PROGRESS REPORT

INSTRUMENTATION OF CULVERT PIPE UNDER DEEP FILL

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SUMMARY

This report summarizes the results of studies conducted to date on the instrumentation of two pipe culverts under deep fill on Interstate 77 near Fancy Gap, Carroll County, Virginia.

At this writing, both culvert pipes and essentially all of the instrumentation have been installed. Readings of strain and gross deformation are being obtained periodically on both pipes. The settlement of fill, both above and adjacent to the concrete pipe, is being monitored.

Computer programs have either been written or obtained which will enable the researchers to analyze much of the data being collected.

This analysis of data is currently under way and will be reported later.

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INTRODUCTION

Prior to the letting of a contract, during the summer of 1974, for the construction of a section of Interstate 77 near Fancy Gap in Carroll County, Virginia, studies and planning were commenced looking toward the instrumentation of two pipe culverts to be placed under a deep fill on this project. These two culverts were to be employed to pass the flow of a mountain stream under the fill. One is a 60-inch (1.52 m) diameter corrugated structural plate pipe that serves as a temporary culvert through which the stream has been diverted. It will eventually be buried under approximately 230 feet (70.10 m) of fill. The other pipe is a 96-inch (2.44 m) diameter precast, reinforced concrete pipe that will eventually be buried under approximately 150 feet (45.72 m) of fill and provide a permanent outlet for the stream.

Representatives of the Virginia Department of Highways & Transportation and the Federal Highway Administration held the opinion that this installation offered a unique opportunity to observe and monitor the performance of pipes under such high fills, since few pipes with overburden fill in excess of 230-250 feet (70.0-76.2 m) have been installed in the United States. Moreover, since the 60-inch (1.52 m) diameter metal pipe need function only until the 96-inch (2.44 m) diameter concrete pipe is operational and might subsequently deform plastically, an unusual opportunity was provided to observe the performance of this type of pipe.

In late 1971 an advisory committee was formed with representatives from the Virginia Department of Highways & Transportation, Virginia Highway & Transportation Research Council, University of Virginia, and the Federal Highway Administration to plan the general scope of the work. Personnel from the University of Virginia and the Virginia Highway & Transportation Research Council were selected to conduct the research work.

SCOPE OF THE WORK

Due to time and budget considerations the scope of this investigation was of necessity limited, nevertheless the following program of investigation was undertaken.

In the case of the 60-inch (1.52 m) corrugated structural plate pipe it was decided that three "circular" rings of SR-4 electric resistance strain gages should be installed on one 12-foot (3.66 m) section of the pipe. Eight gage positions were located on each ring at approximately 45 degree intervals. Four 45 degree strain gage rosettes were located at each of these gage positions. Two of these four rosettes were placed on the inside of the pipe while the other two were located on the outer skin. One rosette in each of these pairs was placed in the valley and the other on the top of the ridge of the corrugations. Internal and external rosettes were so positioned that each on the outside had a mate directly opposite on the inside of the pipe. Dummy, or compensating, rosette gages were placed at eight positions on the inside and outside of the test section. These compensating gages were placed on small samples of the pipe metal which were then encased in a protective device which was attached to the pipe. All active and dummy leads were carried out of the pipe to a switching and readout console via a 400 conductor shielded and waterproof, underground telephone cable. Strain readings were obtained with a Vishay VE 20 Strain Indicator.

In addition to the strain readings on the metal culvert, gross deformation readings were obtained on two circular rings located on the test section. Twelve positions approximately 30 degrees apart were located on the inside of the pipe along each of the two circular rings. Chord measurements were obtained with an extensometer that locked into small insert holes drilled into the sides of acorn head nuts placed at each of the 30 degree positions.

Strain and gross deformation readings are being obtained for approximately each 10 feet (3.05 m) of fill placed above the metal pipe. At the time of this writing, approximately 150 feet (45.72 m) of fill has been placed over this pipe.

Due to budget considerations, soil pressure gages and settlement plates were not installed over or adjacent to the metal pipe.

In the case of the 96-inch (2.44 m) diameter concrete pipe, gross deformations are being obtained on two circular rings on two sections of pipe. Twelve positions, 30 degrees apart, were located on each ring. As in the case of the metal pipe, chord measurements are being taken with an extensometer between acorn head nuts set into the pipe. These readings are being taken for approximately each 10-foot (3.05 m) increment of fill over the pipe.

In the case of the concrete culvert, baled straw was placed above the top of the pipe. At the test section approximately 19 feet (5.79 m) of straw was used. In order to help monitor the effectiveness of this straw, it was decided to locate settlement plates over and beside the test section and throughout the full depth of the fill.

Settlement plates were spaced approximately 10 feet (3.05 m) apart vertically in four columns. These vertical arrays of stacked donut shaped plates were placed around a vertical column of plastic tubing and were located as follows: (a) one column over the center of the pipe (b) one 1 1/2 diameters (12 feet, 3.66 m) from the centerline (c) one 3 diameters from the centerline and (d) one 4 1/2 diameters (36 feet, 10.97 m) from the centerline. Idel Sonde equipment employing a small radio transmitter was lowered into vertical columns of plastic tubing to locate the position of each plate at various time intervals.

In an attempt to obtain at least a few strain readings, 12 single element SR-4 electric resistance strain gages were placed on the inside surface of the concrete pipe. These were placed to measure circumferential strains.

At this time approximately 50 feet (15.24 m) of fill has been placed over the concrete pipe.

INSTRUMENTATION

The placing, wiring and waterproofing of the SR-4 strain gages and the placing of the acorn head nuts (for gross deformation measurement) on the metal pipe were done in the laboratories of the Department of Civil Engineering at the University of Virginia.

Following the installation of this instrumentation, the test section of metal pipe was transported to the construction site and placed in the embankment.

The acorn head nuts for gross deformation measurements were mounted in the test section of the 96-inch (2.44 m) diameter concrete pipe at the manufacturing plant and this section was subsequently transported to the site and placed in the fill. The SR-4 strain gages were mounted on the test section of the concrete pipe at the construction site. The Idel Sonde settlement plates and associated plastic pipe columns are being installed as construction of the fill over the concrete pipe proceeds.

DATA COLLECTION AND ANALYSIS

Gross deformation readings have been taken on both pipes for approximately each 10-foot (3.05 m) interval of fill. A computer program has been written to analyze and plot these data. Shown in Figures 1 and 2 are plots of shape and deformation for the metal pipe under two depths of fill.

An analysis of SR-4 strain gage data is under way. A computer program is available for analyzing these data and subsequent reports and papers will report on this work which is in progress.

Measurements of fill settlement and the installation of additional settlement plates over and adjacent to the 96-inch (2.44 m) diameter concrete pipe are continuing. The last settlement plates will probably be installed in June 1975, when the fill is expected to be completed. Settlement readings will continue for several months thereafter.

FUTURE WORK

If the SR-4 gages continue to function, strain readings on the metal pipe will be continued until the fill is completed and for several months thereafter. Gross deformation readings on this pipe will be continued as long as it is deemed safe to enter the pipe for this purpose.

As noted earlier, settlement readings, strain measurements and gross deformation readings will be continued for several months.

Analysis and study of these collected data will be continued during the period of the research. Reports and papers will be prepared and presented as these studies progress.

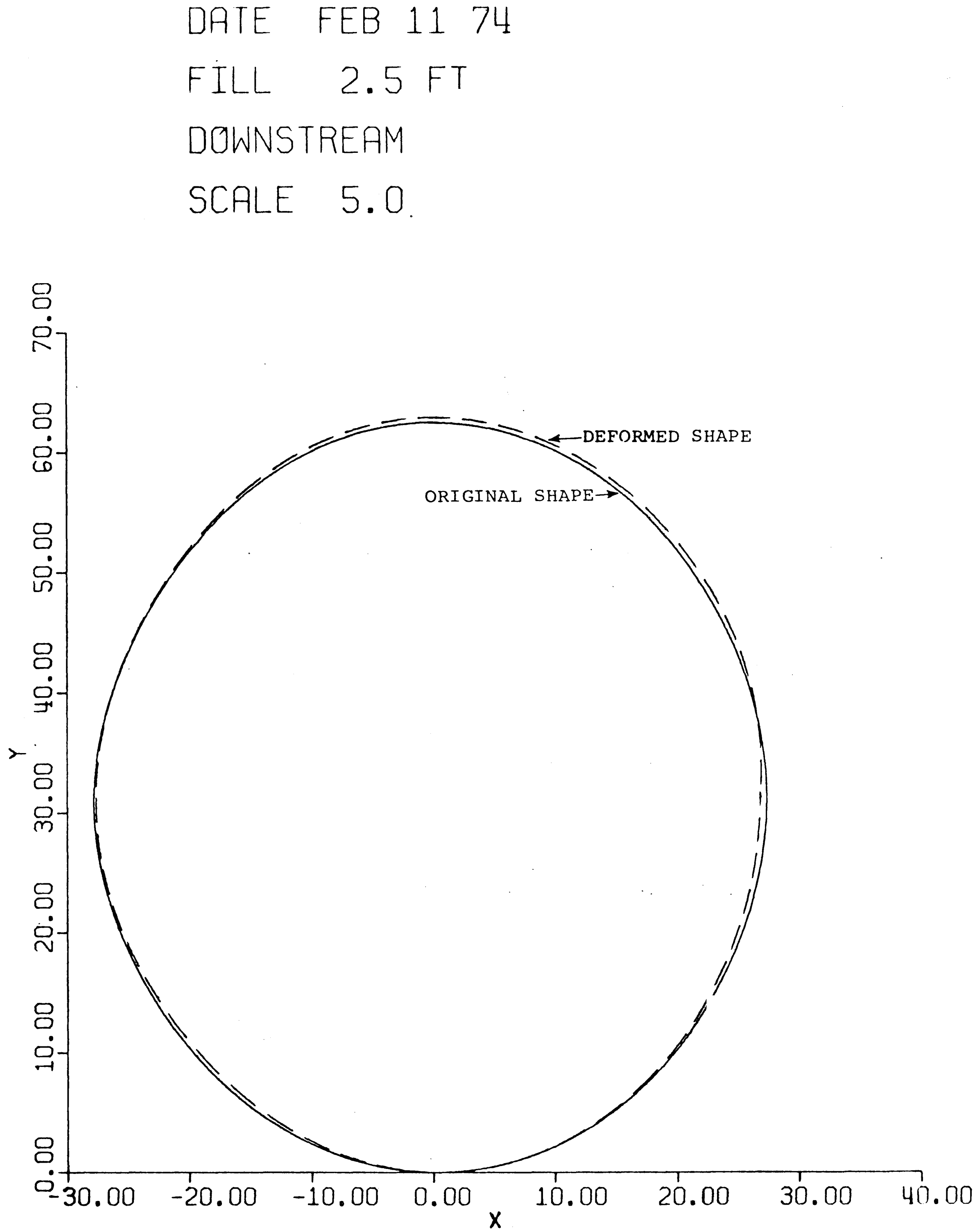

Figure 1. Change in Shape of 60-inch (1.52 m) metal culvert.

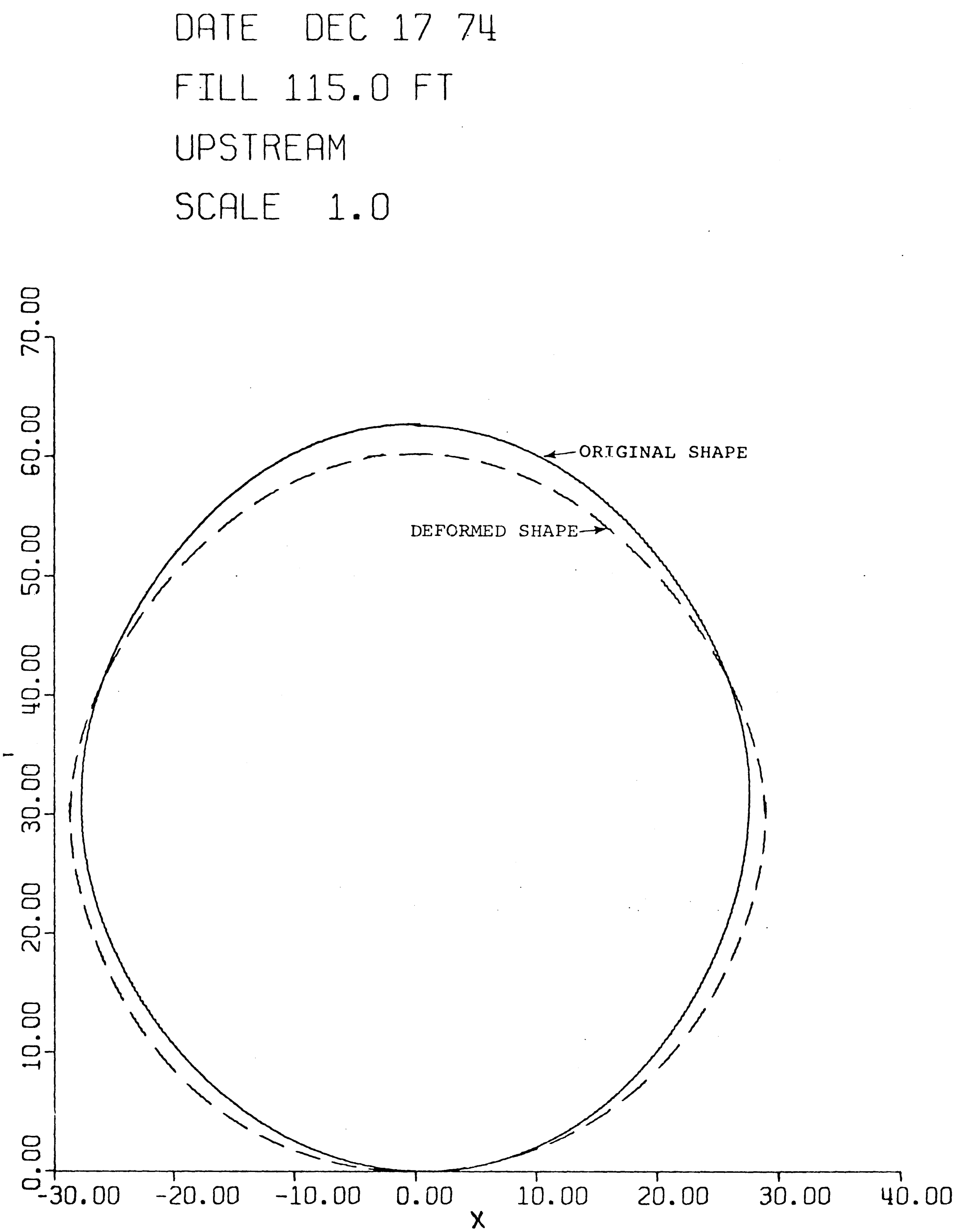

Figure 2. Change in shape of 60-inch (1.52 m) metal culvert.

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