous lining or the concrete lining offers any corrosion protection.

JOINTS

CLCMP joints are generally the same as that used for corrugated metal pipes without concrete lining with the following major exception. After CLCMP is laid and joints are coupled, it is common practice to mortar the internal joints. When O-ring gasketed joints are specified, hydrostatic tests should be performed prior to mortaring the joint, other- wise a poor joint may go undetected.

CONCERNS

Because the concrete lining is intended only as a "hydraulic improvement", it must stay intact and adhere to the pipe for the intended project design life. To achieve this, proper structural design is needed to limit deflection and therefore cracking and spalling. Higher gages and/or cement enriched slurry backfill may be required. Enforcement of installation specifications is also critical so that the very important soil contribution to strength is achieved. As diameters increase, these concerns magnify.

Of major concern is the fact that this product has not been proven to last as long as other pipeline materials. Under development since 1964, it was first marketed in 1982. The oldest test installation in 1964 consisted of "21-inch diameter cement-lined CMP". Most installations of this product have occurred since 1985. Potential long-term maintenance expense should be considered in evaluating this product.

SPECIFICATION AND DESIGN SUGGESTIONS

- Design for 3% deflection or less as a function of pipe diameter and require it be checked after installation.
- Pipe with cracks larger than 1/8 inch should be rejected.
- Cracks greater than 1/32 inch should be repaired with a quality concrete epoxy.

- Any pipe with a lining that has separated from the pipe should be rejected.
- Use standard quality control procedures for the concrete lining, including compressive strength testing.
- Use an "n" factor for hydraulic design of 0.013, plus add 6 inches to the calculated pipe diameter.
- Bedding and backfill specifications and construction inspection need to be such to guarantee adequate structural support. Cement enriched slurry should be considered.
- When O-ring gasketed joints are specified, hydrostatic testing should be required prior to mortaring the joints.
- Total project costs should be evaluated using Life Cycle Cost Analysis procedures.