PIPE REPLACEMENT BY TUNNELING

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

1. OVERVIEW

Other in-line culvert replacement methods include pipe ramming, tunneling and pipe jacking.

Pipe ramming uses a pneumatic tool to drive a pipe or casing into the ground while consuming the existing culvert pipe. ASCE manual (Najafi, 2008) outlines the process in detail.

Pipe jacking installs a new pipe segment by segment in place of an existing culvert pipe using hydraulic jacks that are located in a jacking pit (Figure 1). The method can be used as long as the shield and the jacking pipe can consume the existing culvert and the new pipe allows man-entry.

Tunneling utilizes a simultaneous advancement of a protective shield and the manual removal of the existing pipe in pieces. Replacement is carried out with liner plate, i.e., liner plate rings, typically 16 in. long, are installed instead of a jacking pipe (Figure 2). Hydraulic cylinders located in the tunnel shield push against the most recently assembled liner plate ring advancing the shield forward. As the shield advances itself, it creates the space for adding a new ring (a jacking unit is not required, nor a jacking pit). After the liner plate is in place, it can be sliplined with a new concrete pipe or a wire mesh reinforced shotcrete lining can be applied.

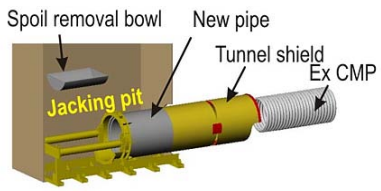

Figure 1. Replacement with jacking pipe (Tenbusch and Tenbusch, 2008)

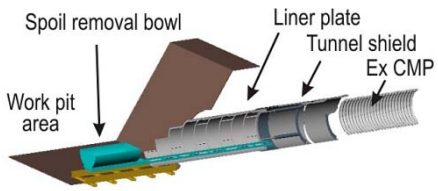

Figure 2. Replacement with liner plate (Tenbusch and Tenbusch, 2008)

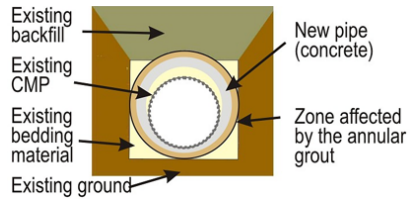

Figure 3. Placement of a new RCP through the existing CMP culvert (Tenbusch et al., 2009)

During the process of pipe replacement by tunneling, some of the surrounding soil is removed along with the existing pipe to accommodate the outside diameter of the new pipe (most of the soil removed consists of the original bedding, as shown in Figure 253). The grout and bentonite lubricant permeate the granular bedding material that remains, stabilizing the soil envelope around the new pipe and potentially limiting groundwater migration along the new pipe. If pipe upsizing is involved, the face material is excavated as needed (Tenbusch and Tenbusch, 2008).

2. CONSTRUCTION ISSUES

2.1. PIPE RAMMING

After the ramming pit is excavated at one end of the culvert, a pipe ramming machine is assembled. A pneumatic hammer is attached to the rear of the steel casing (Figure 254). The rails of the machine are used to support and guide the new casing during the pipe ramming process. A cutting shoe is often welded to the front of the lead casing to help reduce friction and cut through the soil. Bentonite or polymer lubrication can also be used to help reduce friction during ramming operations. An entire length of casing can be installed at once or, for longer runs, one section at a time can be installed. After the

casing is in place, the old culvert pipe is removed and all the spoil cleaned out. (The ramming can also be stopped periodically to clear the casing from the enveloped material, if necessary.) A new culvert pipe, e.g., a RCP, is jacked into the casing and the annular space between the new pipe and the casing is filled with grout.

2.2. PIPE JACKING

During pipe jacking, the protective shield (Figure 4) protects personnel and allows them to control line and grade, and the shield also cuts through the soil (if upsizing) shaping the perimeter of the hole opening. The recommended shield length is between 10 ft and 12 ft. Steerable shields that can be steered by operators inside it are recommended (for better grade maintenance). It is common to use bentonite lubricant to cut down on skin friction around the new pipe (Al Tenbusch, Tenbusch Inc, personal communication).

Figure 4. Pneumatic hammer is attached to the rear of the casing or pipe (Schill, 2007).

Figure 5. Jacking unit inside the pit (Tenbusch and Tenbusch, 2008)

2.3. REPLACEMENT WITH TUNNEL LINER PLATE

Replacement with tunnel liner plate is appropriate when a jacking pit is not available. The work area must be long enough to launch the shield and to allow for the safe entrance and exit of the workers and materials. A lubricant is not required (Tenbusch and Tenbusch, 2008).

Figure 6. A protective shield attached to a new RCP for protection of workers during removal of CMP and soil excavation (Tenbusch and Tenbusch, 2008)

Figure 7. Two rings of liner plate assembled on the launch track (Tenbusch and Tenbusch, 2008)

3. EXAMPLE CASE HISTORIES

In Newark, DE, a failing 48 in. corrugated metal culvert was replaced with a new 54 in. reinforced concrete pipe (RCP) utilizing pipe insertion by pushing. The existing corrugated metal pipe (CMP) had deteriorated seams that allowed the bedding material to migrate into the pipe (Figure 8). The culvert was replaced in both directions from a work pit in the highway median. A shield was attached to a joint of new RCP (Figure 9), which protected the men as they removed the old CMP and excavated the needed amount of material to accommodate the larger diameter pipe. Because the ground was stable, a simple shield was all that was required. Only a small footprint was required to do the work. (Underground Construction, 2009; Tenbusch and Tenbusch, 2008).

Figure 8. Deteriorated CMP culvert (Tenbusch and Tenbusch, 2008)

Figure 9. The traffic along the highway was not affected as the existing 48 in. CMP culvert was replaced with a new 54 in. concrete pipe (Tenbusch et al., 2009).

In High Prairie, Alberta, Canada, 300 miles north of Edmonton, a rotted 36 in. corrugated metal culvert under Highway 2 was replaced by pipe ramming. A 42 in. steel wall carrier pipe (0.562 in. thick) was installed (Werner and Dworsky, 2003).

Five drainage culverts were replaced by ramming between Louisville, KY and Bedford, IN. One of the culverts was a deteriorated 36 in. corrugated metal pipe, through which a small creek ran. The 50 ft of 42 in. casing (0.562 in. thick steel wall carrier pipe) was pounded through limestone floaters, boulders cobble, and railroad ties in less than 90 minutes (Werner and Dworsky, 2003).

4. ADVANTAGES AND LIMITATIONS

Camp et al. (2010) outlined pros and cons of pipe ramming, pipe jacking and tunneling when used for culvert replacement.

Table 31: Pros and cons of pipe ramming, pipe jacking and tunneling (Camp et al., 2010)

	Pros	Cons
Pipe ramming	▪ Can be used for consumption or parallel construction ▪ Works best with smaller diameters ▪ Can eliminate sags in the existing culvert ▪ Does not use a lot of equipment (easy to stop and start if the weather changes) ▪ Allows existing stream to flow through the culvert during construction ▪ Initial work is completed with no personnel entry	▪ Needs to be used in soil conditions ▪ Requires a second liner if the exposed steel is not acceptable ▪ Has to push out old culvert/old materials after the new casing is installed ▪ Cannot see the condition of the backfill materials during the installation process (working blindly)
Pipe jacking	▪ Can be used for consumption or parallel construction ▪ Allows the direct installation of concrete or other pipe material that does not need a secondary lining ▪ Can eliminate sags in the existing culvert	▪ Needs to be used in soil conditions ▪ Requires a large diameter for personnel entry ▪ Needs more equipment, including jacking frame and reaction block

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	Pros	Cons
Tunneling	▪ Can be used for consumption or parallel construction ▪ Excavating as you go allows you to see backfill material ▪ Can be used in soil or rock conditions ▪ Can eliminate sags in the existing culvert ▪ Allows for the construction of different shapes of culvert ▪ Allow longer distances to be installed ▪ Permits larger diameter openings	▪ Needs more equipment; therefore difficult to stop and start ▪ Requires a larger diameter for personnel entry ▪ Requires a second liner if liner plate or steel ribs are used

5. REFERENCES

Camp, C., G. Boyce, and A. Tenbusch, 2010."Culvert Replacement Using Pipe Ramming, Tunneling, or Pipe Jacking," *NASTT No-Dig 2010 Conference*, Chicago, IL, May 2-7, 2010, Paper A-5-05, 11p.

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Werner, S. and M. Dworsky, 2003. "Pipe Ramming Replaces Drainage Culverts," AREMA 2003 Conference, Chicago, IL, Oct 5-8, 2003

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