SEGMENTAL LINING (PANELS)

Concrete Culvert Overview Flowchart
Structural Defects Flowchart (Concrete)
Bedding Deficiencies Flowchart (Concrete)
Hydraulic Capacity Flowchart (Concrete)

1. SYNONYMS

GRP, FRP and RTRP are synonyms abbreviations for fiberglass reinforced pipes (glass-fiber reinforced plastic; fiberglass reinforced plastic; and reinforced thermosetting resin plastic).

2. OVERVIEW

Segmental lining is used to rehabilitate man-entry pipes (medium to very large size) and is especially suitable for odd-shaped pipes. The method utilizes panels that are individually set in place inside the host pipe where they are bonded together, and the annular space is subsequently filled with a low viscosity, free flowing, rapid setting and high strength grout. The result is usually a structurally integrated composite pipe consisting of the existing pipe, grout and panels (Figure 61). However, beside the composite design (Channeline International, 2009b), segmental lining is also suitable for stand alone or corrosion barrier designs.

The panels can be discrete 360° pipe segments of various shapes (i.e., short length, full-perimeter, and shaped as circular, oval, or box) or individual arc panels assembled into full-perimeter pipe either inside the pipe (Figure 62) or on the ground surface before insertion (Figure 63).

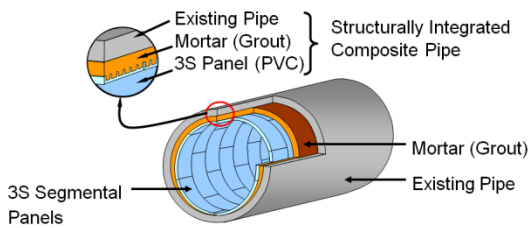

Figure 1. Segmental lining can create a structurally integrated composite pipe consisting of the existing pipe, high strength grout and panels (Kampbell, 2009)

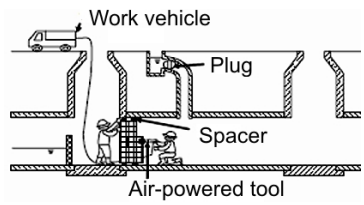

Figure 2. Assembly of panels inside the pipeline (Shonan Plastic, 2009)

Figure 3. Two-piece arc units being bonded together before insertion (Channeline International, 2009b)

3. MATERIALS USED

GRP panels are composite materials. One example of sandwiched GRP panel construction is shown in Figure 64, where the panel is made of several layers. (1) The inner structure has a 1.5 mm resin-impregnated coating (isophthalic or vinyl ester resin) that acts as a corrosion barrier, and an inner skin made of several layers of resin impregnated multi-axial engineered fabric, e.g., CSM[1] impregnated with unsaturated polyester resin. (2) A central core is made of silica and resin that are mixed and evenly applied to a specific thickness. (3) An outer skin is made of several additional layers of multi-axial fabric and CSM-resin. The outer surface is treated with a bonded graded aggregate to enhance adhesion to the annular grout, which is used during the installation phase (Channeline International, 2009b).

[1] *Chopped Strand Mat (CSM) is a form of reinforcement used in GRP that consists of glass-fibers laid randomly across each other and held together by a binder. The binder dissolves in resin, and the material easily conforms to different shapes when wetted out.*

PVC panels are made of mold-injected plastic (Figure 66) identical to the material of PVC wastewater pipelines.

Corrugated metal structural plates are made of field bolted galvanized steel plates (Figure 66) or aluminum, in a variety of shapes, including round, pipe-arch, arch, ellipse (horizontal and vertical), and underpass shapes. Complete structures can be pre-assembled on-site and lifted into place without heavy or specialized equipment.

High strength structural grout is a mix of ordinary Portland cement, fly ash and water, which when correctly mixed and installed develops compressive strength in the range of 3,000 to 5,000 psi at 28 days (Channeline International, 2009b).

Figure 4. Cross-section of sandwich panel construction (Channeline International, 2009b)

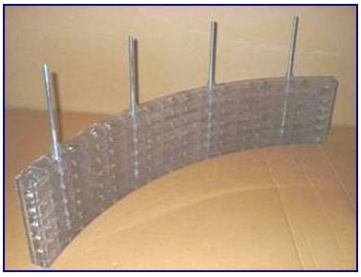

Figure 5. Transparent PVC panels (Kampbell, 2009)

Figure 6. Corrugated steel structural plate (CONTECH, 2009c)

4. APPLICABILITY

There is no theoretical limit to the shape and size of pipe that can be rehabilitated (with multi-piece segmental construction). The most commonly encountered pipe shapes are: circular, oval, egg shaped, elliptical, flattened elliptical, arch barrel, box shaped, and flattened box shaped (Channeline International, 2009b).

PVC panels are used in circular pipes in. 40 to 157 in. in diameter and box culverts ranging in size from 40 in.×40 in. to 197 in.× 197 in., as well as in other pipe shapes (Kampbell, 2009).

5. CONSTRUCTION ISSUES

5.1. PLACING THE PANELS INSIDE THE CULVERT PIPE

If GRP panels are used, access pits are dug at suitable locations along the length of the culvert structure (if needed) and the crown of the culvert is removed to allow insertion of sections. For short runs, excavations at each end of the culvert are typically adequate. Multi-segmented panels are bonded on site to “full perimeter” liner segments using epoxy bonding compound. The segments are lowered into the pipeline opening using a suitably rated crane until they rest in the invert of the culvert at the pit location. A special hydraulic trolley (Figure 67) is used to transport each liner segment along the length of the host pipe to the required location. Once in position, the liner segment is centralized and chocked using hardwood wedges. Each liner segment is connected to the previously installed one by means of the socket and spigot joint. Once butted together, the joints are injected with a flexible mastic epoxy adhesive/filler. The annular space between the liner and the host pipe is filled with a low viscosity, free flowing, rapid setting, and high-strength grout (Channeline International, 2009b)

If lightweight PVC panels are used, they are carried by hand into the existing pipe where they are bolted into rings (Figure 68, Figure 69) using air-powered tools. For centering the liner inside the culvert pipe, spacers of appropriate size are positioned approximately 3 ft apart (Shonan Plastic, 2009).

Figure 7. GRP segment on installation trolley (Channeline International, 2009b)

Figure 8. Paneling inside a pipe (Kampbell, 2009)

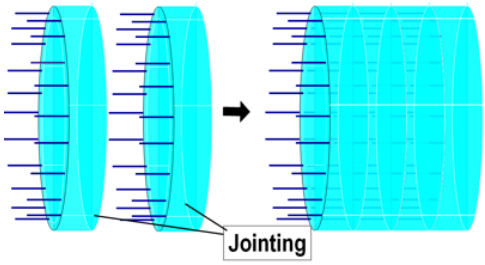

Figure 9. Ring-paneling with PVC panels (Kampbell, 2009)

5.2. GROUTING

In GRP liners, the grout ports are drilled at intervals along the crown of the liner and the grout pumped into the annular space (Figure 70) (Channeline International, 2009b).

In PVC liners, injection holes are drilled at locations predetermined according to the pipe diameters, at distances of approximately 15 ft, and the grout is pumped through them (Figure 71). The panels are made semi-translucent to allow for positive confirmation of the grouting of the annulus (Figure 72) (Shonan Plastic, 2009).

Figure 10. Injection of grout through grout ports into the annular space (Channeline International, 2009b).

Figure 11. Grout pumping into the annular space (Kampbell, 2009)

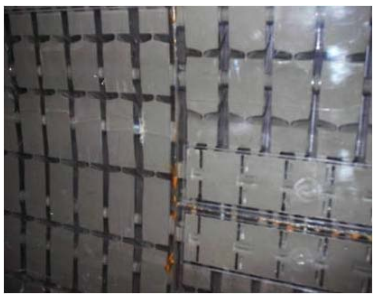

Figure 12. Grout visible through semi-translucent PVC panels (Kampbell, 2009)

5.3. BUOYANCY AND FLOTATION

The practicalities of buoyancy and flotation can be dealt with in several ways, but the most common is to undertake the grout filling of the annulus in three or more stages, dependent upon the height and diameter of the liner (Channeline International, 2009b).

6. QA/QC CONSIDERATIONS

NASTT (2006f) outlined QA/QC issues for thermoset panels. QA/QC should address the component products (the resin, the fillers and the reinforcing agents), the design (thickness, host pipe configuration, corrosion resistance, hoop strength and fit), and installation (joint fit, installation method, lateral restoration and grouting).

For QA/QC of GRP panels, daily and batch testing of each production run should be carried out by the QC department to verify conformity with design dimensions (wall thickness, ID, OD, height and width),

bending and flexural modulus, tensile tests, socket and spigot fit, Barcol hardness, and visual appearance (Kevin David, Channeline International Ltd, personal communication).

7. STANDARDS AND SPECIFICATIONS

ASTM D3262 covers machine-made glass-fiber-reinforced thermosetting-resin (fiberglass) pipes (Material standard).

ISO/TR 10465-1 describes the procedures for underground installation of flexible GRP pipes (Installation standard).

ASTM A761 covers corrugated steel structural plate, zinc-coated, used in the construction of pipe, pipe-arches, arches, underpasses, and special shapes for field assembly.

ASTM A796 covers the structural design of corrugated steel pipe and pipe-arches, ribbed and composite ribbed steel pipe, ribbed pipe with metallic-coated inserts, closed rib steel pipe, composite corrugated steel pipe, and steel structural plate pipe, pipe-arches, and underpasses for use as storm sewers and sanitary sewers, and other buried applications.

AASHTO M 167 covers corrugated steel structural plate, zinc-coated, used in the construction of pipe, pipe-arches, arches, underpasses, and special shapes for field assembly. Appropriate fasteners and accessory materials are also described. The pipe, arches, and other shapes are generally used for drainage purposes, pedestrian and vehicular underpasses, and utility tunnels.

8. ADVANTAGES AND LIMITATIONS

The main advantages of segmental lining are the ability to rehabilitate very large and odd-shaped pipes, and to accommodate alignment changes and short radius bends. The method can be effective for localized repair. Lightweight panels (PVC) are easy for handling with less labor and equipment requirements.

The main limitations of this method are the diameter limits (sufficient for man-entry) and the need for excavating access pits (with GRP panels).

9. EXAMPLE CASE HISTORIES

9.1. PVC PANELS

In Orlando, FL, see-through PVC panels were used to rehabilitate a 72 in. concrete storm sewer pipe in 2005. Two pipe segments were rehabilitated, which were 130 ft and 97 ft long (Griffin, 2009; Ray Pavlic, National Liner, LLC, personal communication).

9.2. GRP PANELS

Doherty et al. (2005) reported three projects in which GRP segmental lining was used to rehabilitate storm or combined sewer pipes in Toronto, ON, Canada:

- A 2,343 ft long box shaped poured-in-place concrete storm sewer was relined in 2003. The sewer consisted of four sections whose inside dimensions varied considerably: 40 in.×60 in. (942 ft), 36 in.×48 in. (459 ft), 48 in.×43 in. (384 ft), and 51 in.×51 in. (558 ft).
- A circular corrugated steel storm sewer, 66 in. in diameter and 1,178 ft long, was relined in 2003 using 5 ft long panels with ID 49 in. and OD 52 in.;
- A 1,736 ft long combined sewer was rehabilitated in 2004/05. The sewer consisted of several sections having three different shapes: an arch top brick sewer 48 in.×60 in. (1,440 ft), egg-shaped

brick sewer 47 in.×62 in. (108 ft) and 52 in. circular iron pipe (1,735 ft). GRP panels ranged in thickness from 20 mm to 35 mm.

In Buffalo, NY, a 140 ft long arched culvert, 12 ft × 6 ft, was relined in 2003 using a two piece GRP segmental liner (Channeline International, 2009a)

9.3. METALS PANELS

In Scranton, PA, a stone-arch culvert (U.S. Route 11/Pittston Ave) was rehabilitated after a massive sinkhole developed leading to the collapse of a large section of U.S. Route 11. Aluminum structural plate and galvanized steel tunnel liner plate arch, 13 ft span x 11 ft 4 in. rise, were used (CONTECH, 2009b).

10. REFERENCES

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