

Research Report  
KTC-99-5

EVALUATION OF CORRUGATED STEEL PIPE CULVERTS  
KY 55, SHELBY COUNTY

by

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in cooperation with  
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and

Federal Highway Administration  
U.S. Department of Transportation

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March 1999

1. Report No. KTC-99-5		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle  Evaluation of Corrugated Steel Pipe Culverts on KY 55, Cumberland County.				5. Report Date <b>March 1999</b>	
				6. Performing Organization Code	
7. Author(s) L.eo J. Fleckenstein and David L. Allen				8. Performing Organization Report No.6 <b>KTC-99-5</b>	
9. Performing Organization Name and Address  Kentucky Transportation Center College of Engineering University of Kentucky Lexington, Ky. 40506-0381				10. Work Unit No. (TRAIS)	
				11. Contract or Grant No. Federal Aid Research Task 87	
12. Sponsoring Agency Name and Address Kentucky Transportation Cabinet State Office Building Frankfort, Ky. 40622				13. Type of Report and Period Covered <b>Final</b>	
				14. Sponsoring Agency Code	
15. Supplementary Notes: Publication of this report was sponsored by the Kentucky Transportation Cabinet with the U.S. Department of Transportation, Federal Highway Administration.					
16. Abstract  In February of 1998, the Kentucky Transportation Cabinet requested that the Kentucky Transportation Center investigate excessive deflection occurring in three aluminized Type 2 corrugated metal pipe culverts installed during the realigning and widening on KY 55. The pipes were initially inspected in February 1998. The embankments were only 50 percent completed and in several locations only one-half of the total length of the culvert had been installed. The scope of this project was increased after excessive deflections were observed in other structures throughout the project.					
17. Key Words <b>Pipe Deflection Density</b>			18. Distribution Statement <b>Backfill</b>  Unlimited		
19. Security Classif. (of this report)  Unclassified		20. Security Classif. (of this page)  Unclassified		21. No. of Pages  7	22. Price

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## INTRODUCTION

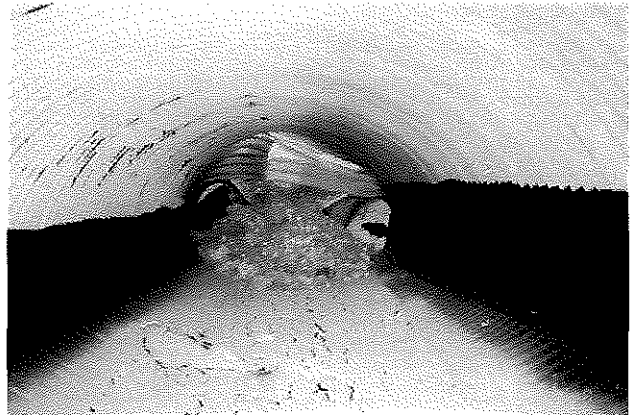
In February of 1998, the Kentucky Transportation Cabinet requested that the Kentucky Transportation Center investigate excessive deflection occurring in three aluminized Type 2 corrugated metal pipe culverts installed during the realigning and widening on KY 55. The pipes were initially inspected in February 1998. The embankments were only 50 percent completed and in several locations only half of the total length of the culvert had been installed. The scope of this project was increased after excessive deflections were observed in other structures throughout the project.

## VISUAL INSPECTION

In February 1998, the three culverts in question were visually inspected. The pipes appeared to be slightly egg-shaped (elliptical) and there were no signs of buckling or excessive deflection. The pipes appeared to be deflected approximately 5 percent. The embankments, at the time of the inspection, were approximately 1/3 completed. It was decided to install monitoring points in the culverts to monitor deflections throughout the course of the construction. This is discussed later in the report.

During the initial inspection it was apparent that several of the other pipe culverts throughout the project were also deflecting more than expected. It was decided that the cross drains in question would be closely monitored.

Several random visual inspections were performed throughout the course of the project. During one of the inspections on August 9, 1998, a failure was observed in a pipe arch at Station 531+15 (Figure 1). From conversations with the inspector it is apparent that a pan driver ran over the pipe with less than one foot of fill over the pipe (Figure 2). The failed section of the arch was removed and replaced.

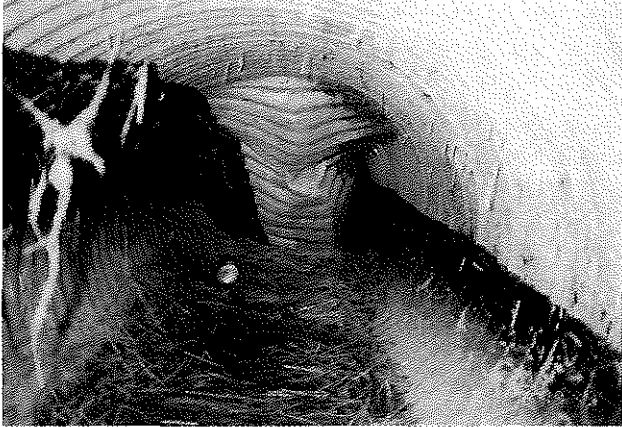


**Figure 1. Failure observed in cross drain at Station 531+15.**



**Figure 2. Top of cross drain damaged by pan at Station 531+15.**

On February 19, 1999, a visual inspection was conducted on every cross drain on the project. During this inspection, significant pipe distress was observed in two cross drains. A 30-inch pipe at Station 602+00 had completely collapsed on both the inlet and the outlet end (Figure 3). The failures had occurred approximately 30 feet from the inlet end and approximately five feet from the outlet end. It is uncertain at this time if the pipe has completely collapsed between these two locations.



**Figure 3. Failure observed in 30" cross drain at Station 602+50.**

At Station 619+00 a severe buckle was observed in a 30-inch cross drain (Figure 4). The top of the pipe had buckled from the eleven o'clock to approximately the two o'clock position. A tear in the wall of the pipe was also noted. It appears that a rock or a piece of equipment may have been pushed against the pipe.



**Figure 4. Damaged 30" cross drain at Station 619+00.**

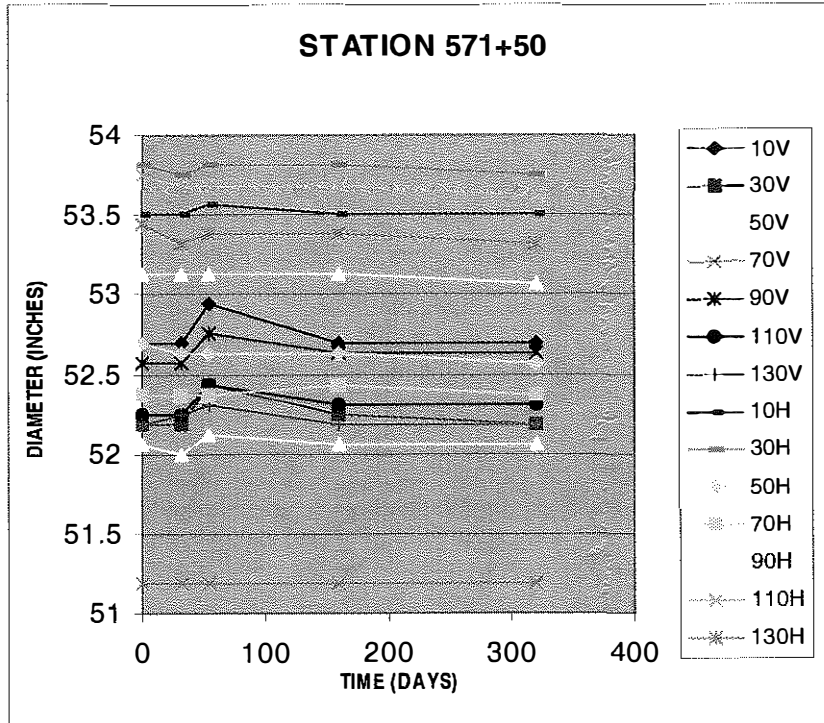
**DEFLECTION MONITORING**

Deflection measurements were taken on five cross drain structures. Deflection measurements are shown in Figures 5 through 9. The 0.5 to 1.0-inch of paved invert was not taken into account during the vertical deflection measurements. In four out of five pipes, the maximum deflection has exceeded the design value of five percent. The deflections appear to have stabilized in most of the pipes except for one location in the 60-inch cross drain at Station 701+50. At monitoring point number 87 approximately midway through the structure the pipe had continued to deflect while the remainder of the structure had stabilized. The pipe was monitored in March and April of 1999. In March, the horizontal deflection remained unchanged and the vertical appeared to have continued to move. Approximately one month later (in April) neither the horizontal nor vertical deflections had changed. Currently the pipe has deflected approximately eight percent.

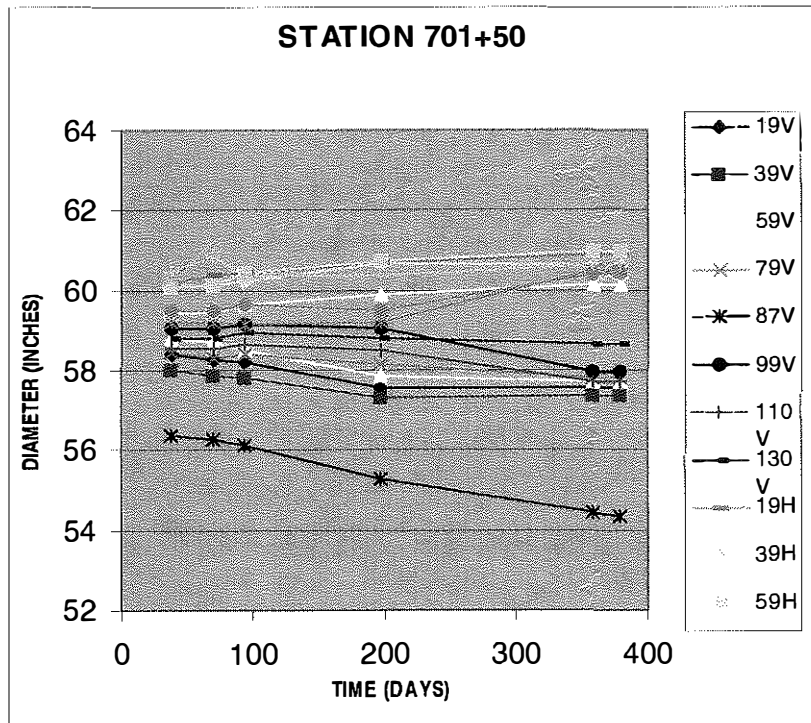
taken into account during the vertical deflection measurements. In four out of five pipes, the maximum deflection has exceeded the design value of five percent. The deflections appear to have stabilized in most of the pipes except for one location in the 60-inch cross drain at Station 701+50. At monitoring point number 87 approximately midway through the structure the pipe had continued to deflect while the remainder of the structure had stabilized. The pipe was monitored in March and April of 1999. In March, the horizontal deflection remained unchanged and the vertical appeared to have continued to move. Approximately one month later (in April) neither the horizontal nor vertical deflections had changed. Currently the pipe has deflected approximately eight percent.

Although the deflection in several of the pipes does exceed the design value of five percent and are approaching 10 percent no buckling or wall distortion has been documented.

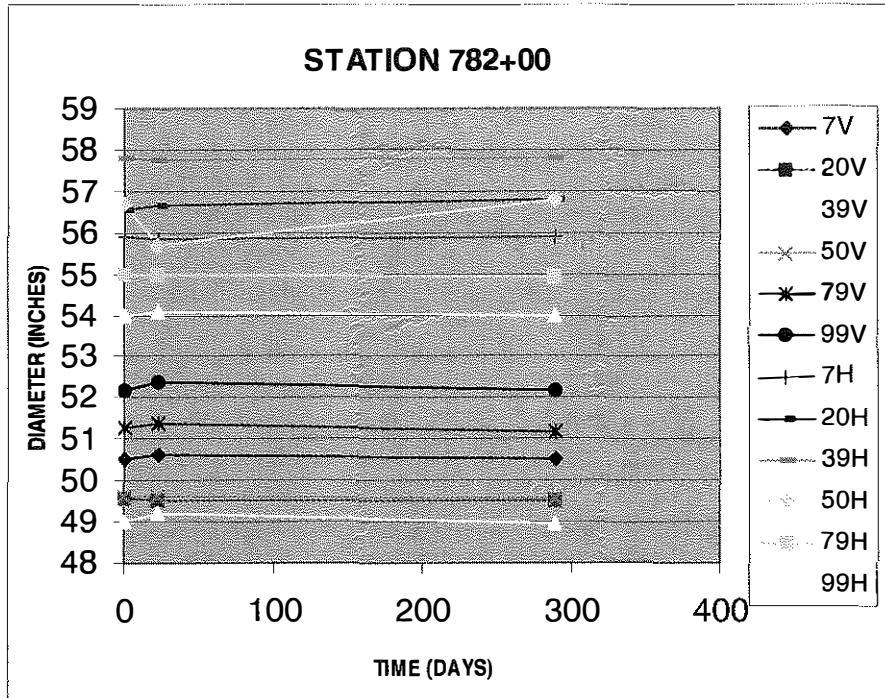
The horizontal deflections observed in the 54-inch pipe culvert at Station 571+50 ranged from 53.25 to approximately 53.75 inches. The horizontal shortening indicates that the soil fill around the haunches and sides of the pipe was well compacted. This compactive effort is likely what is keeping the vertical deflections to 5 percent or less.



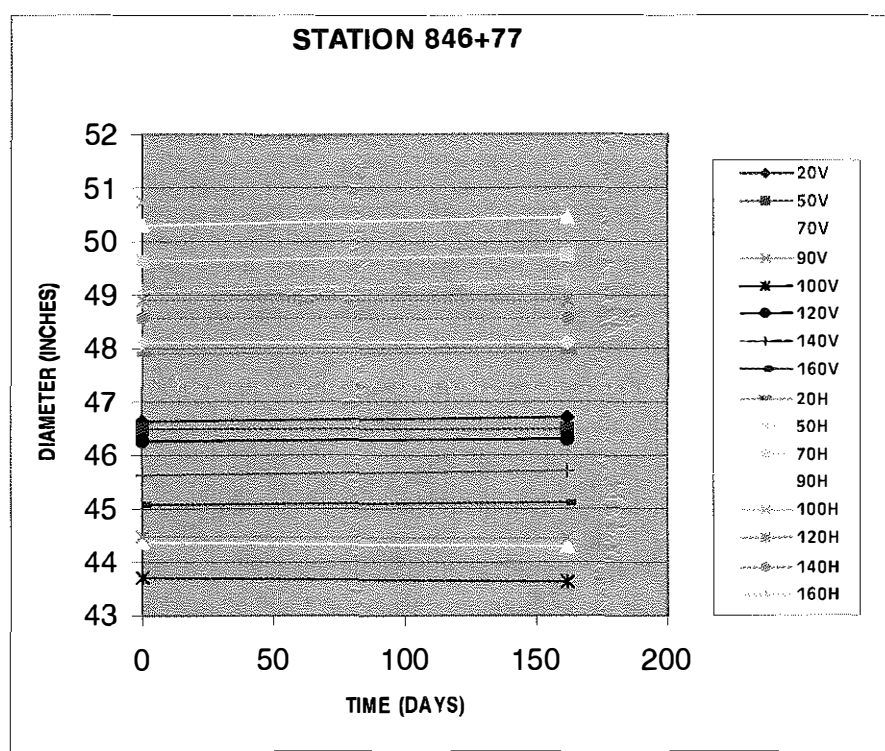
**Figure 5**



**Figure 6**



**Figure 7**



**Figure 8**

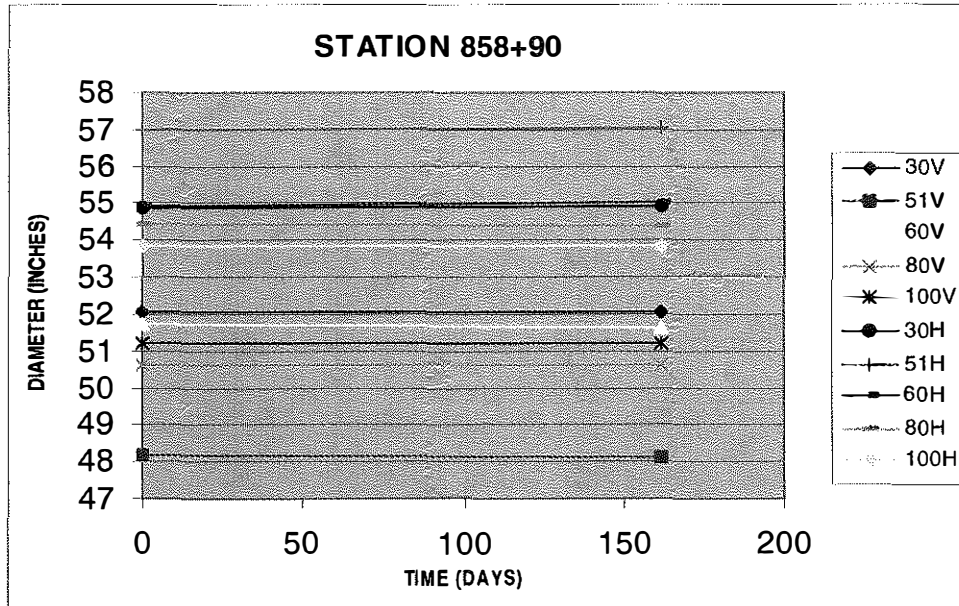


Figure 9

### CONSTRUCTION AND PERFORMANCE SUMMARY

Available construction and performance information from the eight cross drains described previously in the report has been gathered and is contained in Table 1 (gage thickness, contractor information, and backfill information was supplied by the Resident Engineers). To date, field testing has not been conducted to verify gage thicknesses and/or pipe backfill. Conversations with the Resident Engineers and inspectors indicated that the gage thickness of the pipes in the stock pile had been randomly tested and that the pipes were within tolerance.

As shown in Table 1, three out of the eight pipes listed had significant damage. All three of these structures had been backfilled with soil. The soils from the geotechnical report indicate that most of the native soil was classified as CH or CL soil. The report also indicated that more than 50 percent of the soil tested was CH soil with plastic indexes in the 30's and 40's.

Table 1 also indicates that three of the five pipes that were monitored were backfilled with crushed aggregate. Personnel for the construction company indicated that the firm uses crushed aggregate as a standard backfill material. The company indicated that the pipes were backfilled with No. 57 stone. It is of concern that the pipes have deflected more than five percent under relatively shallow fills and backfilled with crushed stone.



## **CONCLUSIONS**

The two culverts that failed on this project were likely the result of construction induced loading. The use of a crushed granular material such as a No. 9 or No. 57 stone will increase the strength of the pipe-backfill systems but may not eliminate all problems.

## **RECOMMENDATIONS**

- It is recommended that the culverts on this project be closely inspected prior to completion of the project.
- It is recommended that processed crushed aggregate be used for standard backfill material and that flowable fill also be considered .
- It is recommended that the QC/QA specification currently under development and review (as part of Research Study KYSPR-99-202) be adopted for storm drains and cross drains and that the specification include video inspection and deflection testing.

Table 1. Construction and Performance Summary

Station	Pipe Type	Pipe Gage (inches)	Pipe Diameter (inches)	Contractor	Backfill	Final Fill Height (feet)	Fill Remaining	Status	Max. Vert. Deflection (%)	Max. Hor. Deflection (%)	Comments
531+50	Aluminized Pipe Arch	14	57x38	Haydon	Native Soil	5.2	1-2	NB side not completed	100	-----	Portion of the pipe arch collapsed due to pan running over the pipe with 1-foot of cover. Pipe has been repaired
571+50	Aluminized	14	54	Haydon	Native Soil	9.3	1-2	NB side not completed	5 (3.4)	3 (decrease)	Pipe appears to be stable. Deflections indicate the pipe is slightly squared.
602+50	Aluminized	16	30	Haydon	Native Soil	6.2	2	NB side not completed	100	-----	Pipe completely failed 30 feet from outlet end and 5 feet from inlet end.
619+00	Aluminized	16	30	Haydon	Native Soil	10.2	1.5	NB side not completed	15-20	-----	Top of pipe is severely buckled on east end of the pipe. Possible rock against pipe. Majority of the pipe appears to be in good condition.
701+50	Aluminized	12	60	Earth & Energy	Crushed Rock	15	0	Road Completed	9.5 (7.8)	5.5	One section of pipe in the center of the culvert has continued to deflect for the last 380 days. Currently monitoring movement. Remainder of pipe appears to be stable.
782+00	Aluminized	14	54	Earth & Energy	Crushed Rock	10.5	0	Road Completed	9.3 (7.5)	6.6	Pipe has shown some slight movement in the last 280 days.
846+77	Galvanized	12	48	Earth & Energy	Crushed Rock	21.73	4-5	SB side not completed	9.1 (7.0)	5.5	Pipe appears to have been stable for the last 160 days.
858+90	Galvanized	12	54	Earth & Energy	Crushed Rock	13.84	2-3	SB side not completed	10.9 (9.0)	5.4	Pipe appears to have been stable for the last 160 days.

( ) vertical deflection measurements taking into account approximately 1-inch of bituminous coating (paved invert)

