Engineering Tech Tips

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Paving of Corrugated Metal Pipe Inverts for Repair and Fish Passage

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REPAIRING DAMAGED CMP INVERTS

The San Dimas Technology and Development Center (SDTDC) has been working with the Southern Region (R-8) on the Ecosystem Roads Management, a project aimed at documenting environmental enhancements in road work. In this effort, R-8 picked up on an innovation of the Oklahoma Department of Transportation (ODOT). ODOT Research Engineers developed repair methods for damaged inverts on corrugated metal pipe (CMP).

The mountainous areas of eastern Oklahoma subject CMP's to acidic, highly oxygenated running water that—in conjunction with bedloads of sharply fractured gravel and rock—rapidly deteriorate the pipe invert through abrasion, perforation, and corrosion. This deterioration leads to saturation of bedding material, piping, erosion, and sometimes settlement of the pipe and road surface. ODOT's objective was to develop simple and economical (yet effective) repair methods—alternatives to removal and replacement of the CMP.

One in-place rehabilitation method successfully implemented involves manually trowelling a cement grout mix onto the CMP invert (figs. 1 and 2). This maintains the integrity of the structure at minimum expense. A total of ten pipes, none of which had suffered extreme settlement, were treated in this manner by ODOT. Two different design mixes provided "very good, no cracking" performance ratings. The compositions of the two design mixes were varied as shown below under "Specifications."

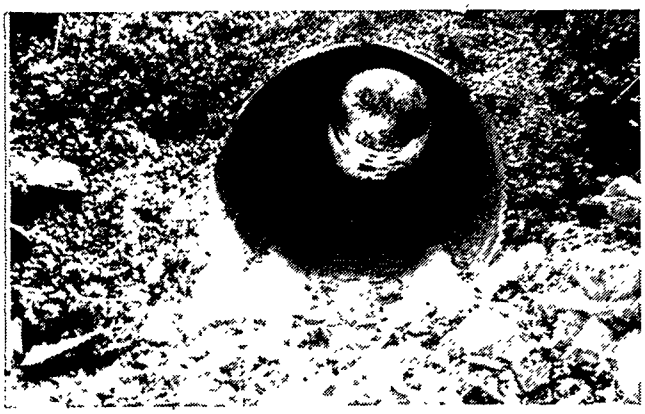


Figure 1. View down barrel of repaired CMP.

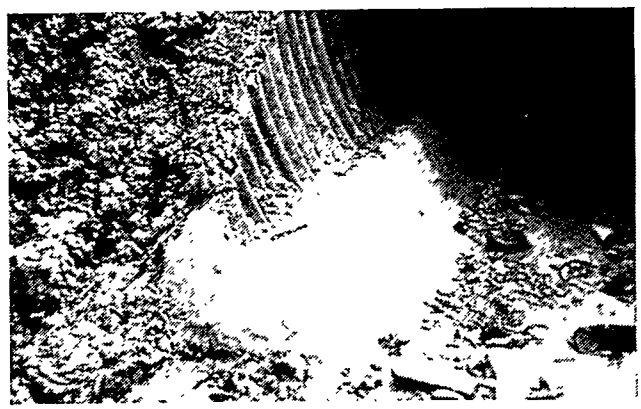


Figure 2. Close-up of grouted invert.

Another repair method detailed by ODOT involves placing a reinforcing liner (consisting of a smaller diameter corrugated polyethylene pipe) into the pipe being repaired. The space between pipes is filled with cement grout. This method was developed for extreme corrosion and metal loss conditions on the CMP; it is *not* discussed further here.

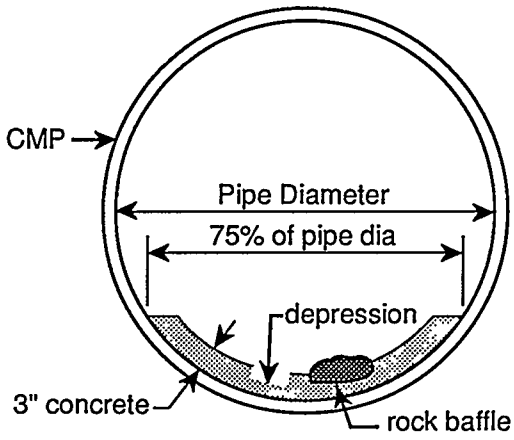
ENVIRONMENTAL BENEFITS

Herb Mansbridge, Civil Engineer, and Richard Standage, Fisheries Biologist, on the Ouachita National Forest, Ark., realized that additional benefits from CMP invert paving were possible. In terms of environmental concerns, two main benefits are fish passage and streambed stability.

Fish Passage

Rock baffles may be installed in the grout, in addition to formed depressions, to provide resting pools constituting a fish passage modification (fig. 3). The Ouachita National

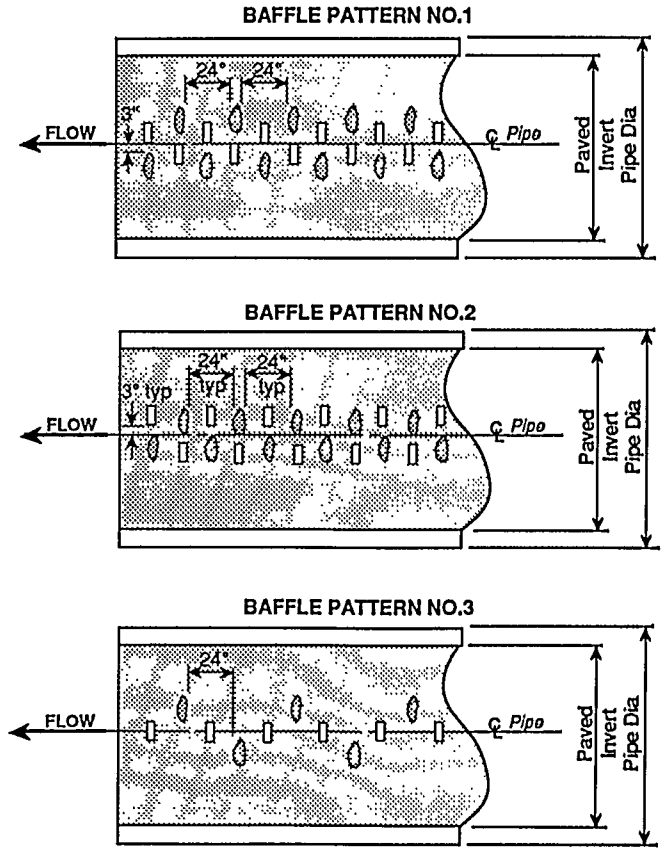
For additional information contact: *Roads Program Leader, San Dimas Technology & Development Center, 444 East Bonita Avenue, San Dimas, CA 91773. Phone: 909/599-1267; FTS 700/793-8000; FAX 909/592-2309; DG, SDTDC:W07A. Also, if you would like to submit an environmentally enhancing roads-related project to the Ecosystem Roads Management (ERM), contact your Regional ERM coordinator or the SDTDC Roads Program Leader.*



Paved Invert
SECTION
No Scale

NOTES:
1. Depressions to be made in concrete 2-in deep, and 4-in wide and 6-in long (12-in long pattern No.3).
2. Rock baffle to be cast in fresh concrete. Imbed 2-in into paved invert. Individual baffle from one stone 4-6 in high, 4-8 in wide, and 10-16 in long.
3. Patterns for depressions and baffles are shown in Fig. 4.

Figure 3. CMP paving repair method.



NOTE: Depressions and baffles are 2-in deep in grout.

= Individual stone embedded in fresh grout.
[] = Depression in grout 4 inches wide and 6 inches long (No.1 & No.2) 12inches long (No.3)

Figure 4. Baffle patterns.

Forest has experimented with various rock baffle and depression patterns, as shown in figure 4. Each pattern has proved functional.

The initial pipe repair project on the Ouachita (the Peninsula Road No. 69B) proved the value of the method in terms of fish passage. Orangebelly darters, acting as a surrogate for the Forest Service-listed sensitive paleback darter, were found, in an electrofishing survey, to be successfully passing through the pipe.

Streambed Stability

Sedimentation and erosion in the streambed is virtually eliminated, since the road embankment is not excavated, nor the pipe bedding disturbed, during repair activities, as is required for pipe removal and replacement. Disruption of normal stream flow is also minimized, as the repair method takes less time and, thus, less damming or diversion of water is needed.

An additional possible benefit may be derived from the raising of the invert elevation. Water is ponded upstream of the pipe, and sediment preserved, making watershed improvements—including increased soil moisture and water table levels—possible. However, downstream treatments, such as gully plugs and splash aprons may be required; and the potential invert elevation increase is moderate at best.

ECONOMIC BENEFITS

Initial project work on the Ouachita National Forest indicates substantial economic benefits are possible when employing this repair method. The paving grout, complete with rock baffles and formed depressions, can be installed for less than 12 percent of the cost of removal and replacement of the CMP. This statistic applies to a 72-inch CMP, and does not include the costs of providing for fish passage or sedimentation control measures on the replaced pipe.

Specifications

The two design mixes successfully used by ODOT are as follows:

COMPOSITIONS OF DESIGN A, WITH FLY ASH

Water/Cement ratio	Cement (lb)	Fly ash (lb)	Sand (lb)	Fly ash (%)	Slump (in)	Water (lb)
0.44	37.6	0.0	150.4	0	5	16.6
0.44	26.3	11.3	150.4	30	9	16.6
0.44	18.8	18.8	150.4	50	9.5	16.6
0.44	30.1	7.5	150.4	80	10	16.6

COMPOSITIONS OF DESIGN B, WITHOUT FLY ASH

Water/Cement ratio	Cement factor
0.5	2.25
0.4	2.25
0.4	1.75

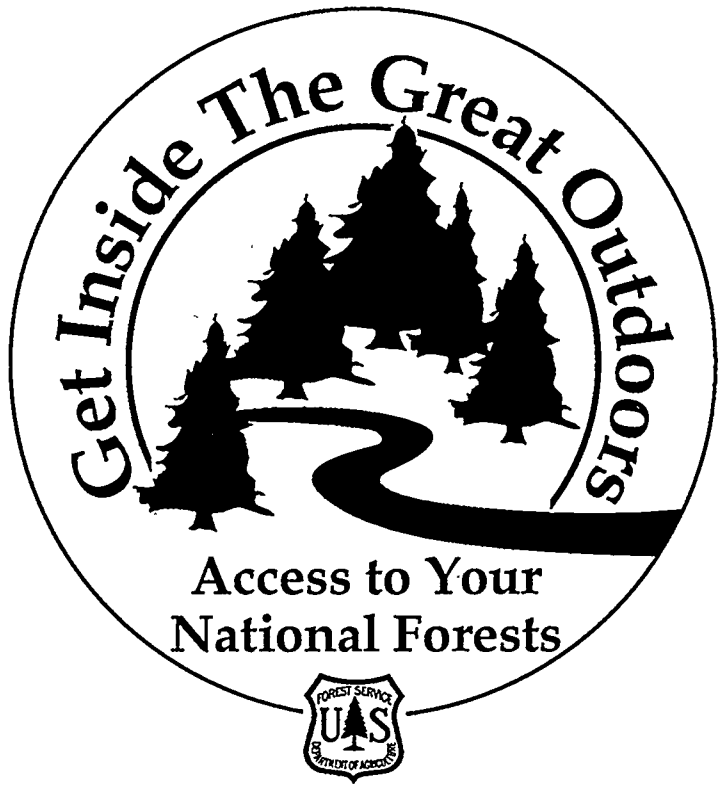
Inspections on Design A installations lend the following observations:

- Increasing fly ash content generally increases the time to harden and slump, while decreasing cost and strength.
- Increasing air entrainment increases slump and decreases strength when the water/cement ratio is kept constant, and does not seem to be needed.
- Wet inverts, or *small* amounts of running water, do not seem to harm the treatment.
- ODOT experienced satisfactory service from the "cheapest and easiest" of the mixes.

The Ouachita National Forest has experienced satisfactory service with concrete specified under Forest Service *Specifications for Construction of Roads and Bridges*, Section 602, Method B, with increased cement and slump. A cement factor of 7 and a slump of 6 inches is specified. Rock for use as baffles shall be hard stone meeting the requirements of Section 622.02 for rubble. Soft stone or shale should *not* be used.

CONCLUSIONS

Initial experimentation with a CMP repair method—consisting of paving the invert with hand-trowelled cement grout—has shown the method to be successful, functional, and economical. Additional benefits include being able to easily install rock baffles and depressions for fish passage, a large reduction in disturbance to the stream during and after the work, and the potential for watershed improvements. Forest Service managers interested in economically extending CMP life and increasing fish passage capabilities should seriously consider employing the method.



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