

## REHABILITATION METHODS



**Figure 1** - A 96-inch dia. CSP being sliplined into a 108-inch dia. failed concrete pipe near Pittsburgh, PA.

Issued 1991

**NATIONAL CORRUGATED STEEL PIPE ASSOCIATION**  
1255 Twenty-Third Street, NW, #850 • Washington, DC 20037-1174  
(202) 452-1700 • Fax (202) 833-3636

Design Data Sheets are illustration only. Do not use for detailed designed purposes.

Rehabilitation of America's infrastructure is a major undertaking now being addressed by our federal, state and local governments. While the magnitude of rehabilitation may at times appear enormous, rehabilitation often is very cost effective when compared to the alternative of new construction.

The reason for CSP's popularity as a slipline material is because of the ease of fabrication of the product to prepare it for this rehab technique. Skid devices, adjusting bolts, grout plugs and connecting bands are very easily and inexpensively provided. Please See Figure 2.

### Sliplining

CSP (Corrugated Steel Pipe) is probably the most frequently used material for sliplining culverts. It is also used in storm sewer rehabilitation where the inherent product feature of long lengths is desired.

Skid devices may consist of "guide rails" placed in the invert of the existing pipe or skid bars placed on the slipline pipe to facilitate moving it in to the desired position. Adjusting bolts are used to secure the slipline pipe in proper position with regard to alignment and

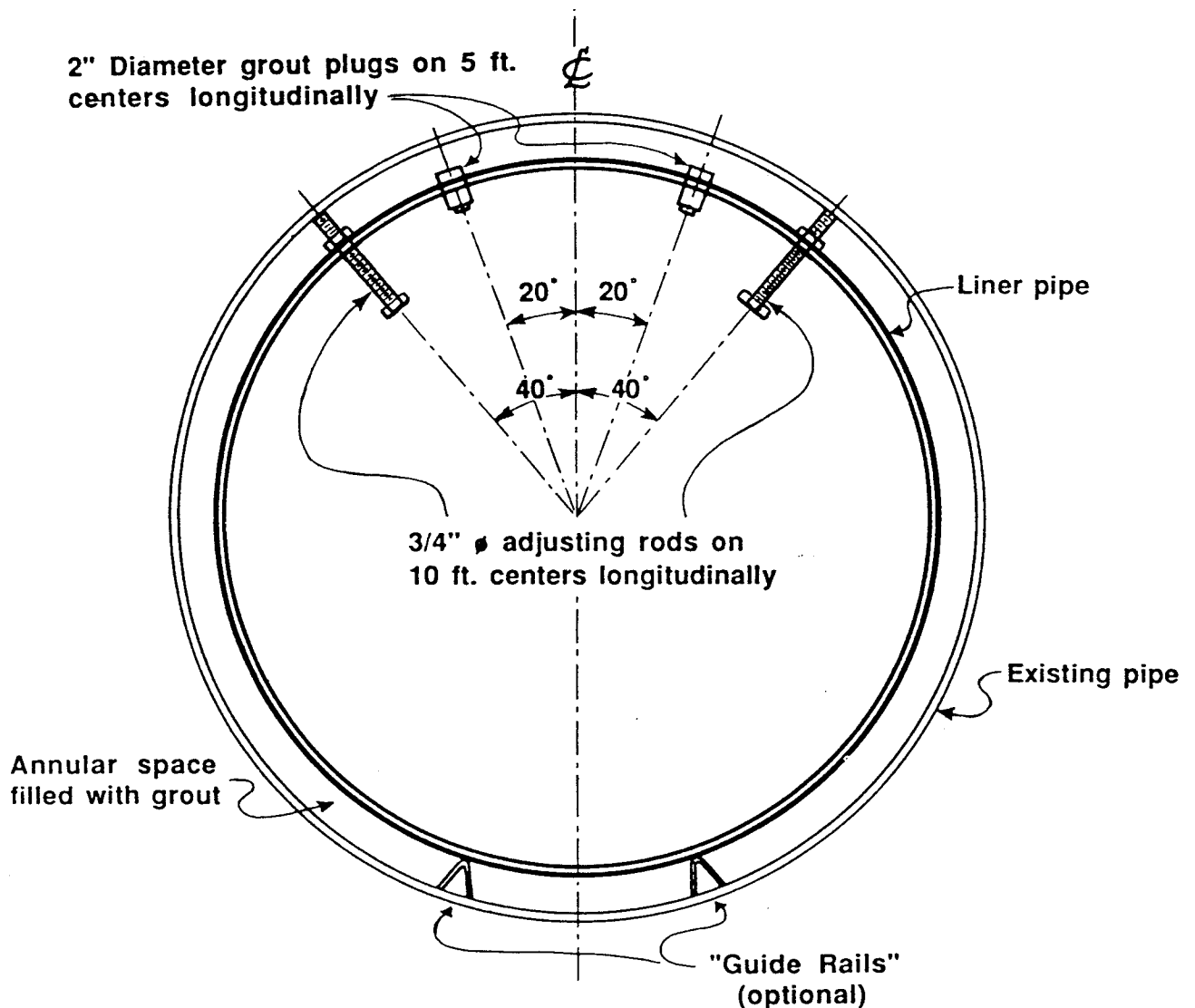


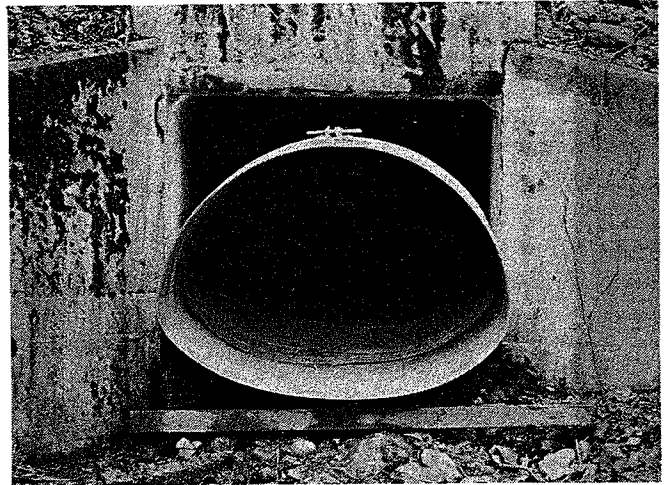
Figure 2

grade after it has reached the desired location longitudinally.

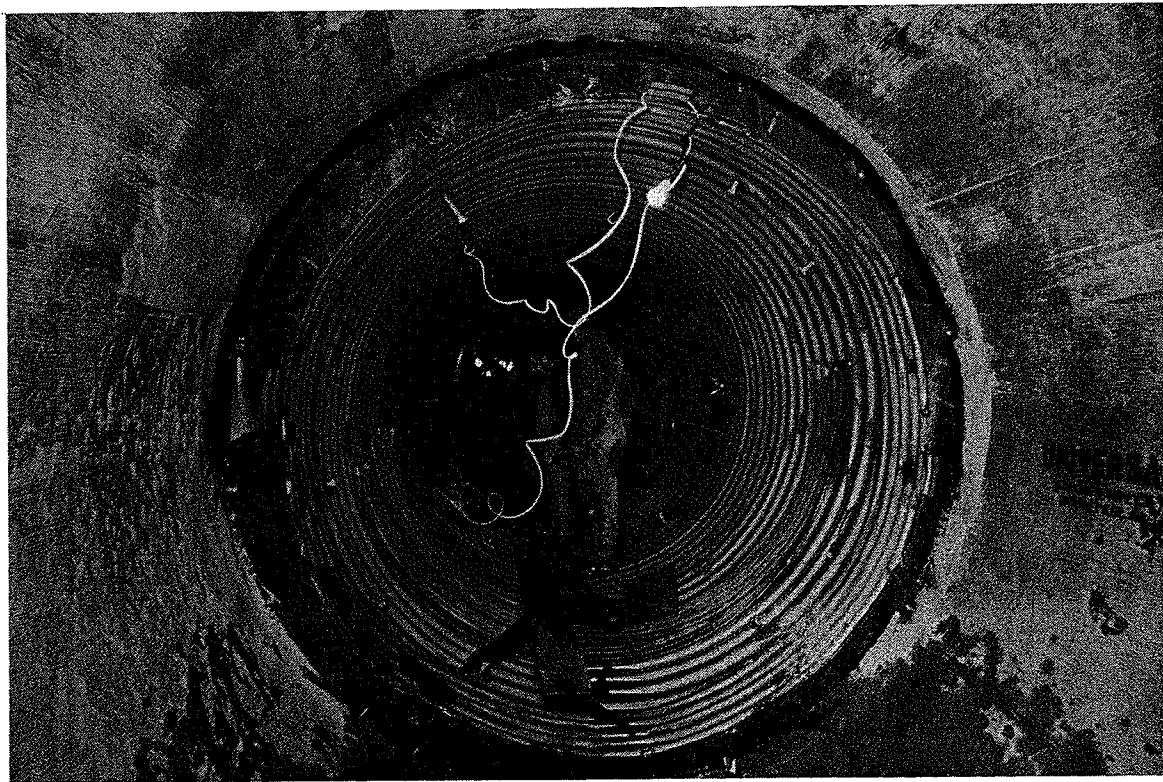
Grout plugs (their number and location are usually specified by the Engineer) are welded in the pipe wall to facilitate filling the void between the existing pipe and the slipline pipe. Various types of connecting bands are available and are usually designed to accommodate the existing site conditions. A popular design is the use of a conventional angle bolt type connecting band minus the angles and secured to the pipe by use of sheet metal screws.

To maintain maximum hydraulic capacity of the existing line the use of smooth lined CSP is recommended. Choices of this type of pipe include:

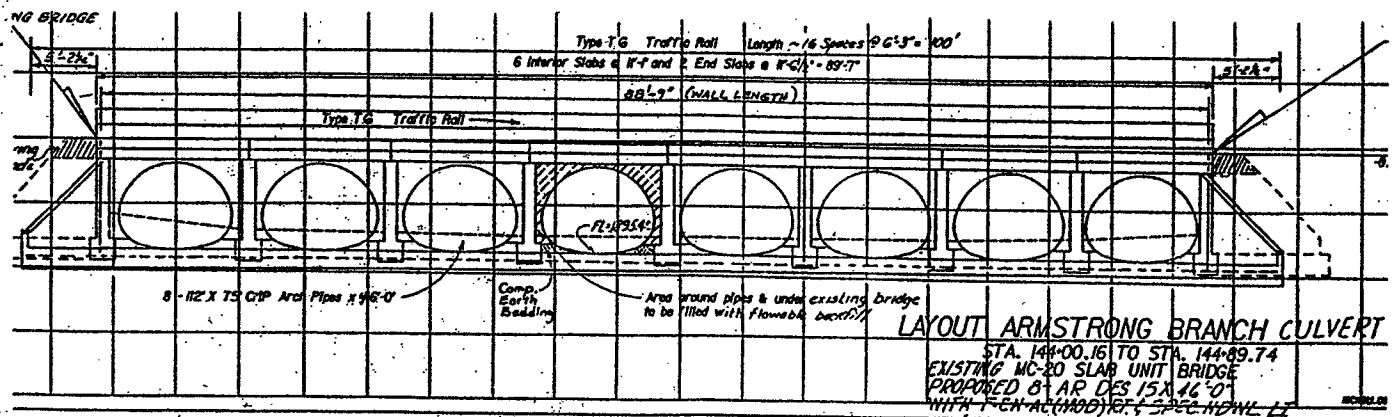
1. 100% Asphalt Lined
2. 100% Cement Mortar Lined
3. Double Wall CSP
4. Spiral Rib CSP



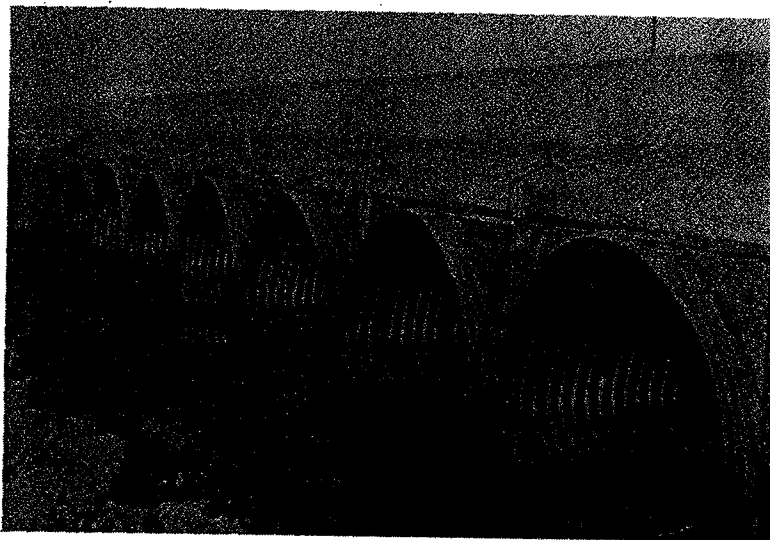
**Figure 3** - At Post Marker 51.1 on I-5 North of Redding, CA. On this project 213 linear feet of 57" x 38" 0.109 Corrugated Steel Pipe Arch was sliplined through a 60" x 48" Reinforced Concrete Box Culvert on CALTRANS Project 02041784.



**Figure 4** - This is the 96 inch Diameter CSP shown in Figure 1 in its final position. The CSP invert was held approximately 4 inches above the concrete pipe invert by the adjusting bolts to permit the grout placed in the void to completely encircle the CSP.

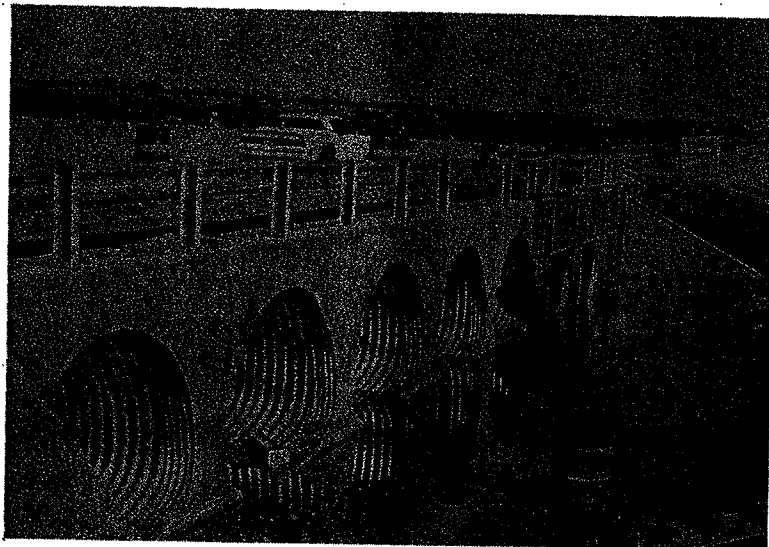


**Figure 5** - This elevation view shows a battery of 8 Concrete Box Culverts which were sliplined with 112 inch by 75 inch Corrugated Steel Pipe-Arch. The project involved increasing clear roadway from 36 feet to 44 feet and upgrading load rating from H-11 to H-20.



**Figure 6** - A view of the 8 lines of Corrugated Steel Pipe-Arch in place ready to receive the placement of headwall. A "Flowable Backfill," designed by the Texas State Department of Highways and Public Transportation was used to fill the void between the corrugated steel pipe-Archs and the box culverts.

**Figure 7** - An end view of the 8 lines of Corrugated Steel Pipe-Arch in place with the headwall completed. This project is located on Taylor County Highway FM 18 east of Abilene, TX. This procedure eliminated construction of a detour and removal of the old structure. Savings over other alternative construction were estimated to be \$150,000 to \$200,000.



Cement Mortar Lining

Cement mortar lining operations are performed in an uninterrupted continuous manner using a centrifugal machine capable of projecting the mortar against the wall of the pipe without rebound -- but with sufficient velocity to cause the mortar to be densely packed in place. Please see Figure 8 for a typical equipment setup for this procedure. This technique may be used in diameter from 4 inches to 22 feet.

Shotcrete/Gunite Lining

Shotcrete/Gunite is a term used to designate pneumatically applied cement plaster or concrete. A gun operated by compressed air is used to apply the cement mixture. The water is added to the dry materials as it passes through the nozzle of the gun. The quantity of water is controlled within certain limits by a valve at the nozzle. Low water ratios are required under ordinary conditions. The cement and aggregate are machine or hand mixed and are then passed through a sieve to remove lumps too large for the gun.

When properly made and applied, shotcrete is extremely strong, dense concrete, and resistant to weathering and chemical attack. Compared with handplaced mortar, shotcrete of equivalent aggregate-cement proportions usually is strong because it permits placement with low water-to-cement ratios.

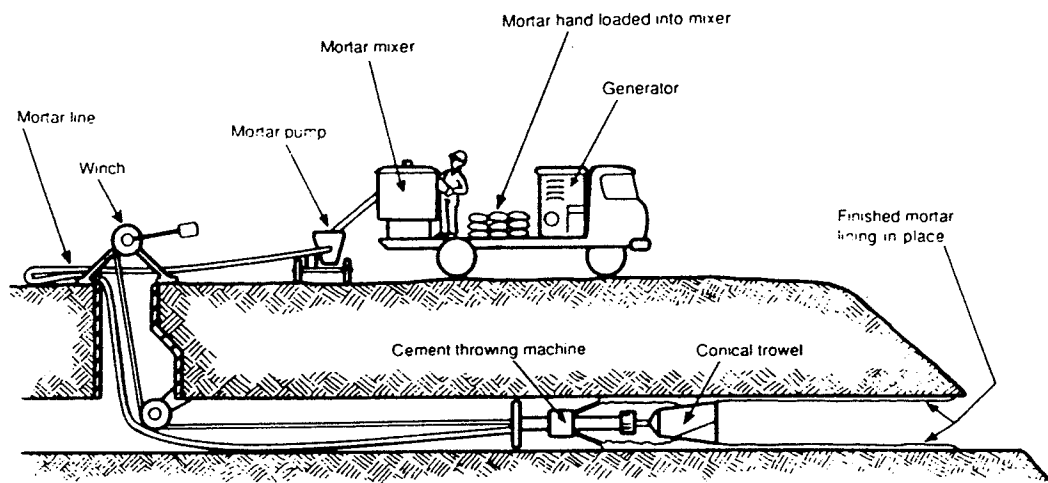
For relining existing structures, the shotcrete should be from 2 to 4 inches thick depending on conditions and may be steel reinforced. The cross-sectional area of the reinforcement should be at least 0.4% of the area of the lining in each direction.

Inversion Lining

Inversion lining is a patented system available through licensed contractors for installing liners from the ground surface using the ends of the culvert or existing manholes for access. This system uses a flexible lining material that is thermally hardened.

The liner is installed through a large tube that is placed at the end of the culvert or into a manhole. At the bottom of the tube is an elbow that guides the liner into the pipe to be lined. The liner is inserted into the tube and attached to the end of the elbow. Then, water or air is pumped into the tube. As the pressure builds, the flexible fabric is pushed through the pipe and is inverted into place. The unique method by which this material is installed allows great flexibility in changes in liner bends.

With the liner in place, the water or air is heated to appropriate temperatures to cause the thermosetting resins in the material to cure and harden. Following curing and cool-down, the water is drained away and the ends of the lining are cut and sealed.



CEMENT MORTAR LINING

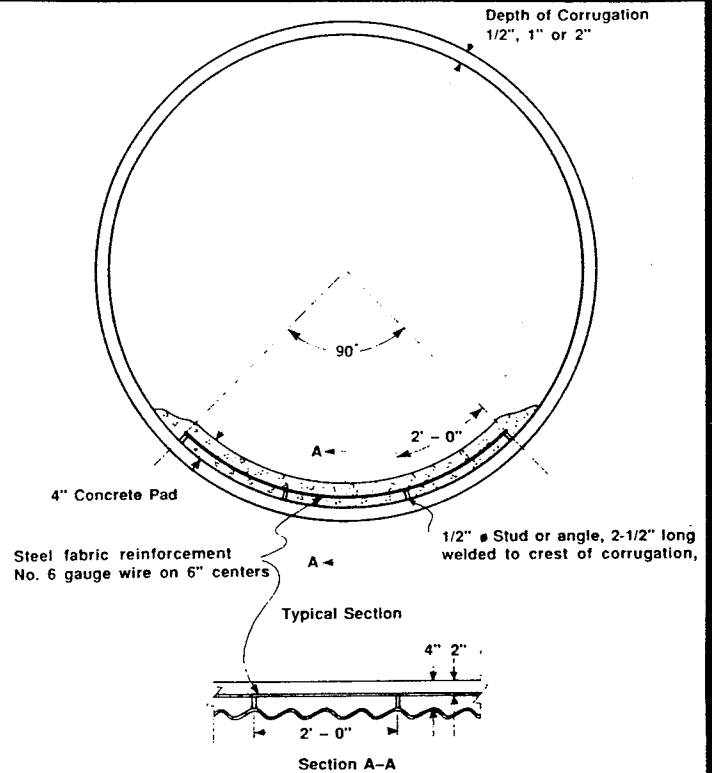
Figure 8

In Place Installation of a Concrete Invert

For diameters where it is possible for personnel to enter the pipe, we recommend a four-inch thick reinforced concrete pad be placed in the invert.

Figure 9 shows a recommended reinforcing and pad thickness. The final design would be in the control of the engineer and would obviously depend upon the extent of the deterioration of the pipe.

Figures 10, 13, and 14 are typical examples of concrete pad placement.



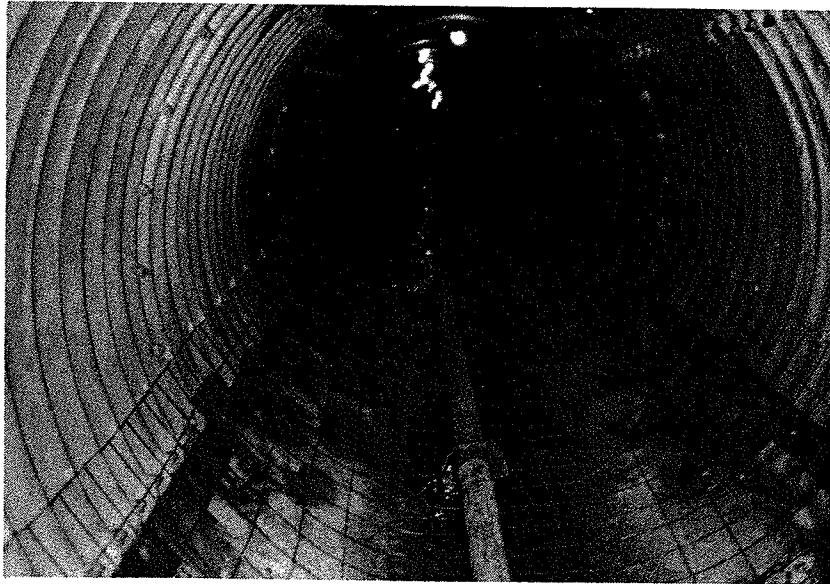
**Figure 9**



**Figure 10** - Sealing the concrete pad surface inside a 58 inch x 36 inch Corrugated Steel Pipe-Arch in Jacksonville, OR.

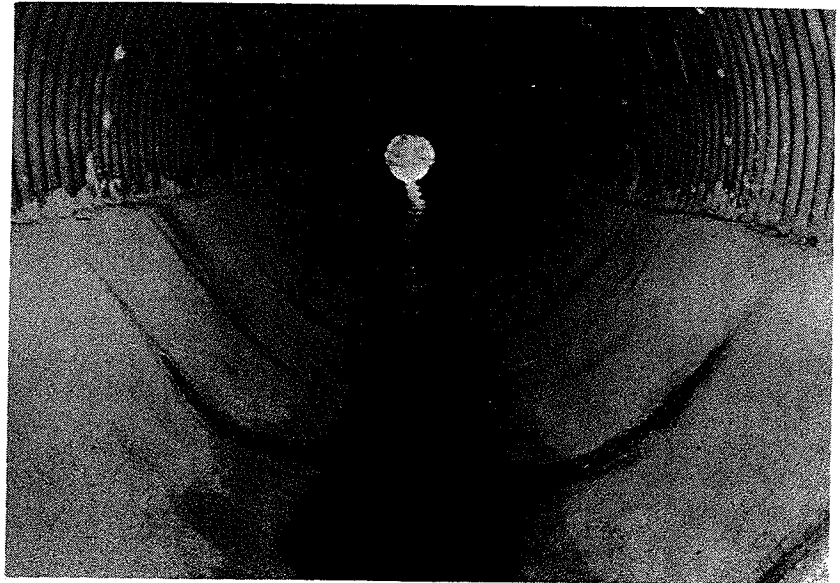
**Figure 11** - An Ohio DOT rehab project. Concrete truck and pump in place on the downstream end of an 84 inch diameter Structural Plate Pipe under I-90.





**Figure 12** - Inside the same 84 inch pipe shown in Figure 11 with the reinforcing mesh and the pipeline for pumping concrete in place.

**Figure 13** - The same 84 inch pipe shown in Figures 11 and 12 with the concrete pad in place.

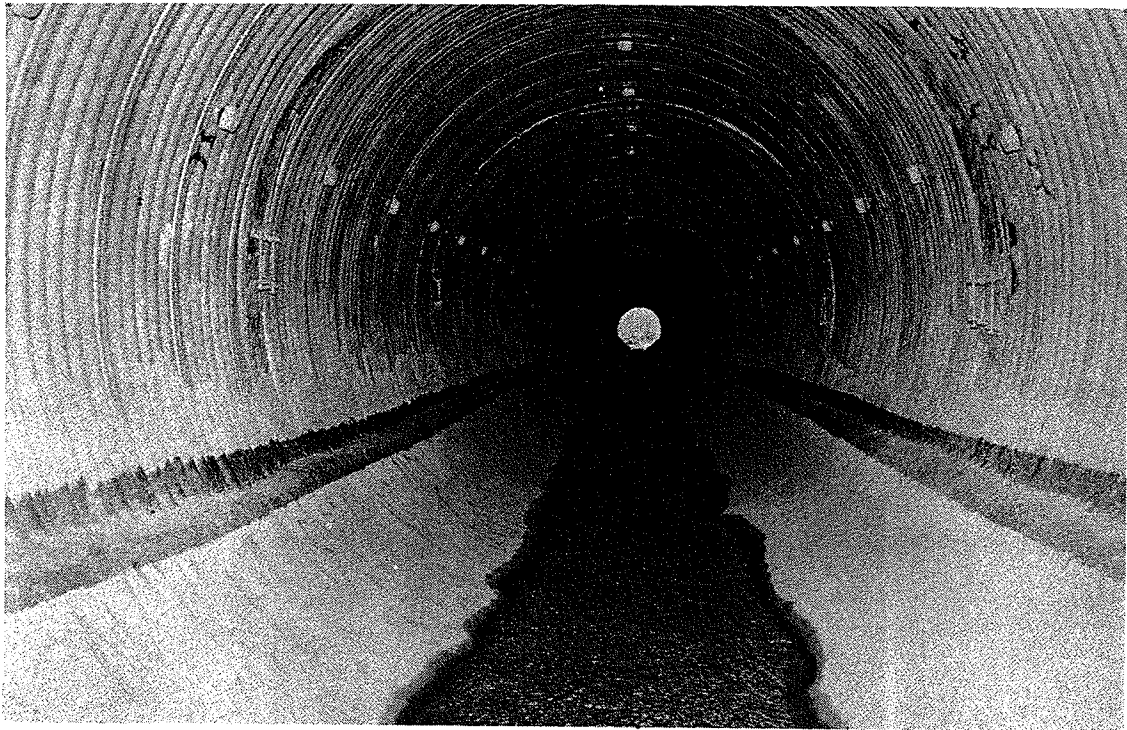


### Summary

All of these methods described previously require a complete inspection and evaluation of the existing pipe to determine the best choice. With CSP, rehabilitation often requires merely providing a new wear surface in the invert. Typically, structural repair is unnecessary. However, if the pipe is structurally deficient, this does not rule out rehabilitation. Repair methods can be utilized and

the structures restored to structural adequacy and then normal rehabilitation procedures performed. Even with 25% metal loss, which occurs long after first perforation, structural factors of safety are reduced only 25%. When originally built, CSP storm sewers often provide factors of safety of 4 to 8 -- far in excess of that required for prudent design.





**Figure 14** - This 90 inch diameter corrugated steel pipe located in Reston, VA received a 4 inch concrete pad in the invert. Note the sealant used on the upper edges of the pad.

#### Bibliography

1. "Rehabilitation of Corrugated Steel Pipe and Pipe Lines of Other Materials", NCSPA Drainage Technology Bulletin, September 1988.
2. "Sewer Manual for Corrugated Steel Pipe" NCSPA-SM89 1989.
3. "Modern Sewer Design," American Iron & Steel Institute, 2nd Edition, 1990.

This Data Sheet is for general use only and should not be used without first securing competent engineering advice as to its suitability for any specific application. The publication of this material is not intended as a representation or warranty on the part of the National Corrugated Steel Pipe Association that such data and information are suitable for any general or particular use or of freedom from infringement of any patent(s). Neither the NCSPA nor any of its members warrants or assumes liability as to its suitability for any given application. Anyone using this data sheet assumes all liability arising from such use.

Design Data Sheets  
are illustration only. Do  
not use for detailed  
designed purposes.

**NATIONAL CORRUGATED STEEL PIPE ASSOCIATION**  
1255 Twenty-Third Street, NW, #850 • Washington, DC 20037-1174  
(202) 452-1700 • Fax (202) 833-3636

Issued 1991