Iowa Flowable Mortar Saves Bridges and Culverts

WILLIAM E. BUSS

The development and use of flowable mortar for various applications are presented. This research used various methods of backfilling pipe culverts to compare settlement and cost of backfill methods. The research resulted in a method of backfilling culverts with sand backfill to midheight of the culvert and then with a maximum of 5 ft of flowable mortar. The remainder of the backfill is normal embankment or other subgrade treatment. This method was expanded to include installing culverts under bridges and then backfilling under the bridge with sand and flowable mortar in two stages; this method resulted in the bridge check becoming the pavement by removing the bridge curb and handrail. Another use of flowable mortar involves placing a pipe culvert in a deteriorated box culvert and filling the void with flowable mortar. The Iowa Department of Transportation has backfilled an "H" pile and wood plank retaining wall with flowable mortar. The present flowable mortar consists of 2,600 lb of sand, 100 lb of cement, 300 lb of fly ash, and water, which results in a 12-second efflux time for the Corps of Engineers flow cone method CRD-C611-80, approximately 70 gal. The Ames Central Office Materials Laboratory uses submitted sand, fly ash, and cement to develop the desired efflux time. The fly ash content may be increased if the sand is too coarse. Sand gradations are 100 percent passing ¾-in. sieve and 0 to 10 percent passing 200 sieve.

DEVELOPMENT

In 1979 the Office of Materials of the Iowa Department of Transportation, under the direction of Ralph Britson, developed a flowable mortar backfill material consisting of 212 lb of Type 1 Portland cement, 505 lb of Type F fly ash, 2,232 lb of sand, and 438 lb of water. By using this material, granular backfill, and soil backfill, a comparison was set up within a project in which nine culverts were being replaced.

Flowable mortar was used to backfill under the pavement by using the soil outside a 1:1 slope as a form to contain the flowable mortar. Granular backfill was used in the same area as the flowable mortar for other locations. Still other locations were backfilled with soil in 8-in. lifts and compacted with a vibratory plate. The methods used are compared as follows:

Type of Backfill	*Settlement (in.)*	*Cost ($)*
Soil	1.5	1,790
Granular	0	1,880
Flowable mortar	0.25	790

More testing resulted in a flowable mortar mix consisting of 100 lb of cement, 300 lb of fly ash, 2,600 lb of sand, and ±70 gal of water to produce a 12-second efflux time by the Corps of Engineers flow cone method CRD-C611-80. The aggregate gradations are 100 percent passing the 3/4-in. sieve and 0 to 10 percent passing the 200 sieve. The best results are with fine sands. Fine aggregate for concrete will work with 400 to 500 lb of fly ash because of the small amount of material that passes the 200 sieve (0 to 1.5 percent). This material will develop a compressive strength of 80 psi but is designed for backfill material that does not shrink. Flowable mortar can be removed without a jackhammer.

The following uses of flowable mortar have been designed with the cooperation of Kermit Dirks, geologist in the Office of Road Design.

Construction Office, Iowa Department of Transportation, Ames, Iowa 50010.

CULVERT BACKFILL

Flowable mortar was designed to be used for culvert backfill with the following requirements: granular backfill for half the height of the culvert and flowable mortar for a maximum of 5 ft above the culvert. The granular backfill provides insurance that the culvert does not float and acts as a filter to keep from plugging the drainage system. The required subgrade treatment must be between the pavement and the flowable mortar. The sand and flowable mortar are contained by soil as shown in Figures 1 and 2.

This type of construction has been used on roads closed to traffic and also under traffic in which one lane is closed. For the one-lane closure method, half the pavement is removed with a bulkhead of sheet piling installed to retain soil under the open lane. The culvert is installed and backfilled with sand, flowable mortar, soil, or granular material, and the

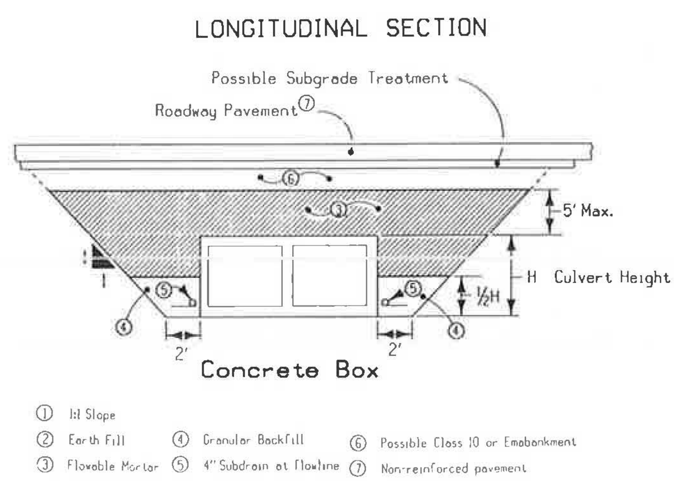

FIGURE 1 Side view of culvert backfill.

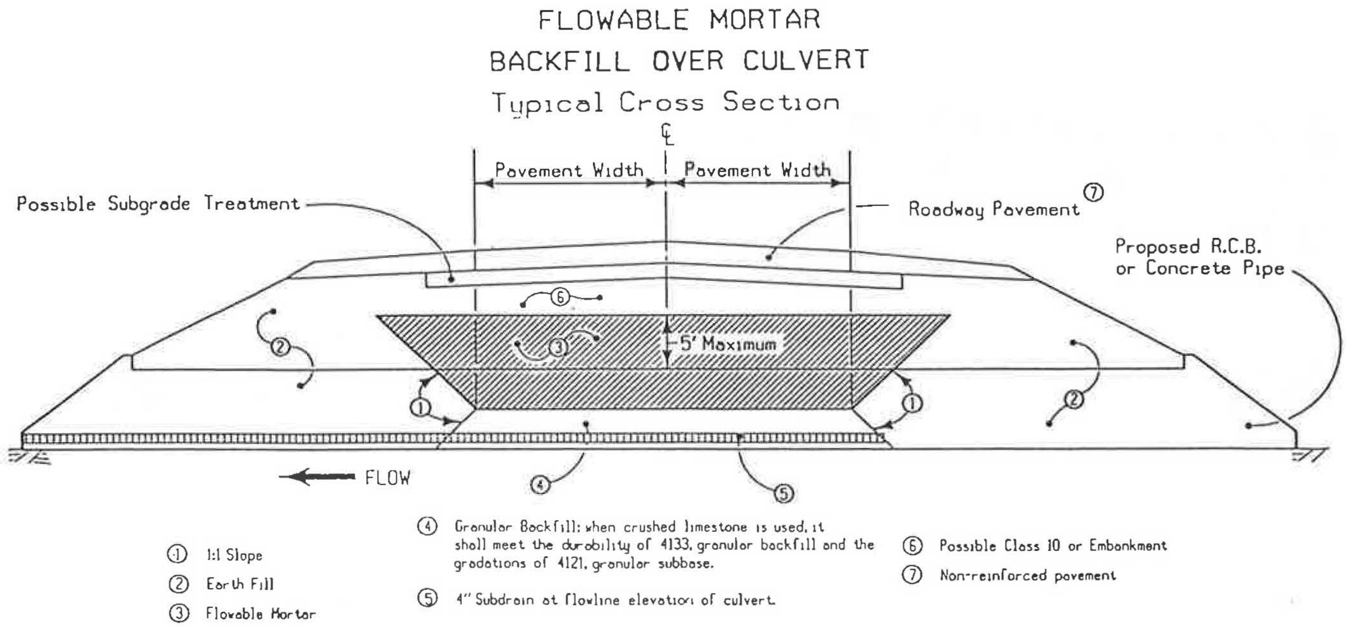

FIGURE 2 Cross-section of culvert backfill.

FIGURE 3 Overall view.

FIGURE 4 Excavation view.

pavement is replaced. The remaining half is constructed by the same procedure (Figures 3 and 4).

In locations in which a culvert is badly deteriorated, a corrugated metal pipe culvert is placed inside the deteriorated culvert and the void between the two culverts is filled with flowable mortar. If possible, granular backfill to midheight is placed before placing flowable mortar. If space is not available, the pipe culvert is blocked into position and backfilled in stages to prevent the floating of the culvert. For long culverts the flowable mortar is introduced at more than one location.

When it is to be abandoned in place, a culvert is filled with flowable mortar after sealing off both ends of the culvert. Sealing it off also fills any voids adjacent to the abandoned culvert to prevent future settlement.

BRIDGE BACKFILL

Where drainage conditions will allow and where space is adequate, Iowa has developed a system that uses flowable mortar to convert the bridge to a roadway without closing the road to traffic. (See Figure 5 for before and after views of a bridge backfill.) This process involves installing the culvert, pipes, or reinforced box culverts under the bridge. The culvert is backfilled by using soil as forms at both ends and filling the area under the bridge with flowable mortar (Figures 6 and 7).

The first stage is filled to within 6 in. of the low member of the bridge. The second stage is placed after a 72-hour delay to allow for the fast settlement of the original soil under the bridge. The second stage is placed sequentially over half of

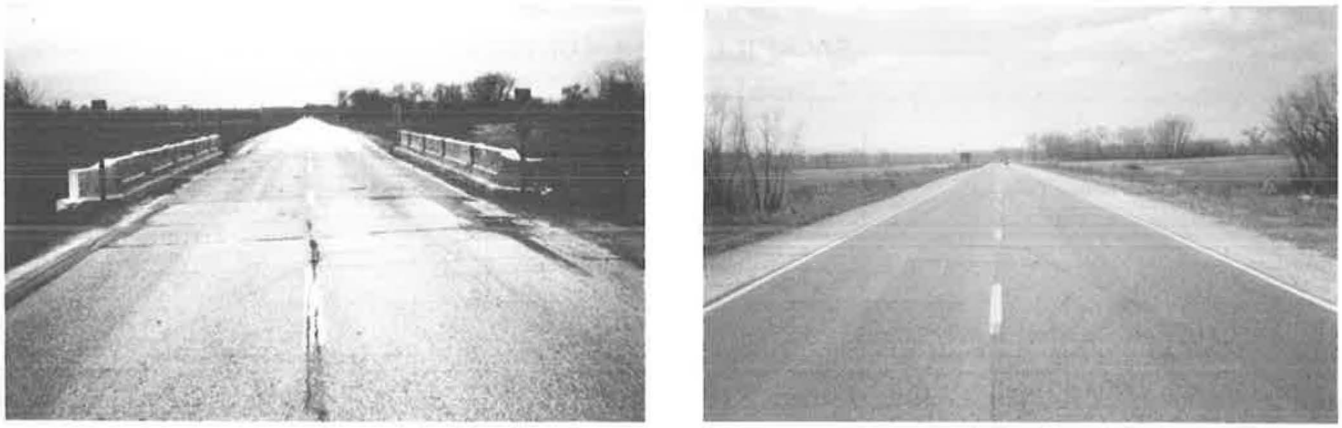

FIGURE 5 Before (left) and after (right) views of a bridge backfill.

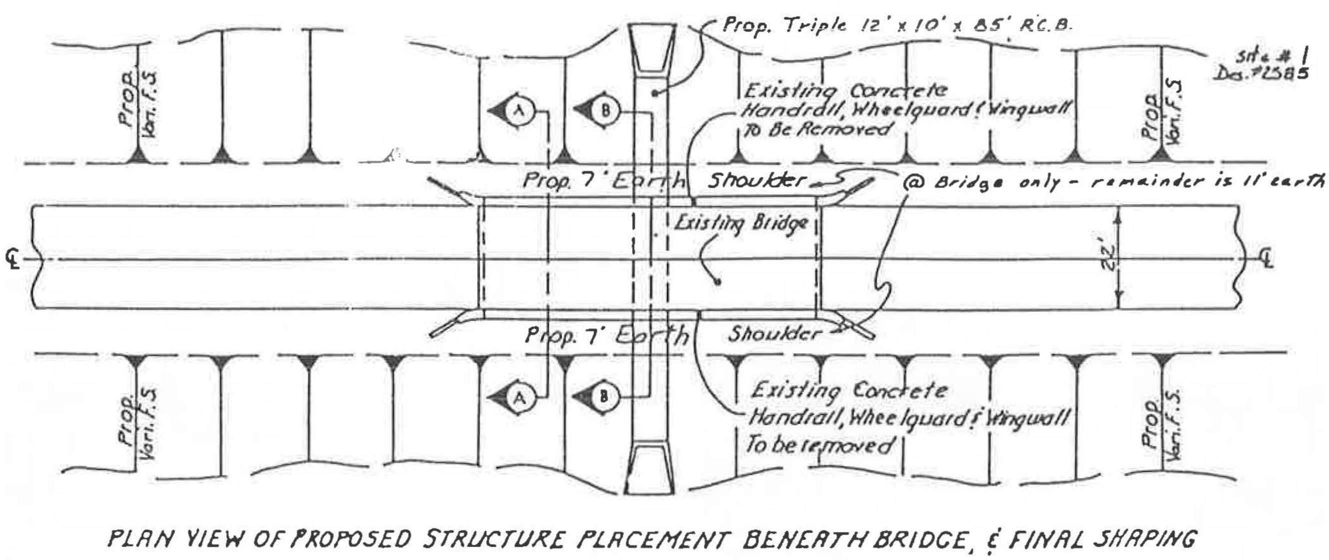

FIGURE 6 Plan view of bridge replacement.

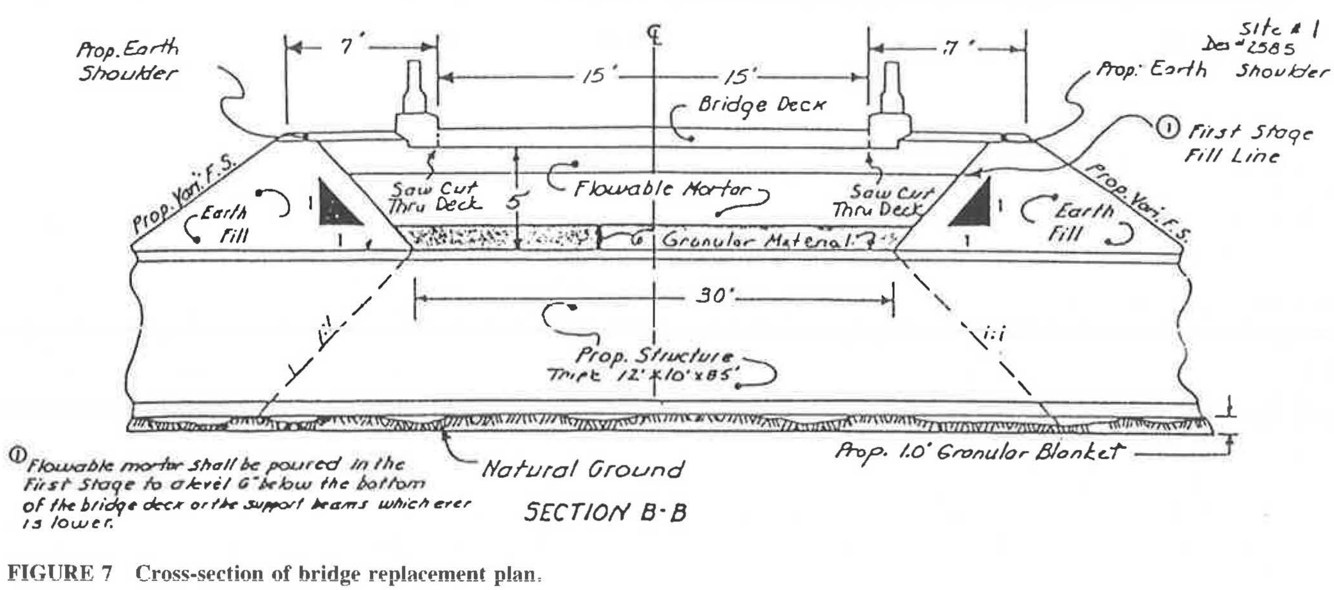

FIGURE 7 Cross-section of bridge replacement plan.

the deck at a time through holes drilled into the floor between beams, abutments, piers, and diaphragms.

The bridge handrail and curb are then removed (see Figure 8). With the construction of shoulders in the bridge area, the bridge becomes a pavement. The culvert is constructed with a limited amount of one-way traffic (see Figure 9). The placement of flowable mortar involves one-way traffic at least during the second stage.

In a 9-mile length of U.S. Route 30 between Woodbine and Logan in Harrison County, Iowa, there were six narrow bridges. Four of these bridges were modified by using flowable mortar with concrete pipe culverts. One was modified by using flowable mortar with a reinforced concrete box culvert, and one was replaced with a new bridge by using a runaround to keep the road open to traffic. A cost comparison is shown as follows:

Type of Work	*Cost ($)*
Pipe culvert installations	50,500
RCB culvert	140,000
Bridge replacement	207,000

At several locations in which a railroad passes over a highway, an at-grade railroad crossing can be safely constructed because of reduced train traffic. In this situation, the railroad underpass was backfilled with sand and flowable mortar by a method similar to the previous method, except that the flowable mortar is placed at one time (see Figure 10).

FIGURE 8 Removal of bridge handrail.

FIGURE 9 Traffic during second stage.

BACKFILL RETAINING WALL

At one location in Iowa, a laid-up limestone block retaining wall bulged out, indicating the initial stage of failure. In this

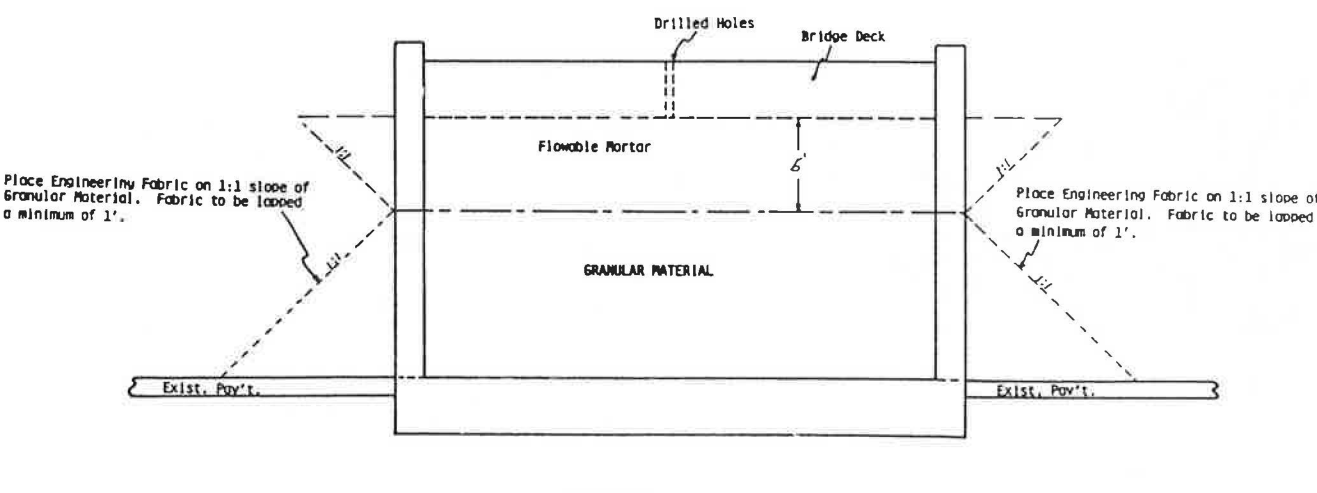

FIGURE 10 Profile through underpass.

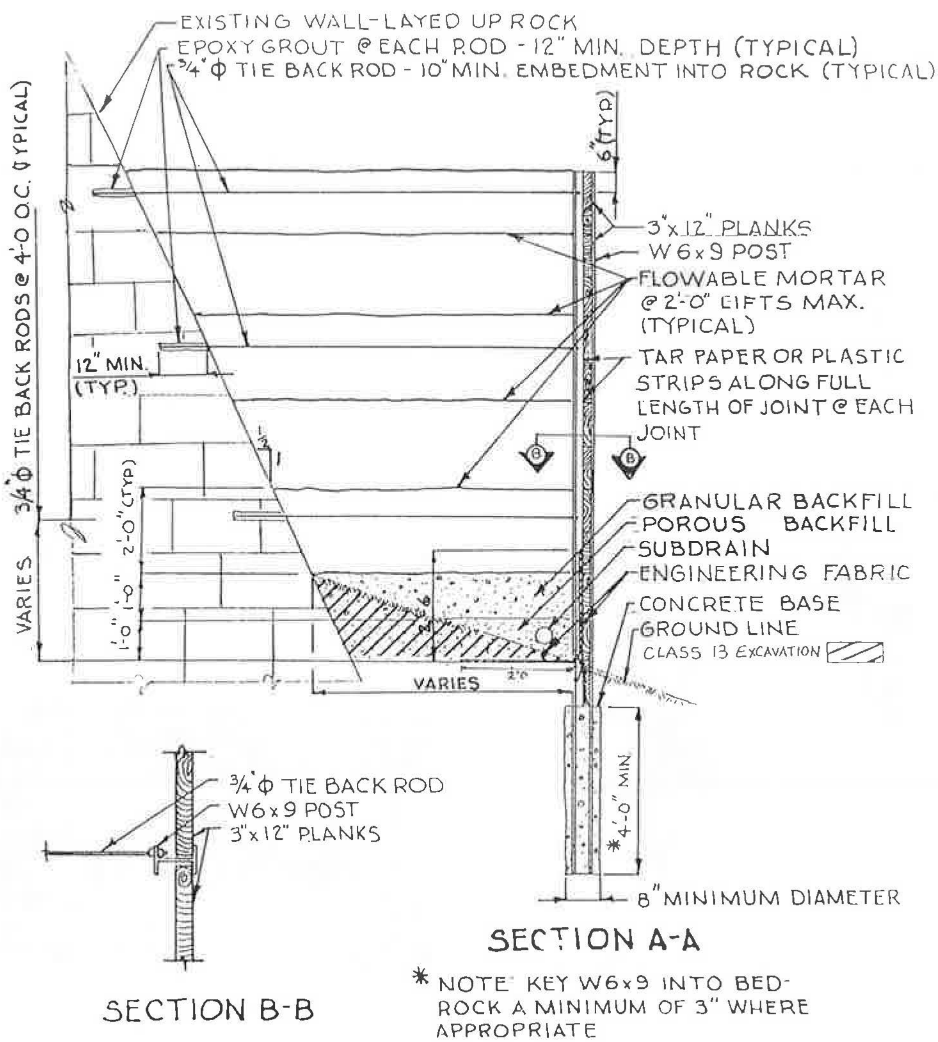

FIGURE 11 Cross-section of retaining wall.

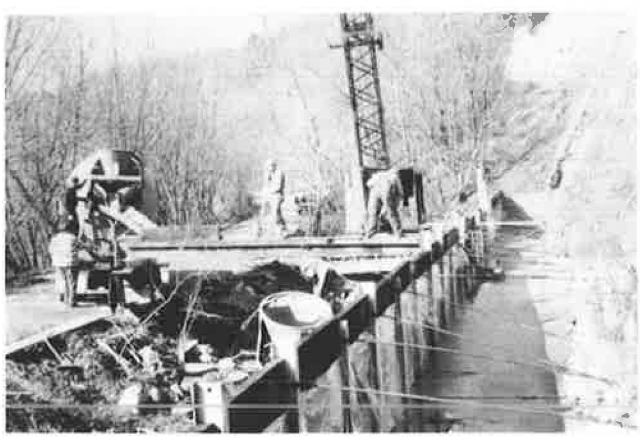

FIGURE 12 Actual placement of flowable mortar.

instance an "H" pile wall with wood planks was constructed in front of the wall and backfilled with sand and flowable mortar, which filled voids behind the limestone block wall (see Figures 11 and 12).

IMPORTANT POINTS

The following are important to remember:

- Pipe culverts will float.
- Bulkheads are designed for liquid pressure.
- Water content is critical: too much is as bad as too little.
- Delivery should be continuous for filling confined spaces.
- Drainage of water through the flowable mortar is a must.

SUPPLEMENTAL SPECIFICATION

The Supplemental Specification for Flowable Mortar (SS-1069) dated December 20, 1988, is available from the author.

The contents of this report reflect the view of the authors and do not necessarily reflect the official views of the Iowa Department of Transportation. This report does not constitute a standard, specification, or regulation.

Publication of this paper sponsored by Committee on Mechanical Properties of Concrete.