Structural Integrity of Danby Process Proven by Tests at Utah State University

Danby Liner Increases Strength of Host Pipe by 3000 PSF

Buried Structures Laboratory
Department of Civil and Environmental Engineering
Utah State University

REPORT SUMMARY

Buried Structures Laboratory Utah State University

STRENGTH

* The Danby liner increased the strength of the host pipe by 3000 PSF before ring deflection started.

STIFFNESS

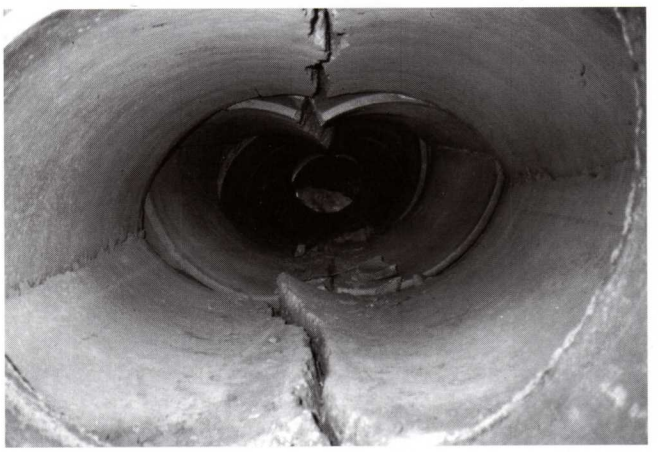
* After ring deflection started, the liner increased stiffness of the host pipe by forty percent.

DEFLECTION

* At nineteen percent deflection, the Danby lined pipe was still serviceable.

BELOW:

Photographs show both pipes when subjected to the maximum test load of 9,100 PSF. At this pressure ring deflection was approximately 19% and the Danby lined pipe could continue to serve as a buried conduit.



UNLINED PIPE

Unlined pipe is no longer serviceable.

DANBY LINED PIPE

At nineteen percent deflection, pipe was still serviceable.

Report of tests on the

STRENGTH OF BURIED BROKEN RIGID PIPES WITH DANBY LINERS

By Reynold K. Watkins *
December 1993

ABSTRACT

Danby liners are used to rehabilitate buried rigid pipes that are broken or deteriorated. Besides eliminating leaks and stopping hydrogen sulfide corrosion, the liners repair breaks in the host pipe and increase the strength of the pipe. Tests were performed to compare the strengths of two strings of broken, unreinforced, rigid pipes, one lined with a Danby liner and the other unlined. The broken pipes were held in conduit shape by loose backfill soil. Vertical pressure was applied. The liner increased the strength of its host pipe by 3000 psf before ring deflection started. After ring deflection started, the liner increased stiffness of the host pipe by forty percent. The liner prevented leaks in the host pipe up to nineteen percent ring deflection at which point (9,100 psf load) the test was discontinued.

The soil cell at Utah State University was used to test the strength of the Danby liner process.

INTRODUCTION

Three primary reasons for rehabilitating deteriorated rigid sewer pipes with Danby liners are: to eliminate leaks, to stop hydrogen sulfide corrosion, and to repair broken or corroded pipes. The liner increases the strength of the host pipe. The question is, how much? Unreinforced rigid pipes can be broken into four quadrants and still remain in conduit shape — held by the backfill soil. With this as a worst case scenario, two pipelines of broken sections, one unlined and the other Danby lined, were buried in loose silty sand in a soil cell. The structural strengths of the two pipelines were compared as vertical soil pressure was applied. Strength is resistance to ring deflection. Strength is increased by the strength of the liner and by grout between the liner and the host pipe. Grout fills both cracks in the pipe and voids in the backfill. The liner eliminates leaks and stops hydrogen sulfide corrosion — even after ring deflection exceeds acceptable limits.

Vertical pressure is applied to the buried pipes in increments by applying pressure from the hydraulic jacks mounted on beams above the soil cover.

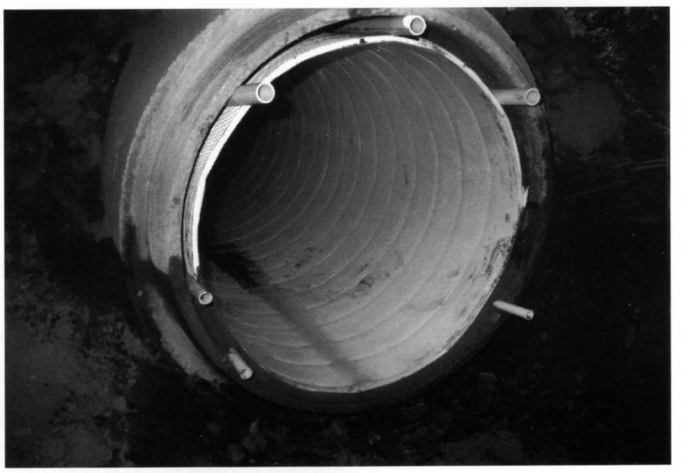
*Dr. Watkins, Professor Emeritus,
Utah State University, Logan, UT

TEST PROCEDURE

Ten 30 inch unreinforced concrete pipes were banded and broken into four quadrants with cracks at 3:00, 6:00, 9:00 and 12:00 o'clock. The sections were four ft. long with tongue and groove joints. They were placed in two parallel pipelines of five sections each in the large USU soil cell. Cracks were oriented. Dry silty sand was placed around them in lifts to just above the spring lines. The bands were cut so that the backfill soil was all that held the broken pipes in conduit shape. Backfill was then continued in layers to six inches above the tops of the pipes. Except for personnel walking on the soil to place and level it, the soil was not compacted. One of the pipelines was lined with a Danby liner and grouted in the annular space between the liner and the host pipe. The grout was allowed to cure for thirty days at which time it attained a strength of 8,600 psi. Backfill was then continued on up to three feet above the tops of the pipes, and the load beams were pinned into place.

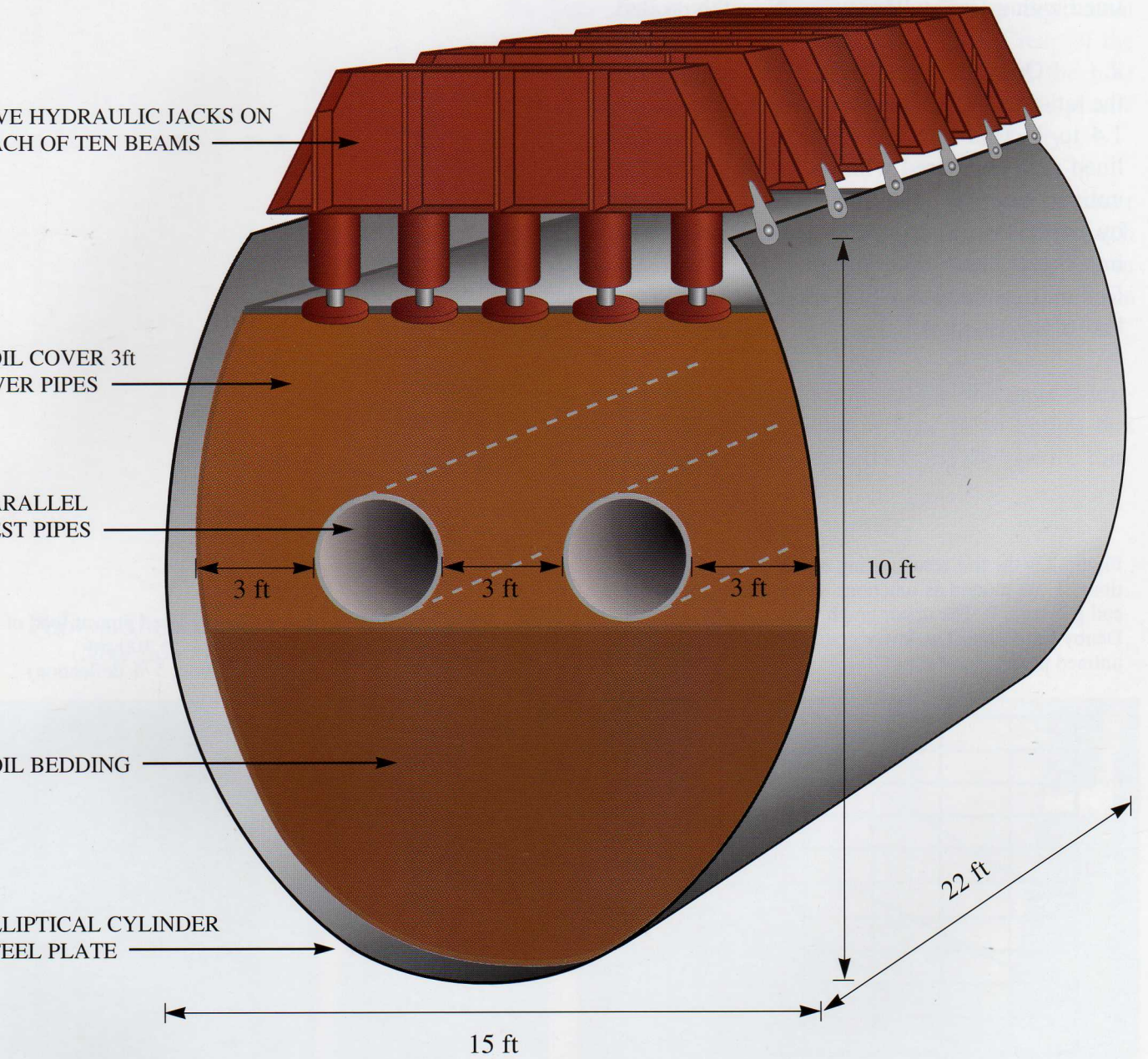
Vertical soil pressure was applied in increments. After each increment of soil pressure, the diameters of the pipes were measured, circumferential strains at mid-length of the liner were recorded, and the condition of each of the pipes was observed.

The 30 inch test pipes were temporarily banded and broken into 4 quadrants. Then all pipe sections were placed in the soil cell with only the backfill supporting them.



Filling and venting tubes are placed in the annular space around the pipe liner and a cement based bulkhead is formed around the circumference of the pipe between the liner and the host pipe.

Figure 1 Diagrammatic sketch of the large USU soil cell showing the locations of two parallel strings of test pipes with five broken sections in each.



RESULTS

1. The pressure, P, at zero ring deflection of the unlined pipe indicates a bit of precompression of the soil due to walking on it while placing and leveling the backfill layers by hand. The greater initial pressure, P', at zero ring deflection of the lined pipe includes the additional strength of about 3,100 psf provided by the liner. From similitude, the strength for any diameter of rigid pipe is increased by about three thousand pounds per square foot if the pipe is lined with a Danby liner proportionately scaled.

2. Once the pipes begin to deflect under soil pressure, the ratio of slopes of the pressure deflection graphs is about 1.4 to 1. This represents the greater ring stiffness of the lined pipe compared with the unlined pipe. Of course, the unlined pipe has no stiffness except that which is provided by backfill soil support. If backfill soil particles migrate into the unlined pipe through cracks, soil support is lost. External groundwater that seeps into the pipe hastens the loss of soil support.

Figure 2 is the test results. Ring deflections, d, are plotted as functions of vertical soil pressure, P. The upper graph is the Danby lined pipe. The lower graph is the unlined pipe.

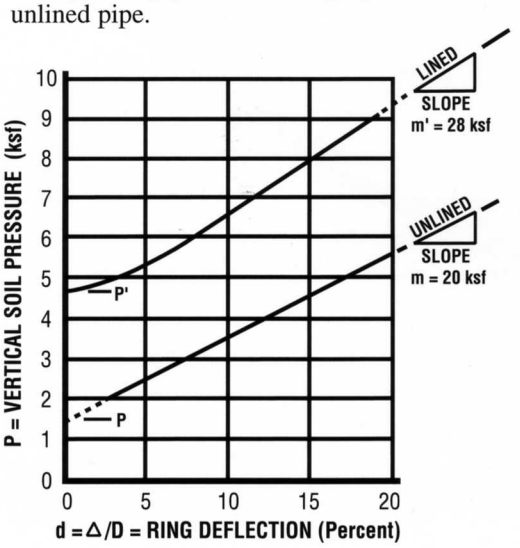


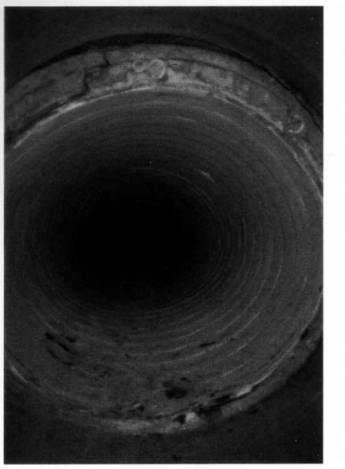
Figure 2 Load-deflection Data for Lined and Unlined Pipes

Effects of Liner

Increase in Strength at d = 0,
P' - P = 3,100 psf

Increase in Stiffness
Ratio of Slopes = m'/m = 1.4

Danby lined pipe at load of
5,100 psf
(about 5 % deflection)



3. The lined pipe is leak-tight at the 19 percent ring deflection at which point the test was terminated. The lined pipe itself could continue to serve as a buried conduit with this excessive ring deflection. Because the liner is leak-tight, hydrogen sulfide corrosion is stopped. Service life of the pipe is no longer a function of corrosion. Because the lined pipe is leak-tight, a water table might rise above the pipe and cause external hydrostatic pressure on the liner. The liner strength of 3,000 psf translates into an equivalent resistance to a head of 48 feet of water table. Creep of the plastic liner has negligible effect on strength of the host pipe. In the event that a sudden load is applied, the plastic retains its pristine strength and modulus of elasticity.

4. The unlined pipe is not leak-tight. Any groundwater flow can wash particles of backfill soil into the pipe such that soil support is lost and the pipe quadrants may fall in on themselves. This condition is incipient even if the pipe is not subjected to increase in external soil pressure.

For the many rigid sewer pipes in service that have deteriorated by cracking or corrosion, a liner is an option that may increase the serviceability and extend the service life.

Photos Showing Grouting of Annulus
(Note flow of grout through cracks)

Grout filler pipes are installed around the circumference of the host pipe. As the grout fills the annular space it flows into the surrounding soil (as evidenced by the grout flowing out of the cracks in the above photographs). The ability to place the grout outside of the pipe adds to the strength of the process.

Danby of North America, Inc.
Post Office Box 5127
Cary, NC 27512-5127
phone: (919) 467-7799 • fax (919) 467-7754
email: danby@mindspring.com • website: www.danbyrehab.com