Rehabilitation of Fully Deteriorated Rigid Pipes

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Rehabilitation of Rigid Pipes

Background

ANSI/AWWA C950-88

McAlpine Papers-1993 (No-Dig & ASCE/PLD)

Schrock & Gumbel Paper-1997

ASCE/PLD PINS Task Group -Jay Schrock

Pipe Rehabilitation Council (PRc) Symposia

Test Data-WRc and Utah State University

"Fully Deteriorated" Rehab Design

Design Equation (from AWWA C950/M45)-The Luscher Equation

$$q_t = (C/N)\ \{32 R_w B' E_s' (E_L I/D^3)\}^{1/2} \quad \text{(ASTM F 1216)}$$

The equation, as originally developed by Luscher in 1966 was Subject to the following limiting assumptions:

1. Circular-symmetric geometry (C=1)
2. Uniform radial pressure q_t
3. Deflection resisted by soil modeled as identical discreet springs Uniformly distributed around the pipe
4. $R_w = 1$
5. Experimental data only for very high SDR (200-500) low stiffness tubes (PS < 1).

Rehabilitation of Rigid Pipes

"If soil migration into the pipe has been limited and soil voids adjacent to the pipe are localized,…, Insituform design techniques are applicable."

"…adequate soil side support is essential to stand-alone, flexible pipe design."

"Typical values of Es' are 700 to 1500 psi"

Insituform Design Guide

Section on "Fully Deteriorated" Design

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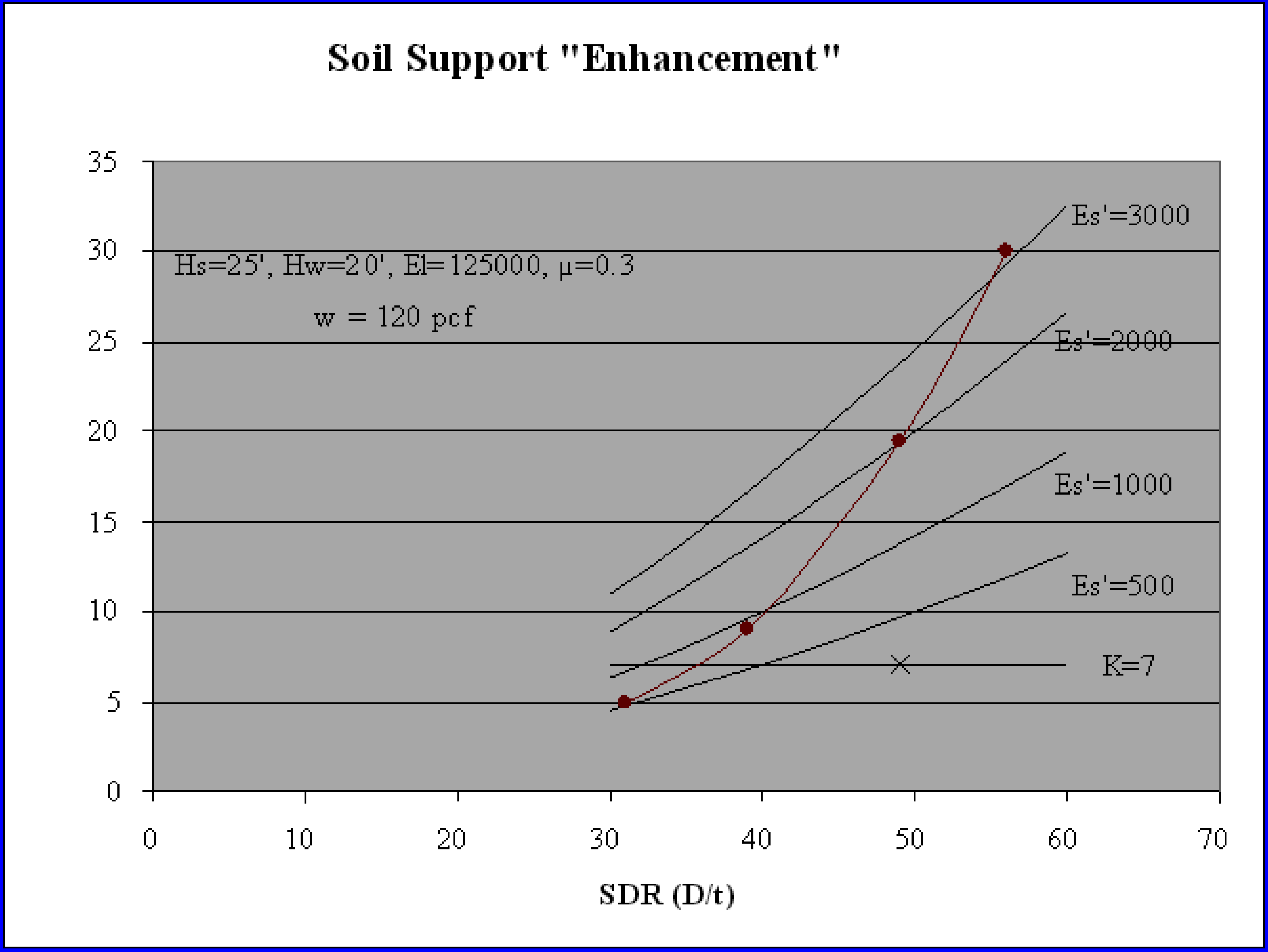

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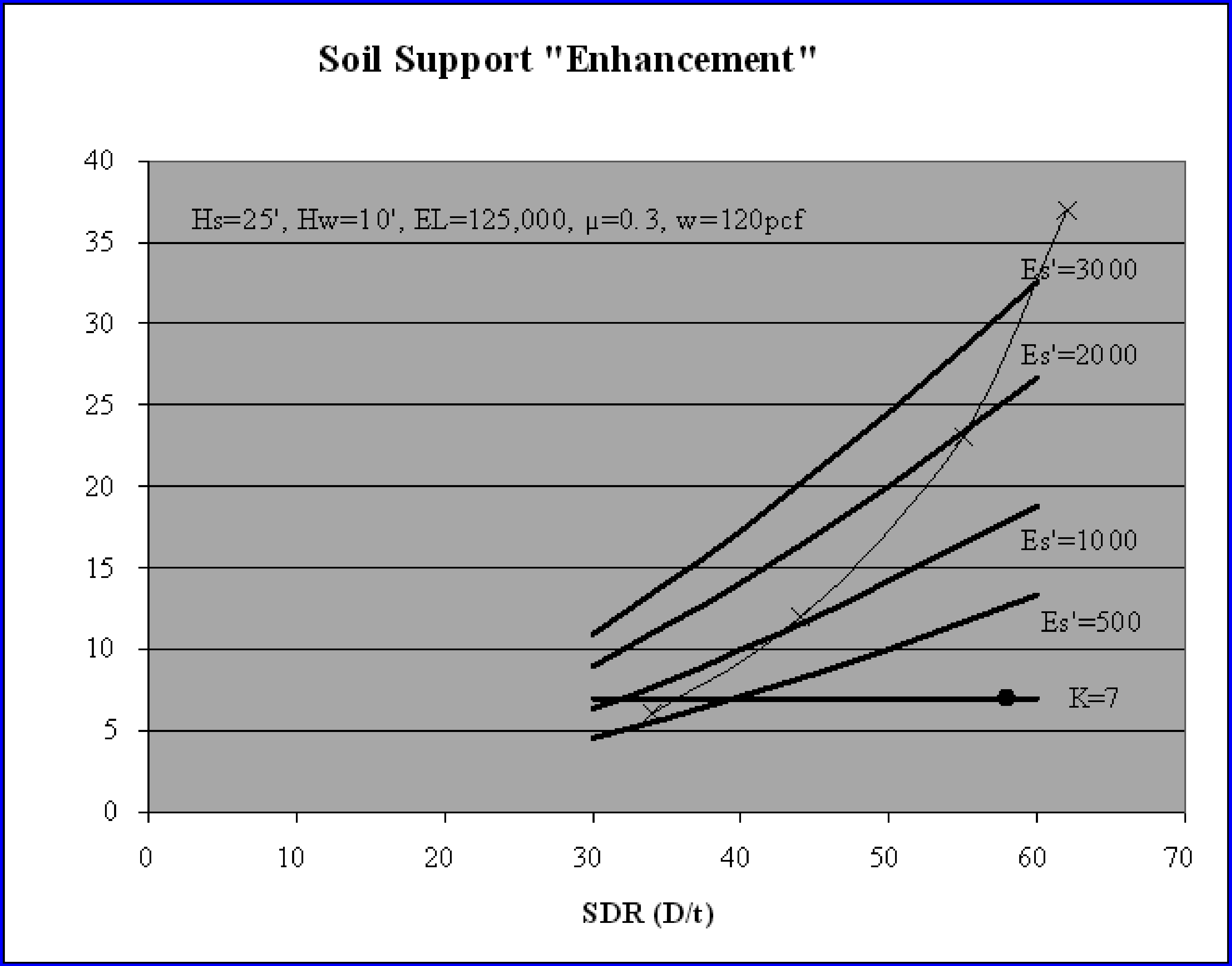

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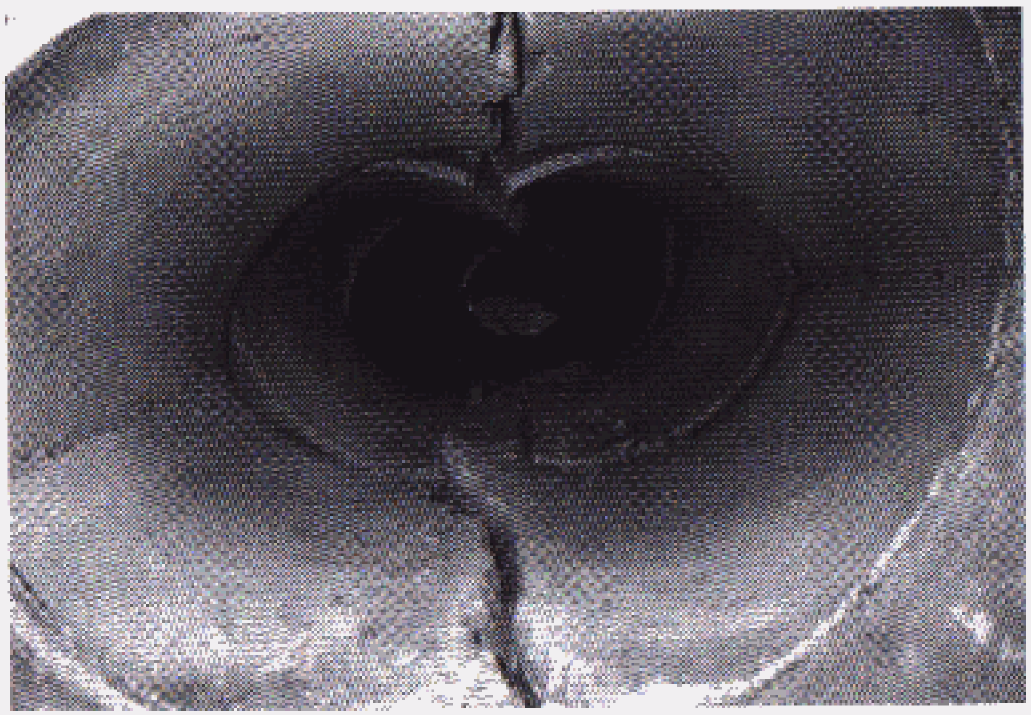
Utah State University Soil Cell Test 1993



UNLINED PIPE

Unlined pipe is no longer serviceable.

DANBY LINED PIPE

At nineteen percent deflection, pipe was still serviceable.

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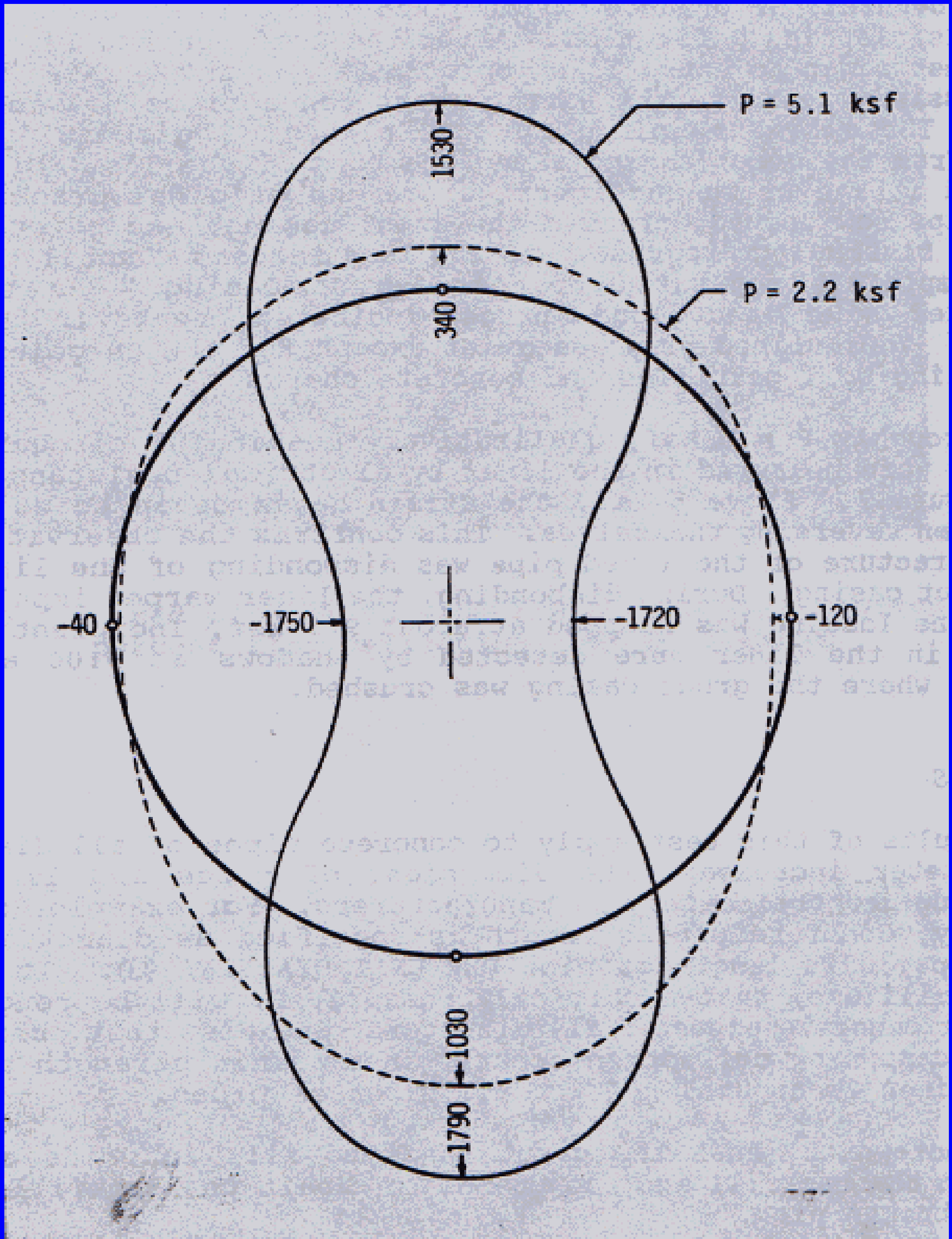

Utah State Univ.
1993 Soil Cell Test

Strains in Danby Liner
(Tension +)

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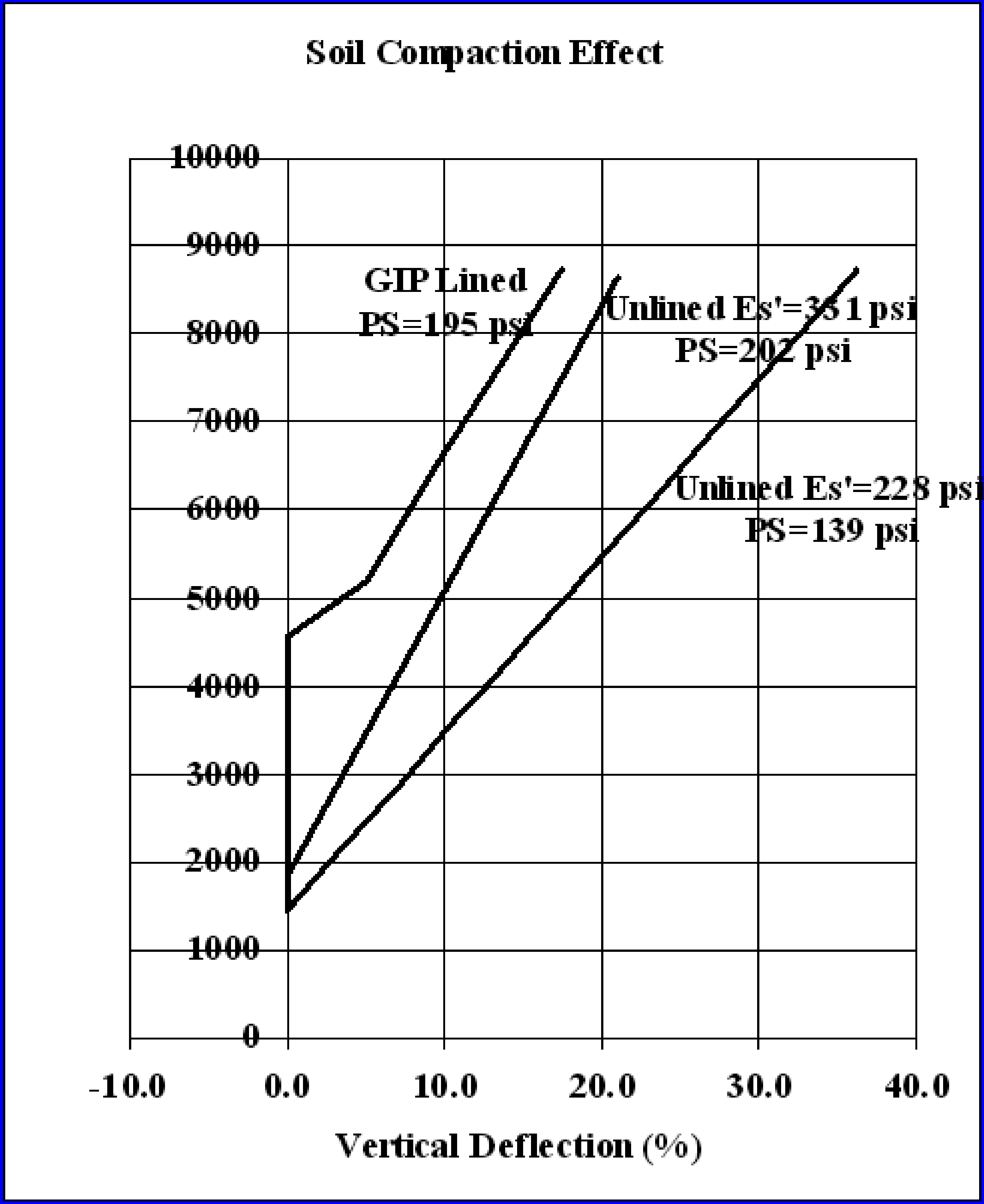
Clearly, the soil load transferred to the liner by the cracked concrete pipe is not uniformly distributed around the liner.

Rehabilitation of Rigid Pipes



Soil Cell Test
Utah State Univ.
1988 & 1993

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Modified Iowa Deflection Formula

□= ?Y/D = LKP/(8EI/D^3 + .061Es’), L=1, K=0.1

Slope of Load (P) Vs Deflection Line = Stiffness

dP/d□= 80EI/D^3 + . 61Es’

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For GIP USU Test Data (t = 0.50", OD = 28")

Unlined Slope = 20 ksf = 139 psi = . 61 E'_s ; E'_s = 228 psi

Lined Slope = 28 ksf = 195 psi; $80EI/D^3$ = 56 psi

EI = 14,558 psi L = 1, K = 0.1

Laboratory ASTM D 790 Test of PVC/Grout Beam
EI = 14,242 psi

Clearly Consistent Values

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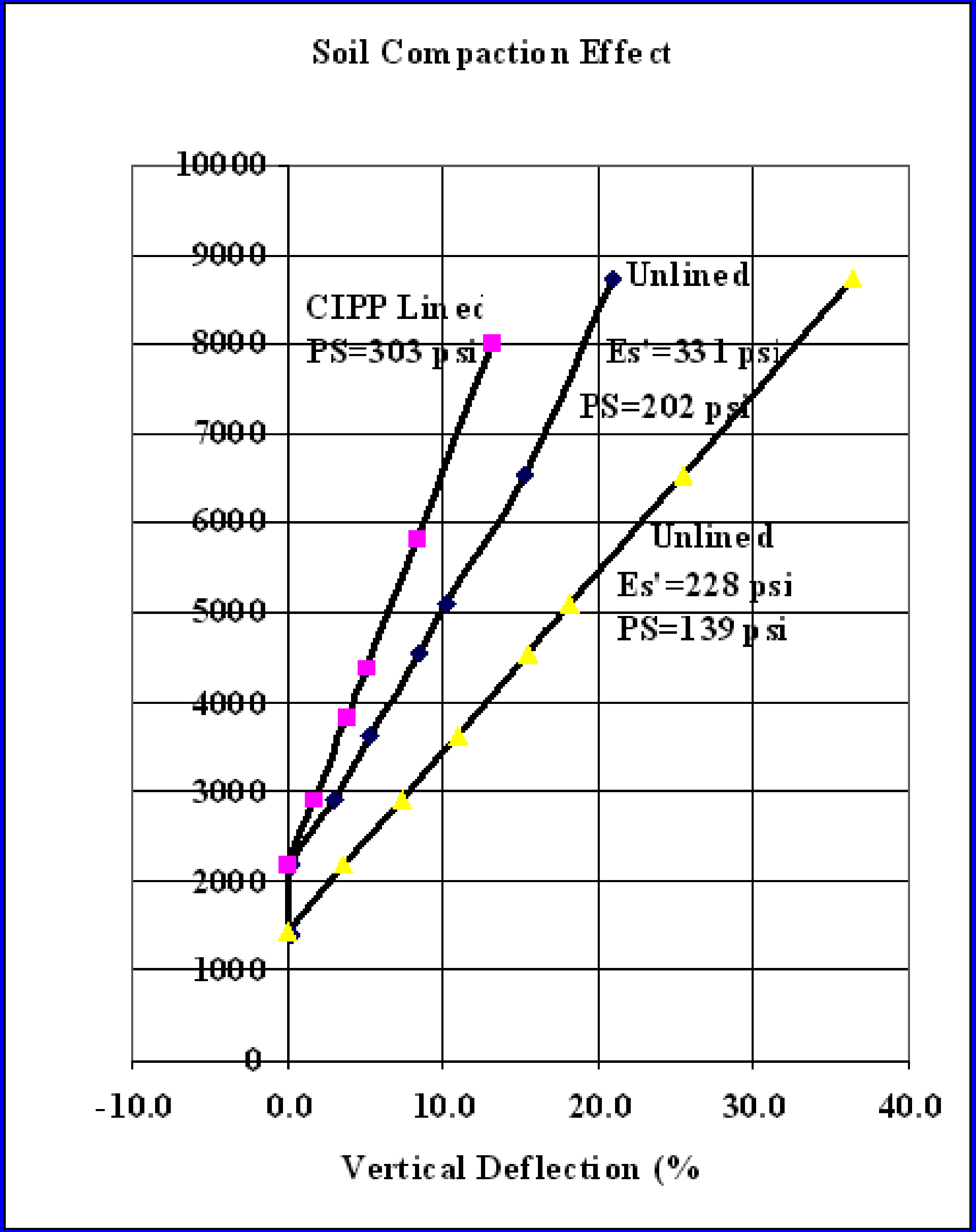

Soil Cell Test
Utah State Univ.
1988 & 1993

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From USU test data it is clear that deflection limit will occur before buckling. In fact no indication of buckling was observed.

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For CIPP USU Test Data (t = 0.83", OD = 30")

Unlined Slope = 29 ksf = 202 psi = . 61 E'_s ; E'_s = 331 psi

Lined Slope = 43.6 ksf = 303psi; $80EI/D^3$ = 101 psi

E = 665,594 psi L = 1, K = 0.1

Probably high by a factor of 1.5 to 2

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If assumed soil support is present, the host pipe-soil structure dominates the structural response to the soil load.

$$dP/d\square = 80EI/D^3 + .61\ E'_s$$

$$= 1.49PS + .61\ E'_s$$

For E'_s =700, SDR=35, E=125,000

$$= 21 + 427$$

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Conclusions

Test Data Does Not Support Buckling As Failure State

If Soil Support Required by Buckling Design Exist, Most Rigid Pipes Would Benefit Little, Sructurally, From Liner

Liners Add Stiffness But Are Less Influential Than Soil Modulus

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Conclusions

Flexible Liner Design Should Be Based On Adding Stiffness OR Hydrostatic Pressure

More Testing & FEA Modeling Is Needed To Determine Relationship Between Soil Modulus and Stiffness Added by Liner

The ASCE PINS Task Group On Rehab Design Should Recommend Changes In "Fully Deteriorated" Design