HOW TO USE THE PTI–3RD EDITION TO DESIGN FOUNDATIONS IN HOUSTON

Foundation Performance Association
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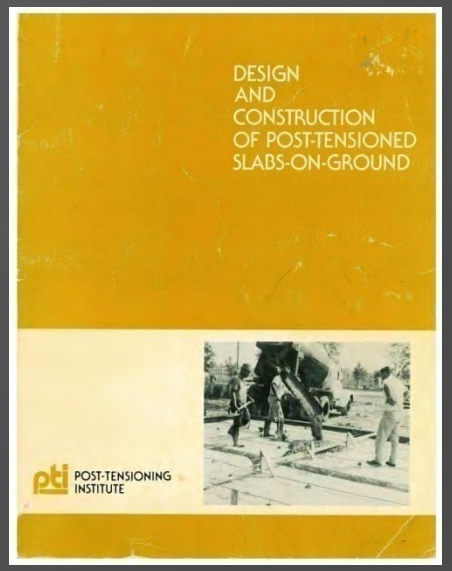
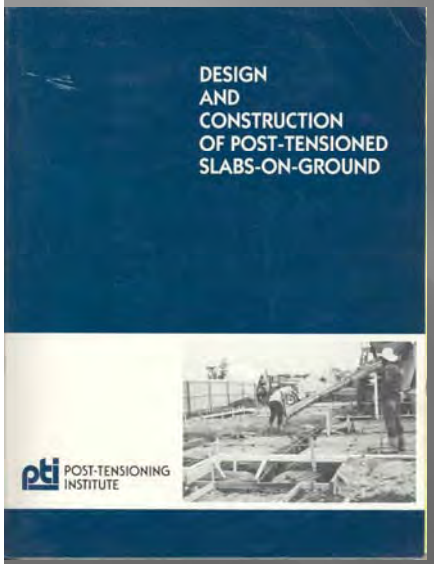
PTI DESIGN MANUALS – 1ST AND 2ND EDITIONS

1st Edition Manual (1980)

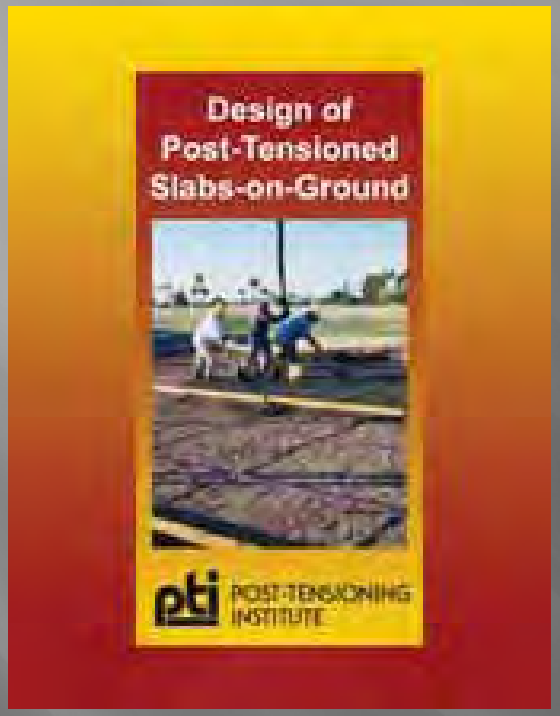




2nd Edition Manual (1996)

- Included minor changes to structural equations (shear for example)
- Included Compressible Soils and Uniform Thickness Foundation analysis

PTI 3RD EDITION MANUAL



3rd Edition Manual (December 2004)

Two standalone "standards" (written in mandatory code language) were also published. The "standards", not the manual, are referenced by IBC

MAJOR STRUCTURAL PROVISION CHANGES IN 3RD EDITION

In addition to major changes in the geotechnical provisions, the 3rd Edition included significant changes to the structural provisions:

- Differential Deflection replaced by **MINIMUM STIFFNESS** requirement.
- Added **CRACKED SECTION CAPACITY** requirement. **Requires tendons or rebar in the bottom of ribs.**
- Part of slab area permitted to be included in bearing area. **May not be appropriate for Houston due to soft surface soils and required penetration (typically 12-18 inches).**

PTI 3RD EDITION MANUAL

The original 3rd Edition procedure was found to be conservative and widely misapplied (for a variety of reasons).

As a result, two Addenda were issued to provide clarification and reduce the level of conservatism.

ADDENDUM #1 – MAY 2007

IN GENERAL, e_m AND y_m WERE REDUCED.

Significant changes to the structural provisions include:

- Allowable shear stress of concrete increased **(approx. 40%)**
- Stiffness coefficient reduced to 12,000 from 18,000
- Cracked Section Capacity coefficient reduced to 0.5 from 0.9 in Addendum #1

Note: Major errata regarding definition of suction profiles was introduced in Addendum #1

ADDENDUM #2 – MAY 2008

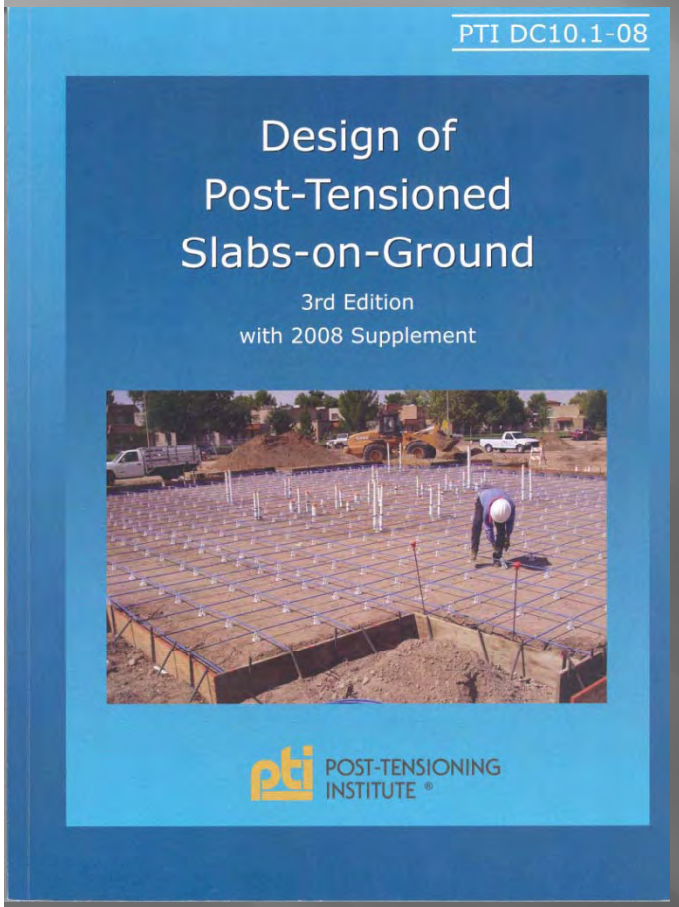
IN GENERAL, e_m WAS REDUCED.

Only minor changes to the structural provisions:

- Decreased minimum rib width to 6 inches (primarily to accommodate stay-in-place form systems)
- Clarified use of ribs spaced closer than 6 feet (primarily to accommodate stay-in-place form systems)
- Removed E_{soil} from the structural equations. Hard coded to 1,000 psi.

Note: Modifications to Soil Fabric Factor table included in Addendum #2 to address issues identified during testing of Houston soils.

PTI 3RD EDITION MANUAL



2008 Supplement

Includes the Addenda, errata and the two "standards"

DESIGN PROCEDURE

Design is performed based on "trial and error" procedure. Assumptions are made and then assumed design checked for "compliance". If assumed design is "out of compliance" or over-designed the assumptions should be modified and analysis performed analysis.

DESIGN PROCEDURE

Trial foundation checked for compliance with the following:

- Flexural Stresses
  - Tension
  - Compression
- Shear Stress
- Minimum Stiffness Requirement
- Cracked Section Capacity
- Soil Bearing

Parametric Equations

Center Lift.

Short Direction Shear

$$V_s = \frac{1}{1350}\left[(L)^{0.19}(S)^{0.45}(d)^{0.20}(P)^{0.54}(y_m)^{0.04}(e_m)^{0.97}\right]$$

Long Direction Shear

$$V_\ell = \frac{1}{1940}\left[(L)^{0.09}(S)^{0.71}(d)^{0.43}(P)^{0.44}(y_m)^{0.10}(e_m)^{0.93}\right]$$

SELECTED TOPICS

- Slab Types
- Foundation Loads
- Plate versus Beam analysis
- Foundation Shape
- Center Lift Shear

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- Foundation Loads
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BRAB SLAB TYPES

- Type I – Unreinforced
- Type II – Lightly reinforced against shrinkage and temperature cracking
  Can be used for sites with Weighted PI<15
- Type III – Reinforced and stiffened
  PTI Design procedure (Weighted PI>15)
- Type IV – Structural
  Should be considered for sites with y_m > 4 inches, steep slopes, deep fills

SELECTED TOPICS

- Slab Types
- **Foundation Loads**
- Plate versus Beam analysis
- Foundation Shape
- Center Lift Shear

FOUNDATION LOADS

The PTI design procedure requires determination of:

- Perimeter Load – Used in determination of applied moment and shear
- Total Superimposed Load – Used only for bearing analysis (very simplified approach)

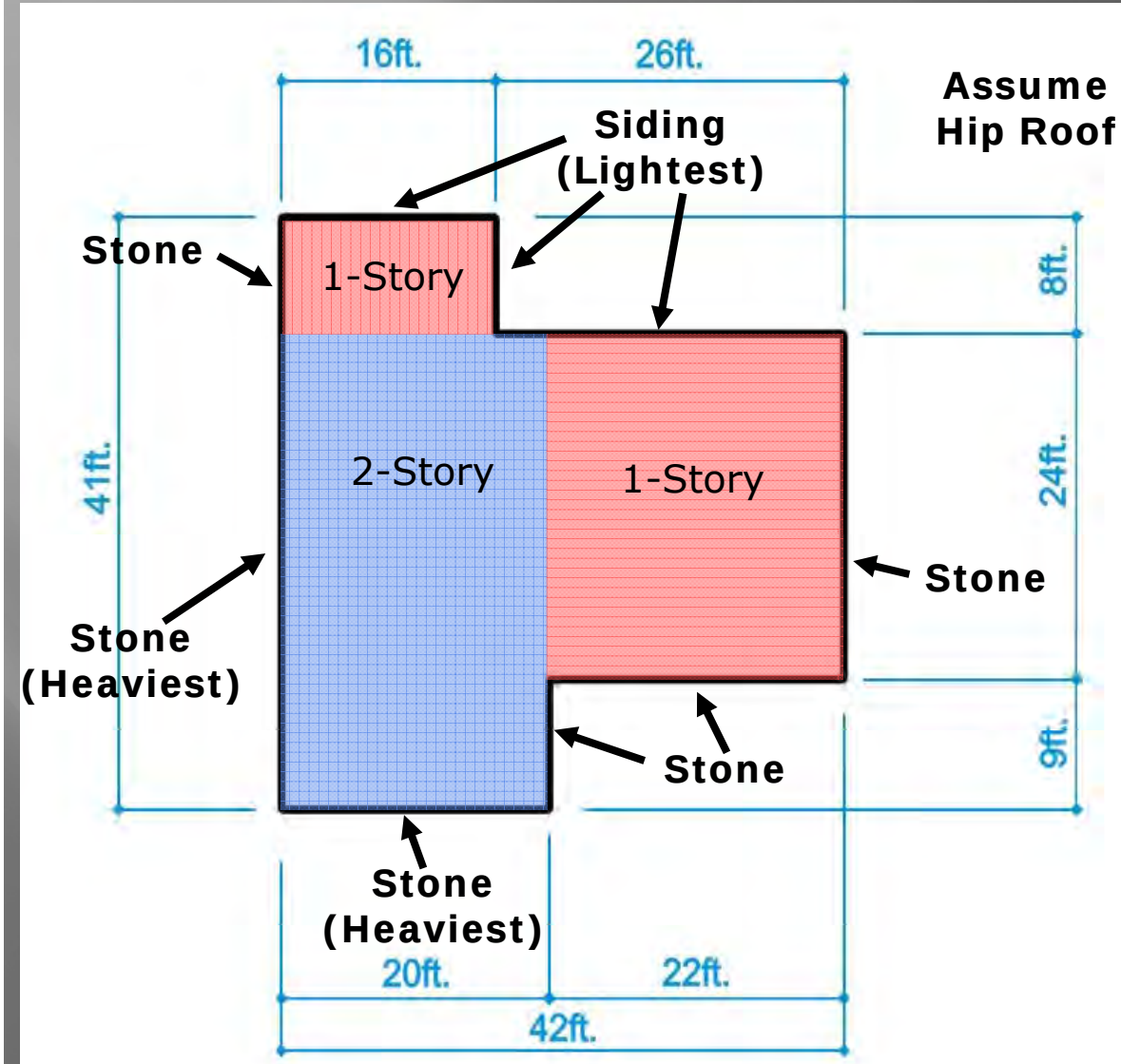
Built into procedure is a 40 PSF live load applied directly to first floor slab AND a 65 PSF dead load to account for the weight of a 4 inch thick slab and first floor partitions.

FOUNDATION LOADS

PTI 4.5.4.3 - "In the edge lift mode, designers are permitted, however to use dead load and **sustained live load**, or to use dead load only."

PTI 4.5.4.3 – "When P varies significantly around the slab perimeter, and the ratio of largest to smallest exceeds 1.25, the largest value should be used for center lift design and the smallest value should be used for edge lift design.

FOUNDATION LOADS



Use representative (weighted average) loads.

Use of localized extreme values (high or low) that are not representative of the overall loading conditions will result in conservative designs.

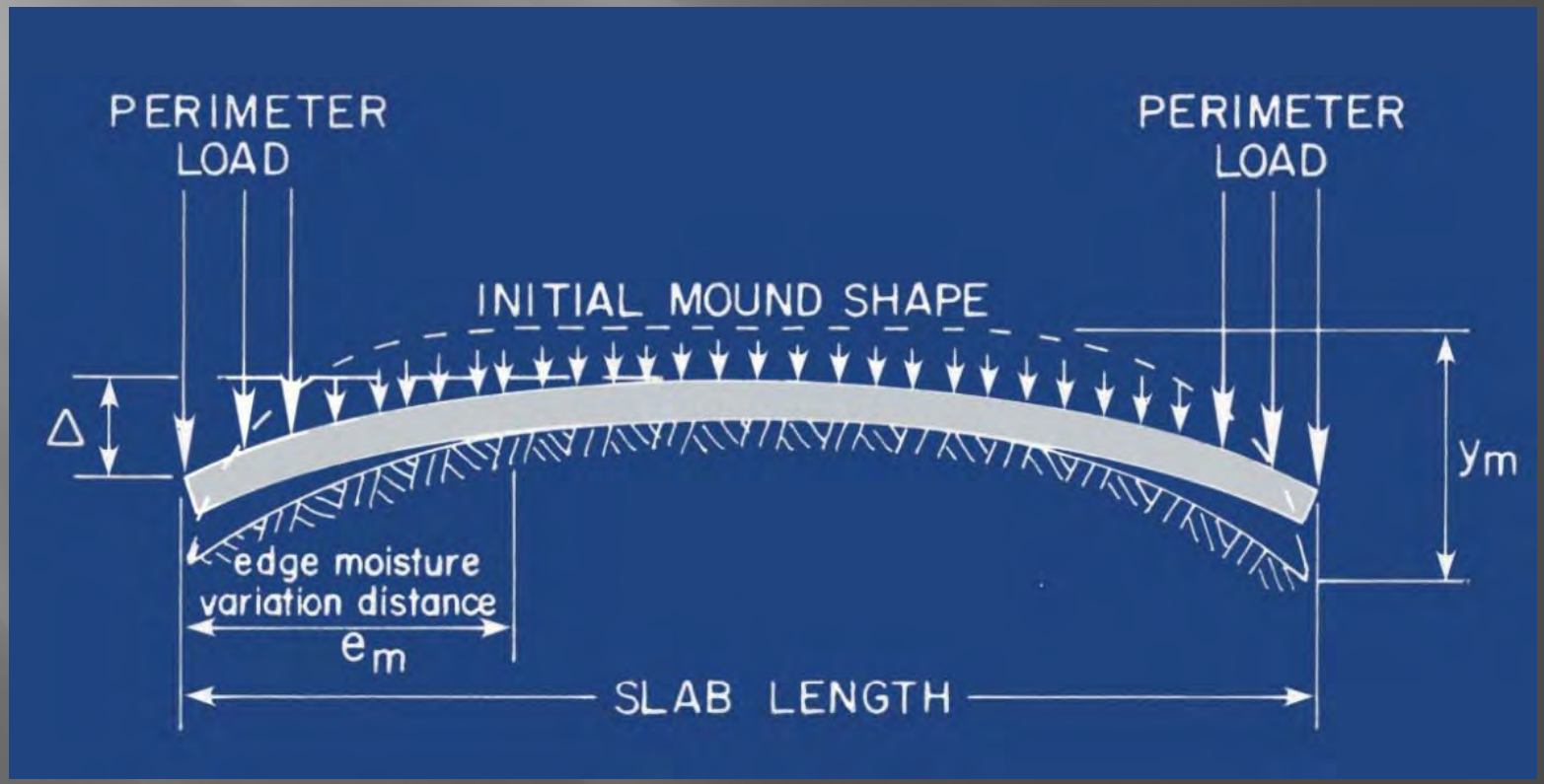
FOUNDATION LOADS

Since the foundation behavior is a function of the creep modulus of both the soil and concrete, long term sustained loads should be used.

Short-durations live loads (wind, seismic, snow, etc.) should not be used.

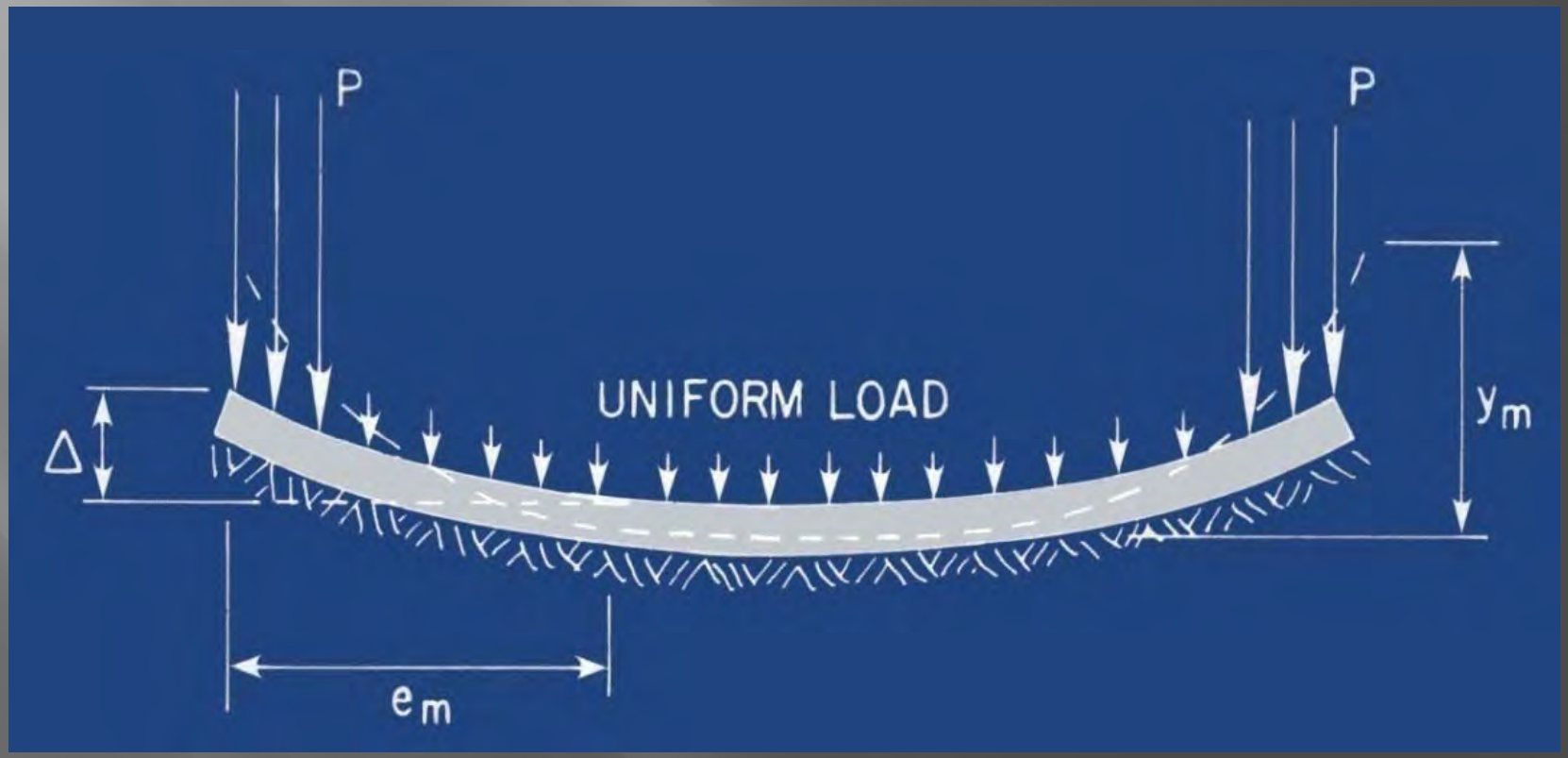
FOUNDATION LOADS

Including short-duration loads in the perimeter load may be **over-conservative** for the Center Lift Mode.



FOUNDATION LOADS

Including short-duration loads in the perimeter load may be **unconservative** for Edge Lift mode.



SELECTED TOPICS

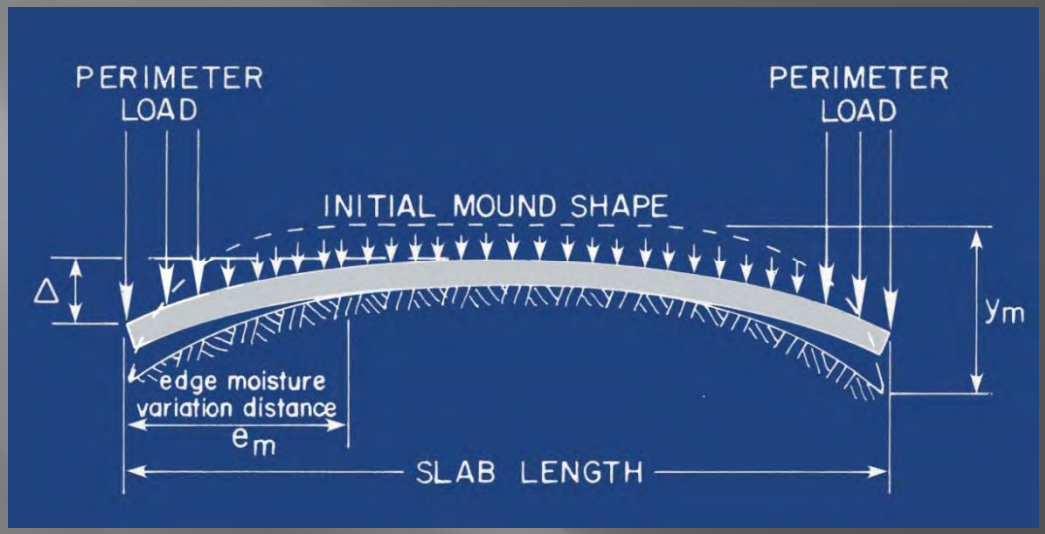
- Slab Types
- Foundation Loads
- **Plate on Uneven Surface**
- Foundation Shape
- Center Lift Shear

PLATE ON EVEN SURFACE

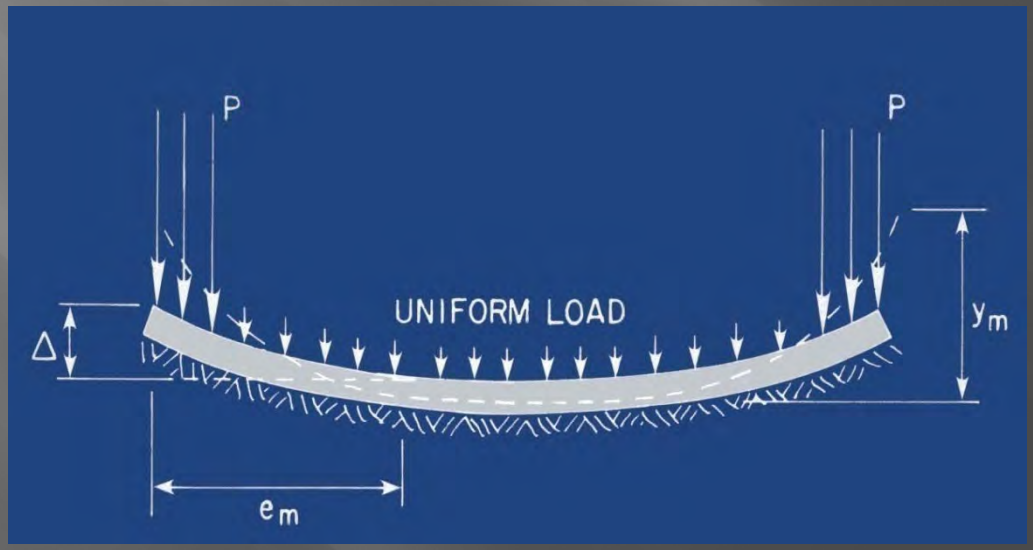
Unlike other foundation design procedures, the PTI procedure is based on a plate on an uneven surface.

As a result, thinking about foundation behavior in terms of beam mechanics is not appropriate.

PLATE ON UNEVEN SURFACE



Center Lift



Edge Lift

PLATE ON UNEVEN SURFACE

The PTI procedure was developed using rectangular plates (not beams) with the soil movement occurring along all four sides simultaneously resulting in interaction between the two orthogonal directions (short and long). This assumption resulted in the "worst case conditions."

PLATE ON UNEVEN SURFACE

From Rifat Bulut's Dissertation

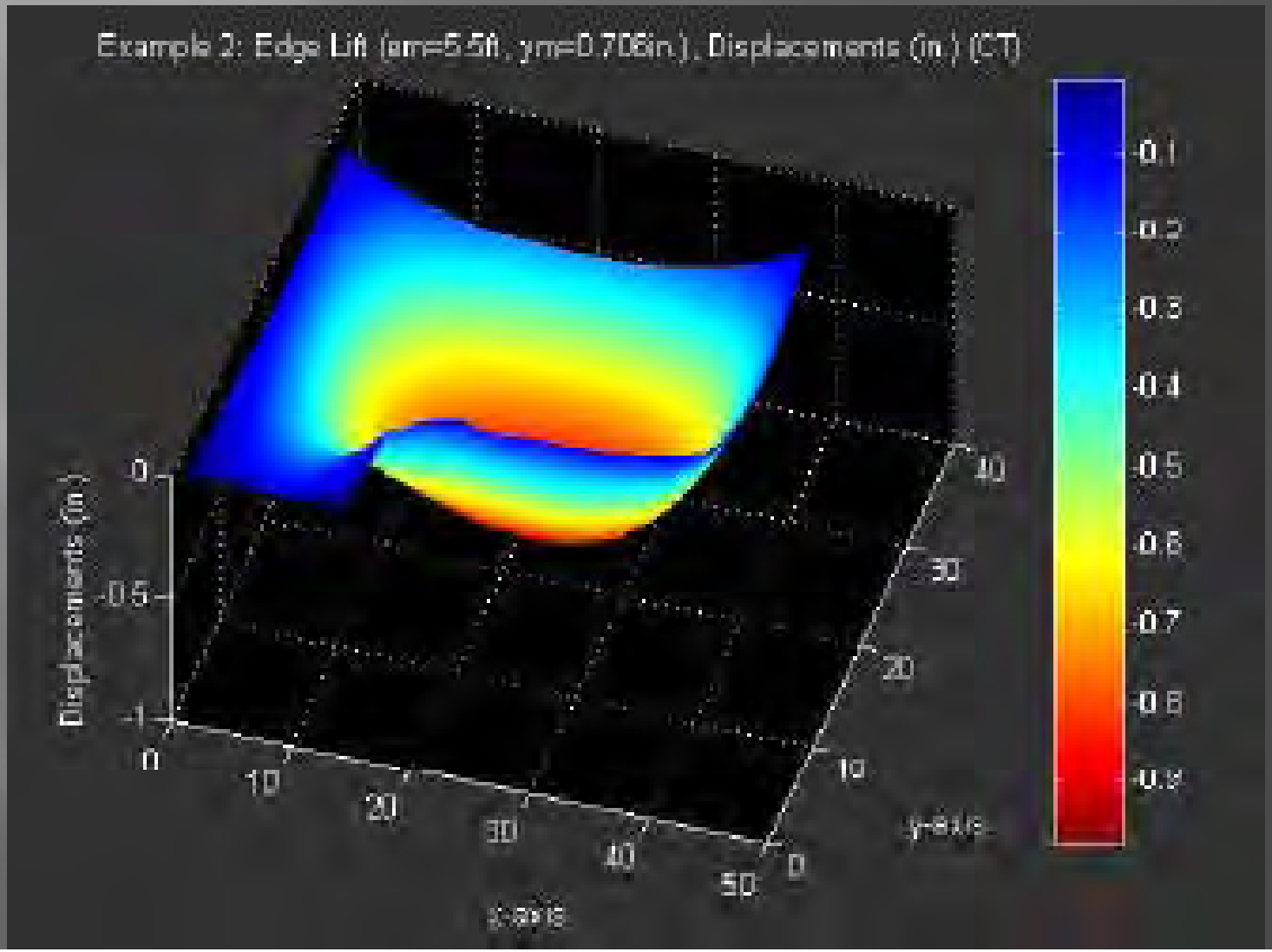
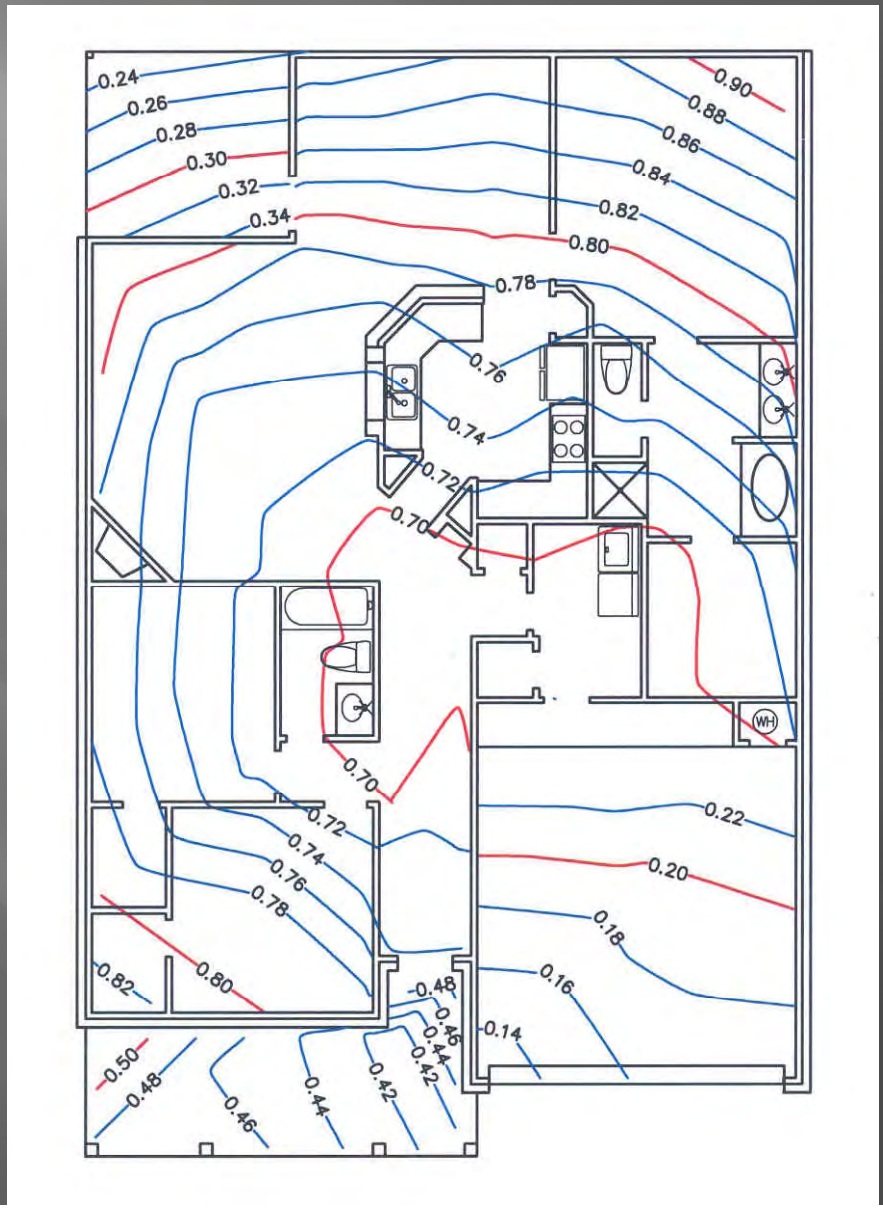


PLATE ON UNEVEN SURFACE

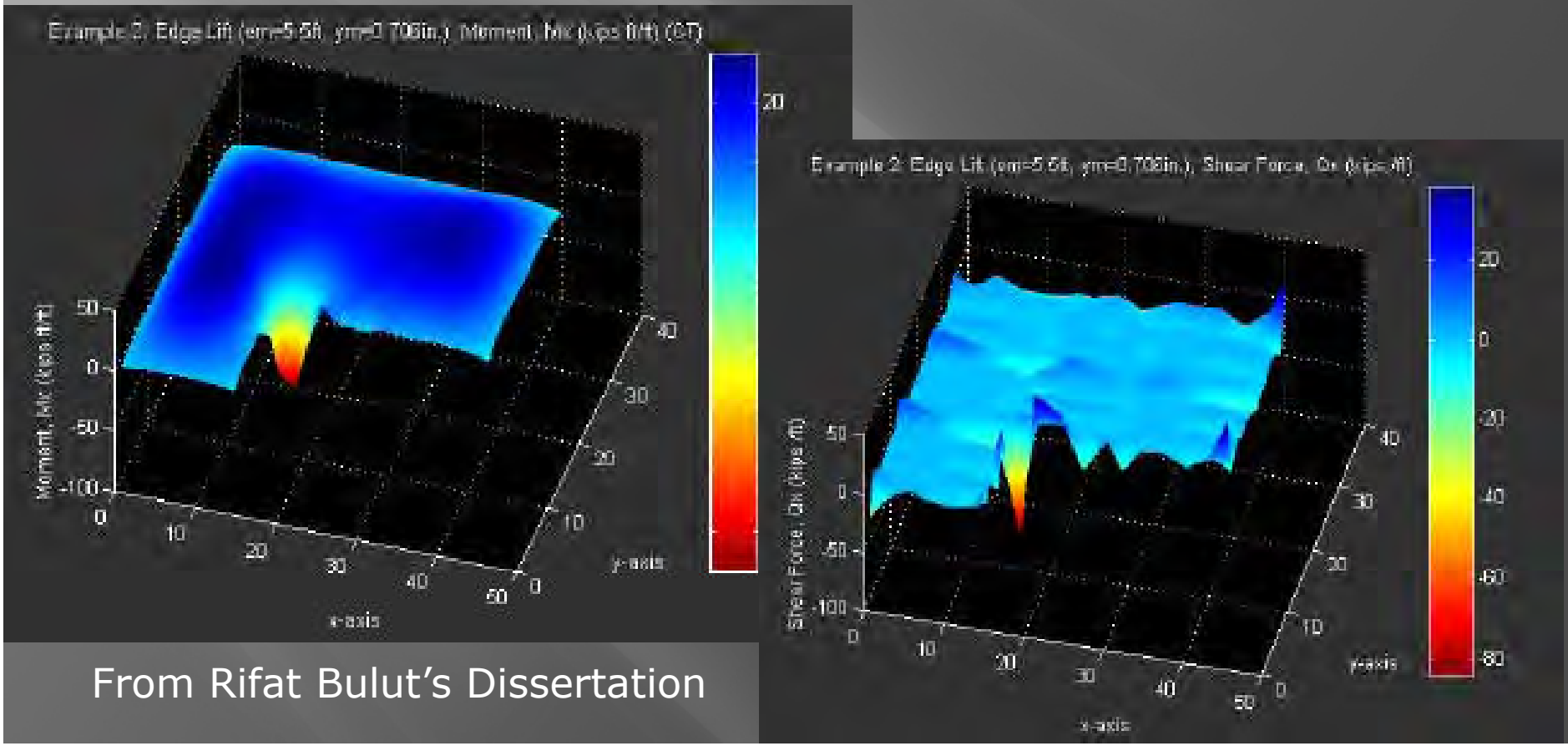


SELECTED TOPICS

- Slab Types
- Foundation Loads
- Plate on Uneven Surface
- **Foundation Shapes**
- Center Lift Shear

FOUNDATION SHAPES

Since the PTI procedure was developed using rectangular shaped plates, irregular shaped foundations can result in stresses significantly higher than determined by the parametric equations.



From Rifat Bulut's Dissertation

FOUNDATION SHAPES

Shape Factor (SF)

(defined as perimeter^2/area)

If the SF is greater than 24 then the designer should consider:

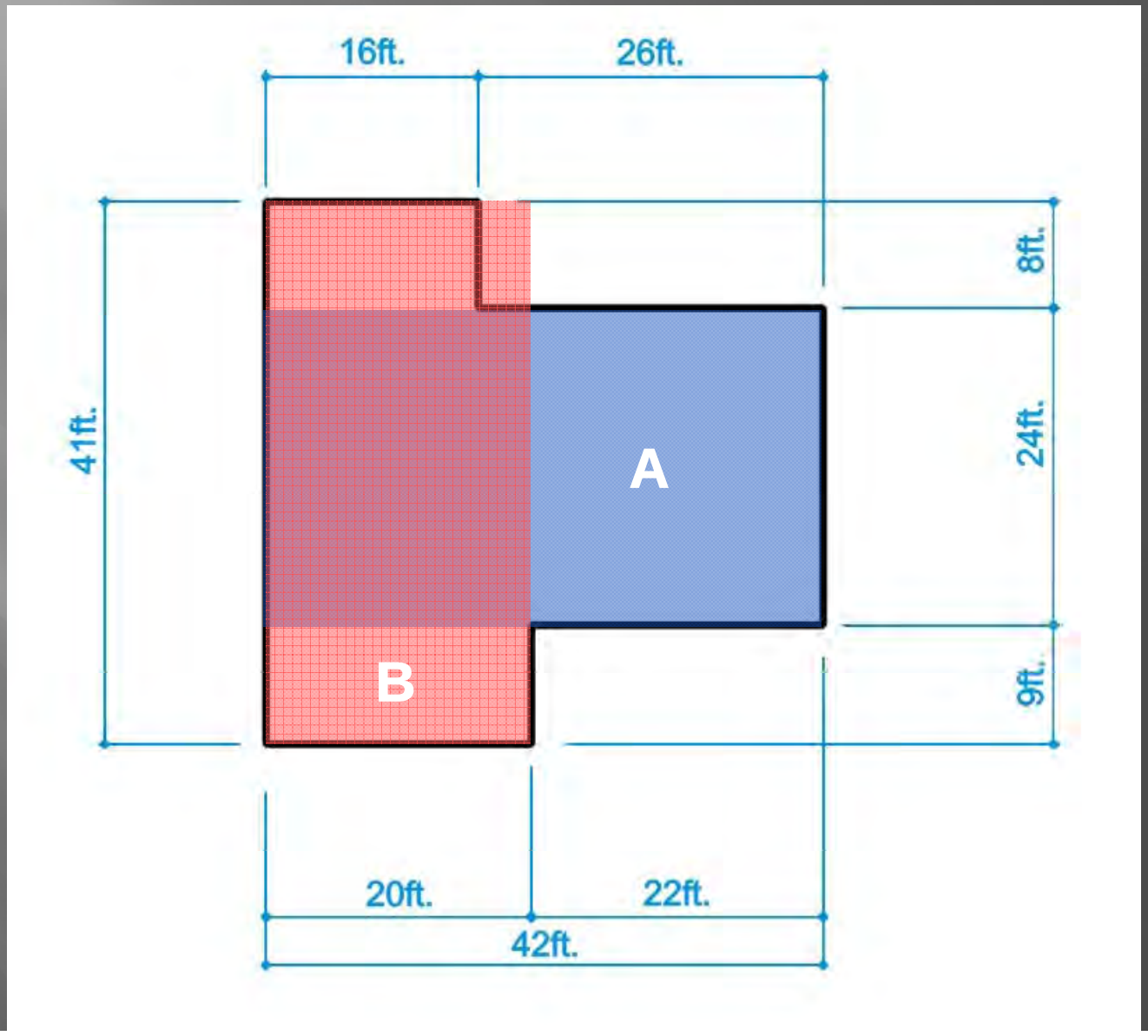
- modifications to the foundation footprint
- Use strengthened foundation system
- Soil treatment to reduce shrink / swell potential
- Use additional non-prestressed reinforcement
- Provide additional beams

FOUNDATION SHAPES

PTI 6.3 – "Slabs of irregular shape should be divided into overlapping rectangles so that the resulting boundary provides reasonable congruence with the foundation perimeter."

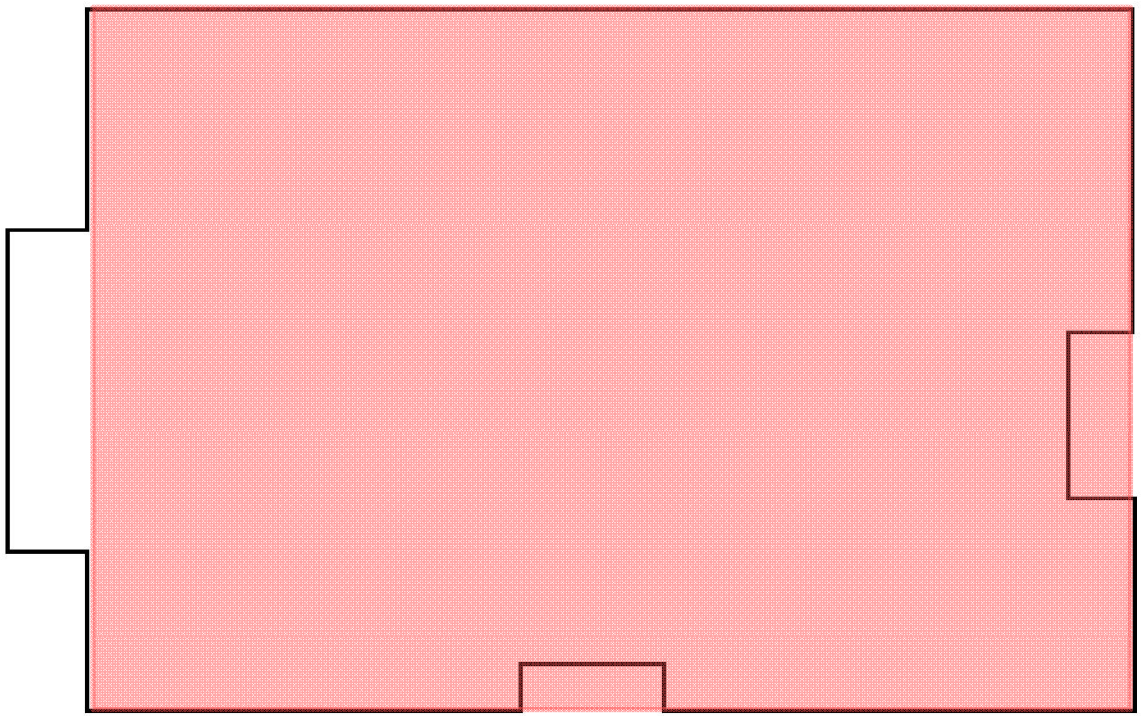
PTI 6.3 –"Long narrow rectangles may not appropriately model the overall foundation and generally should not govern the design."

Foundation Shape



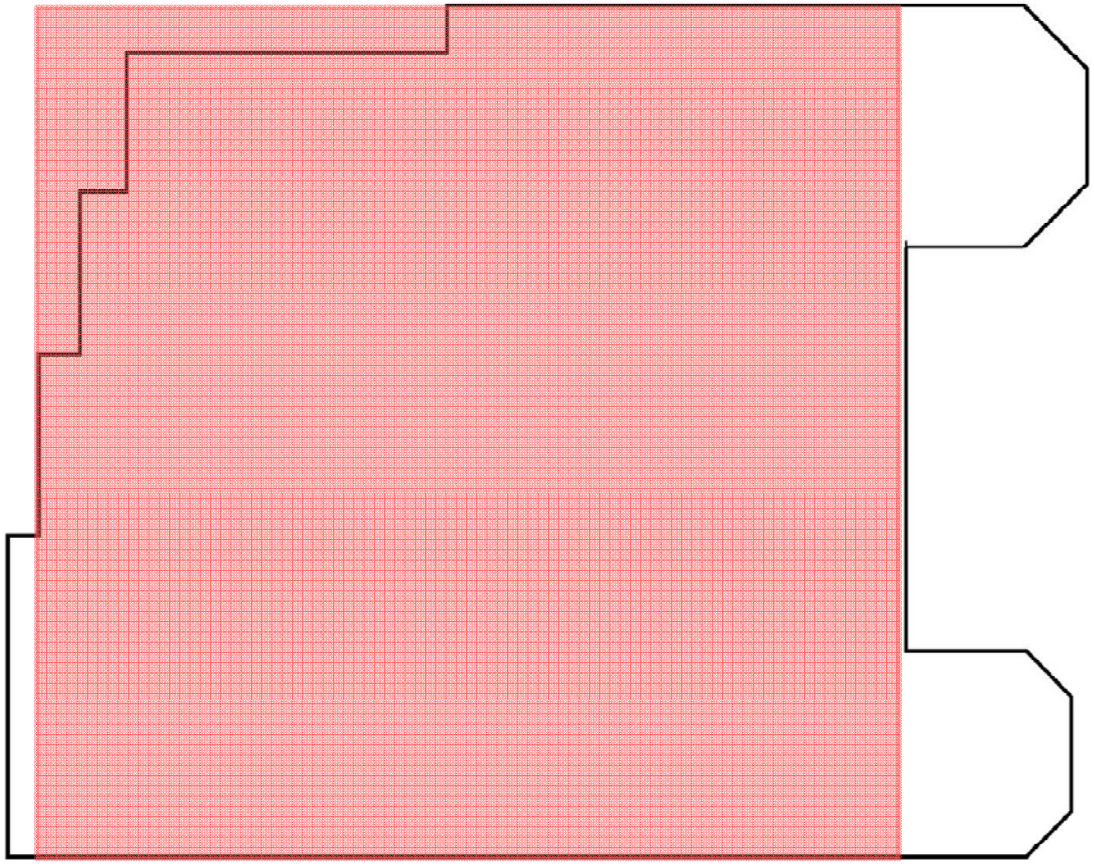
FOUNDATION SHAPES

SF = 20.3



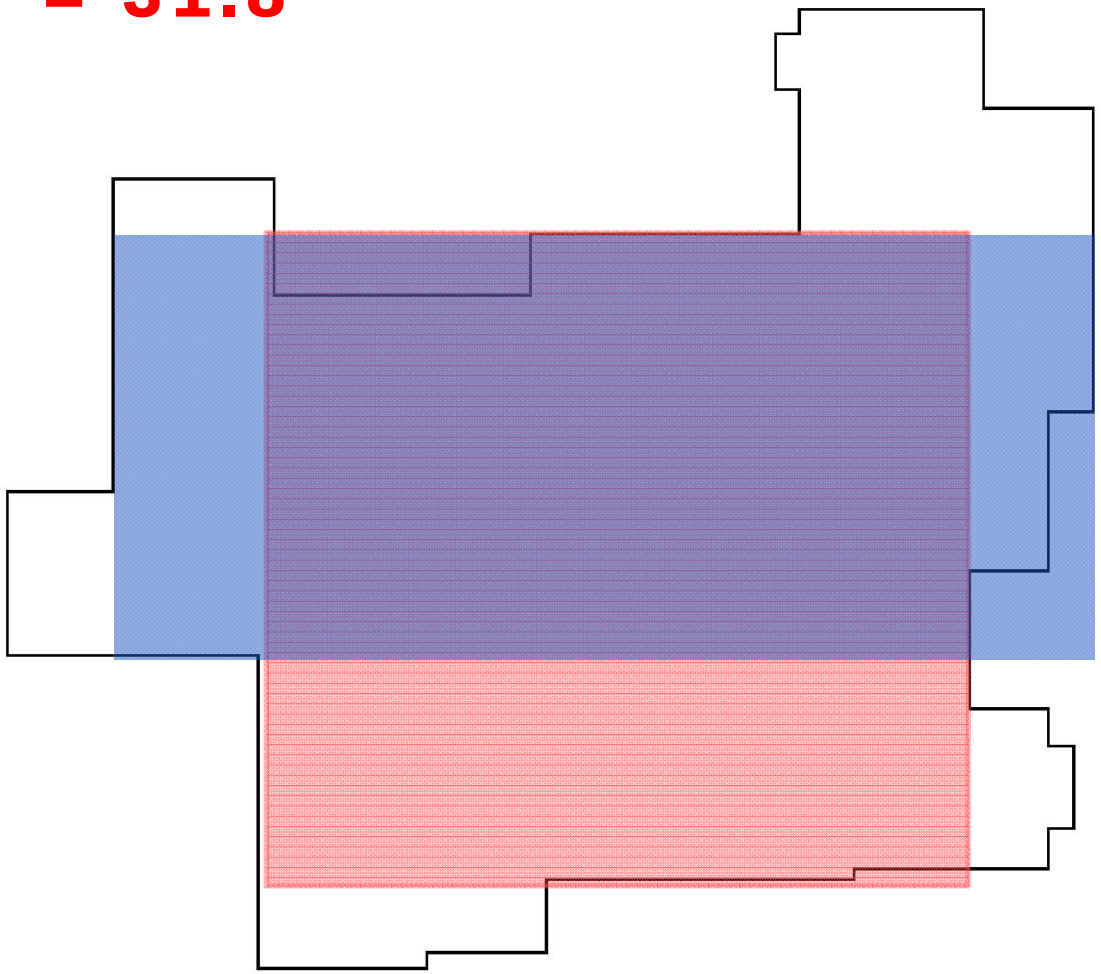
FOUNDATION SHAPES

SF = 41.7



FOUNDATION SHAPES

SF = 31.8

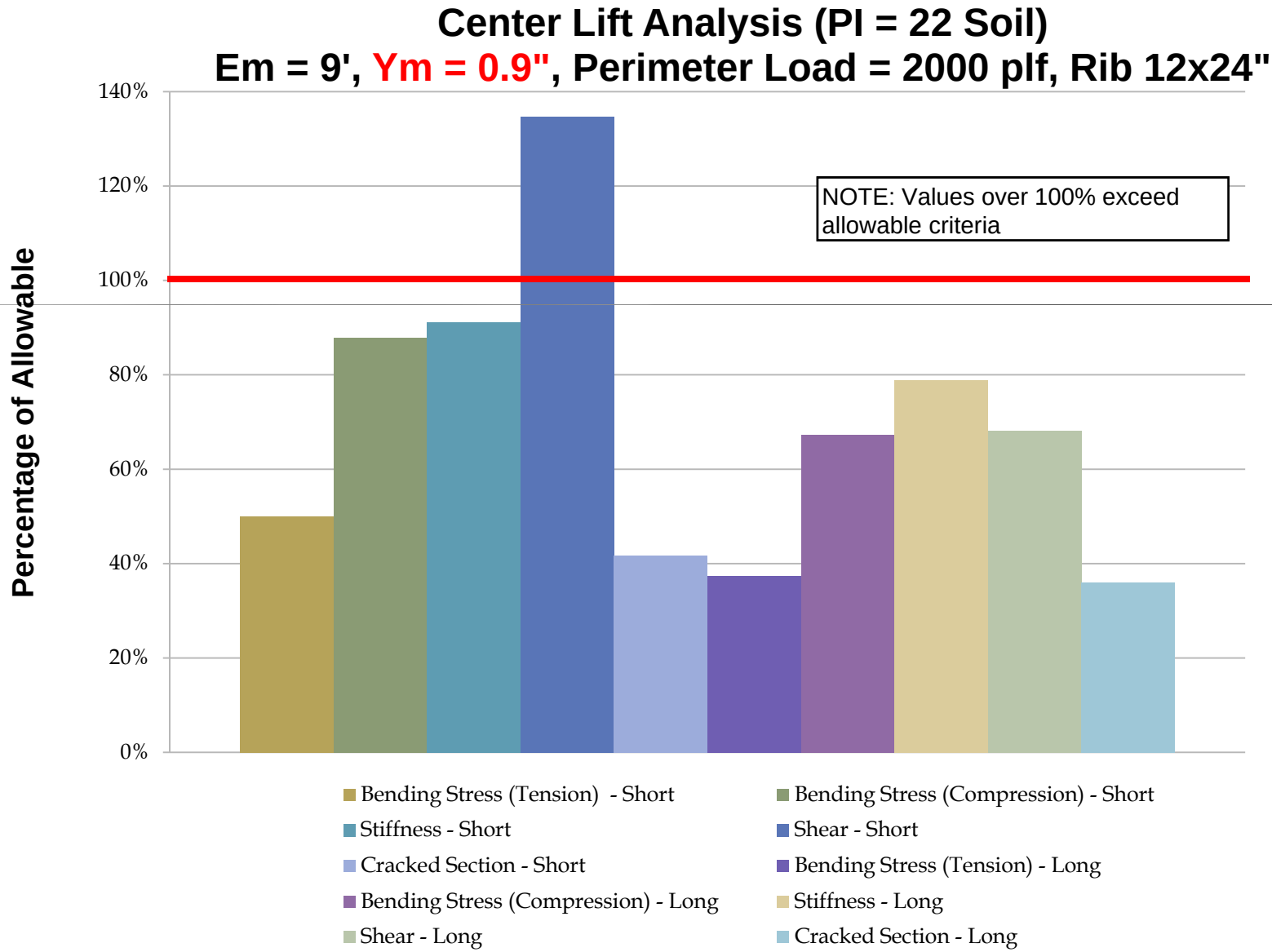


SELECTED TOPICS

- Slab Types
- Foundation Loads
- Plate on Uneven Surface
- Foundation Shapes
- **Center Lift Shear**

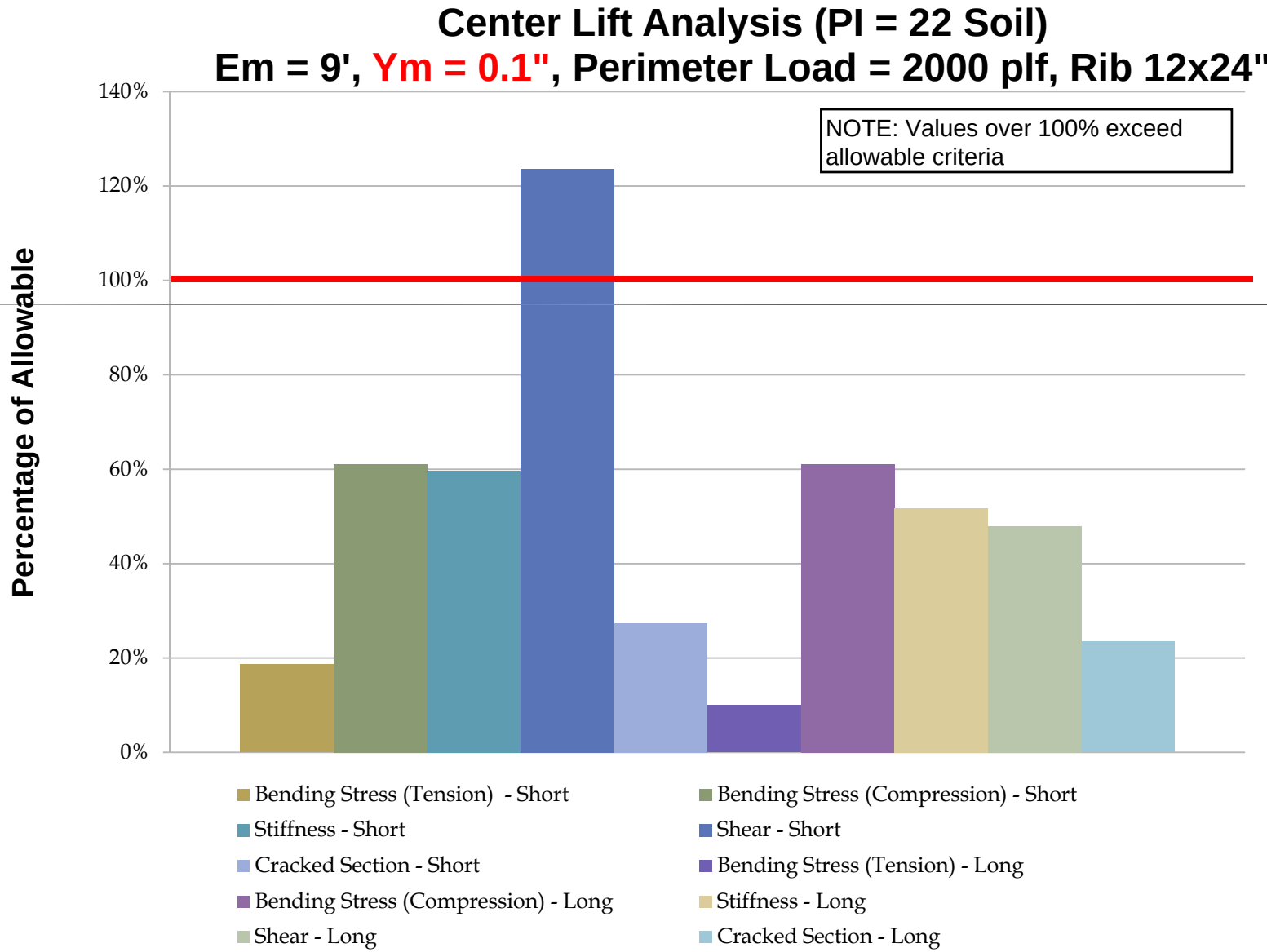
CENTER LIFT SHEAR

Short Direction



CENTER LIFT SHEAR

Short Direction



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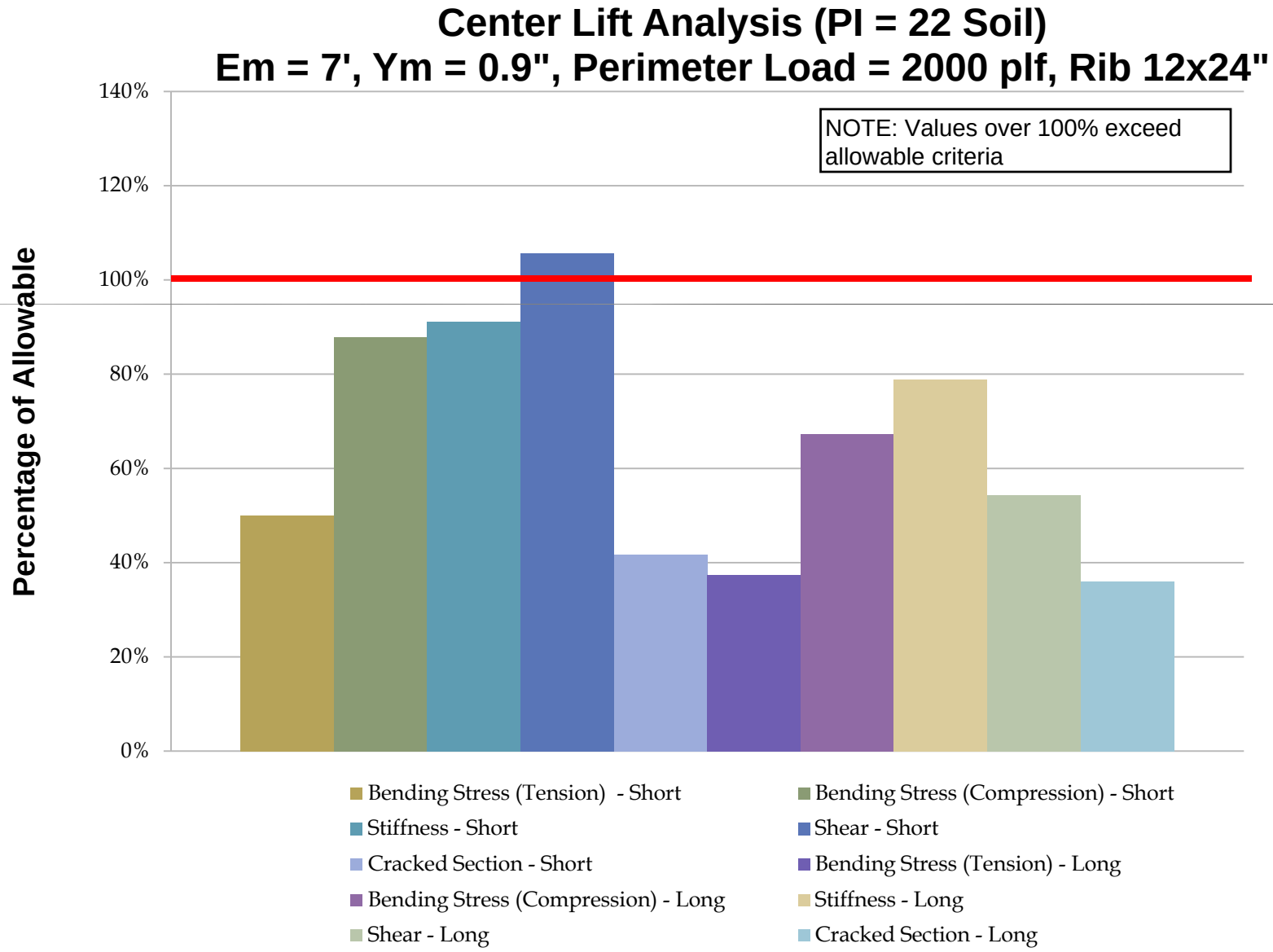
Short Direction



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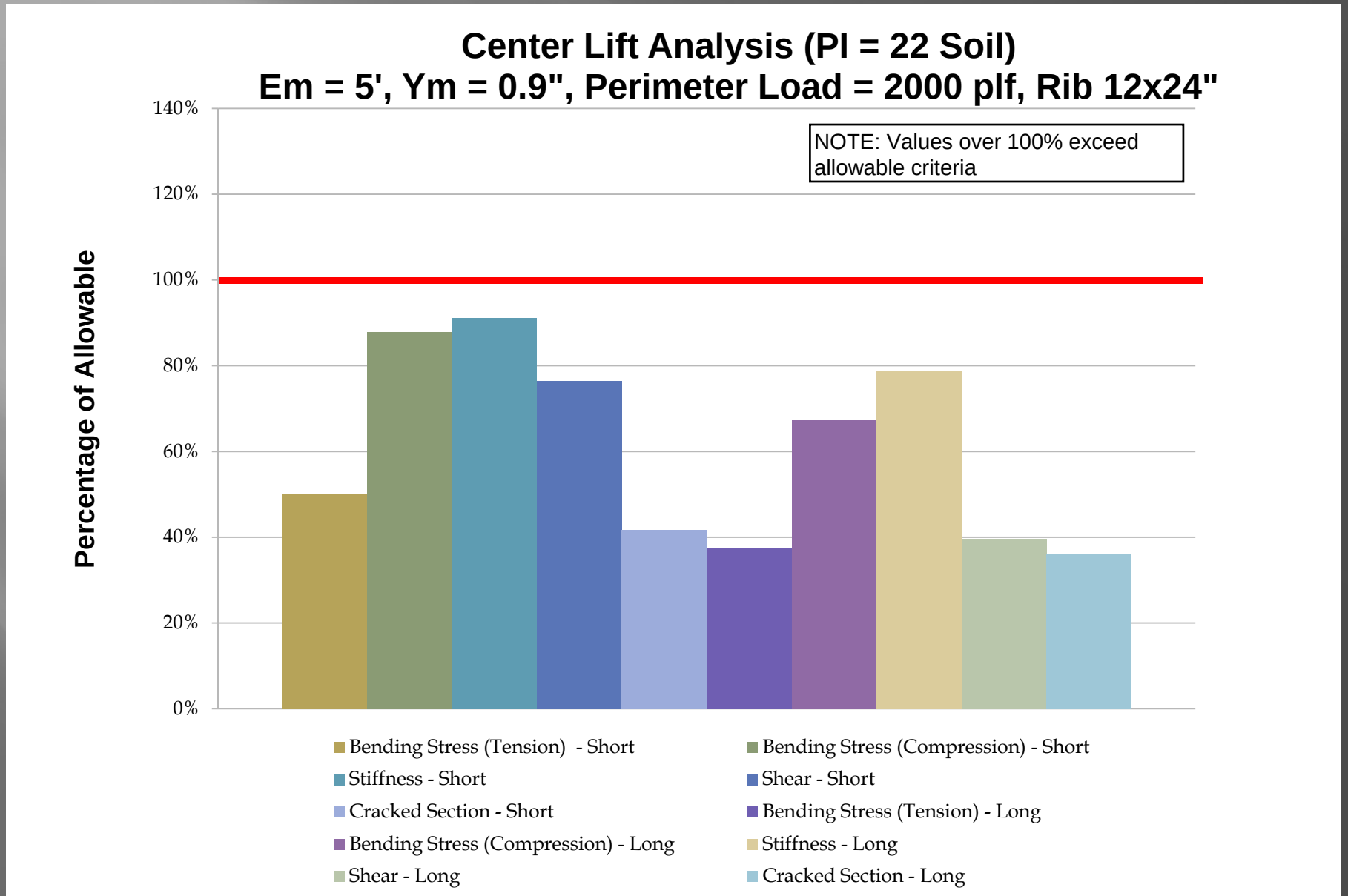
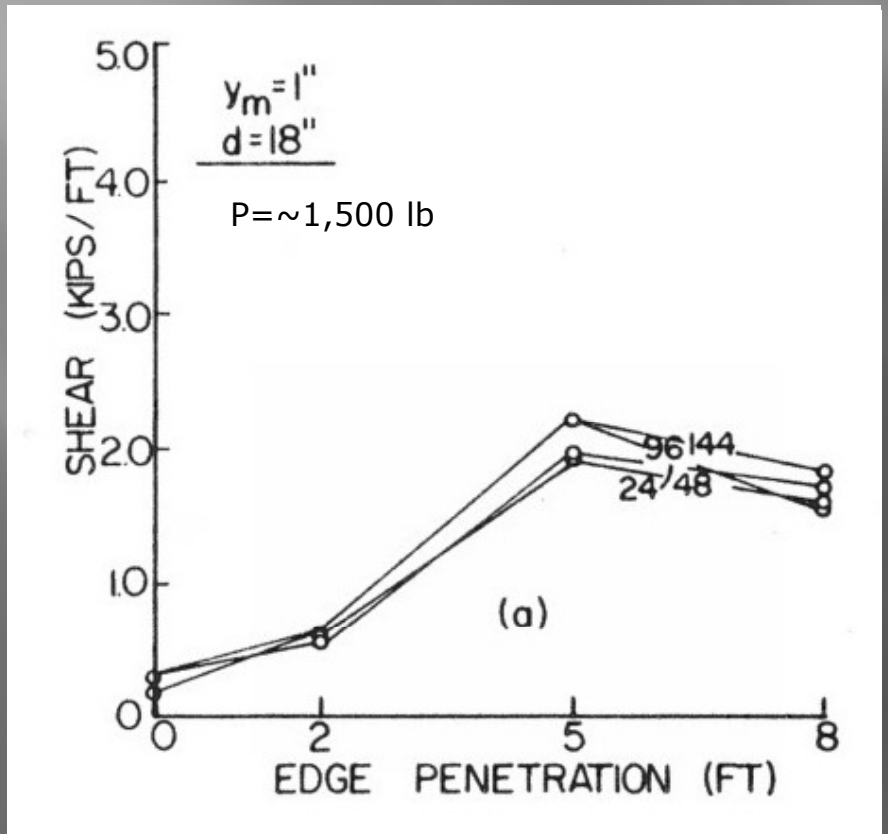
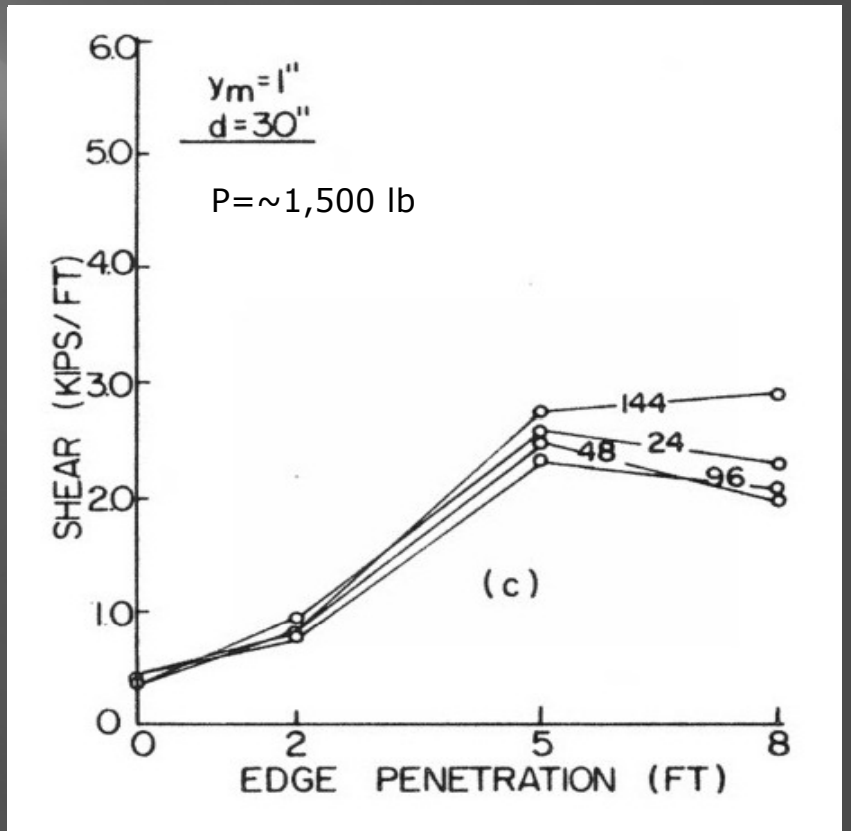
Short Direction



CENTER LIFT SHEAR

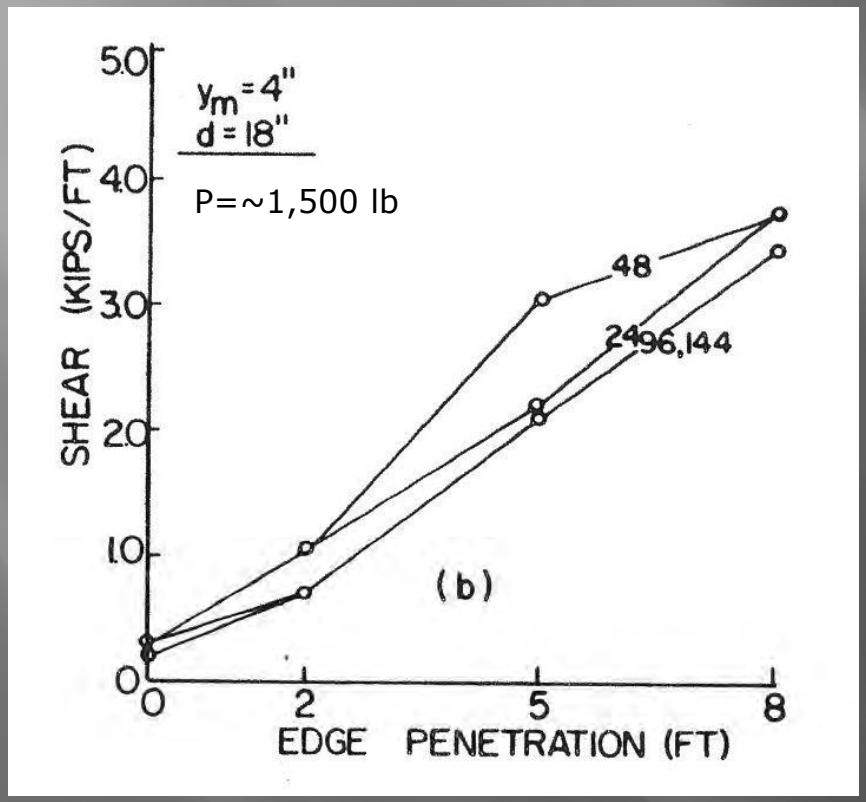
The original plate analysis indicated that for small y_m values, the maximum center lift shear value is reasonably uniform or decreases for e_m>5ft

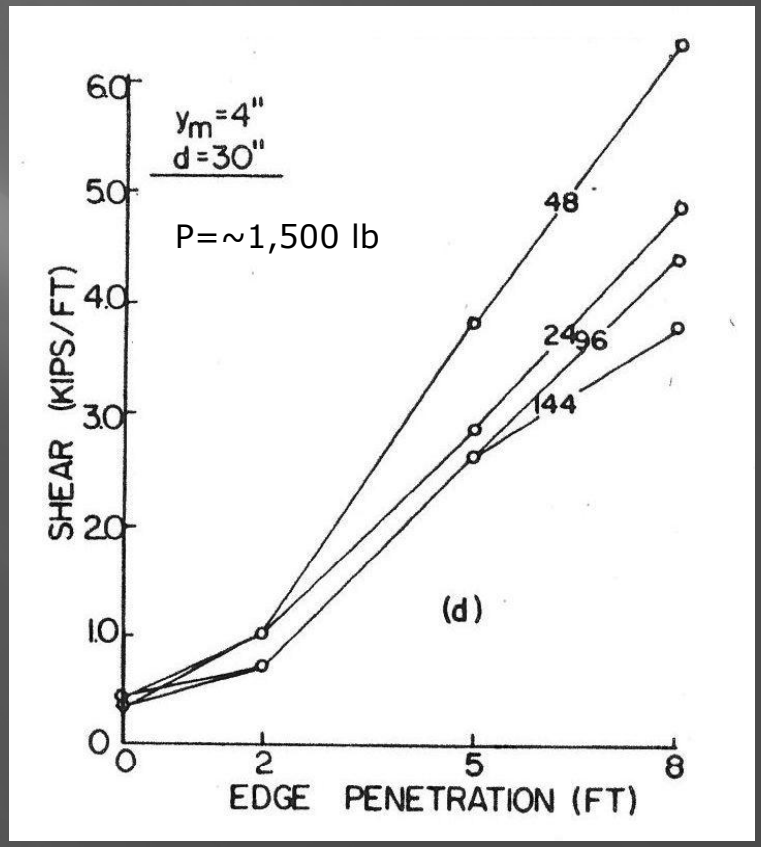




CENTER LIFT SHEAR

For large y_m values, the center lift shear value increases for e_m>5 ft.





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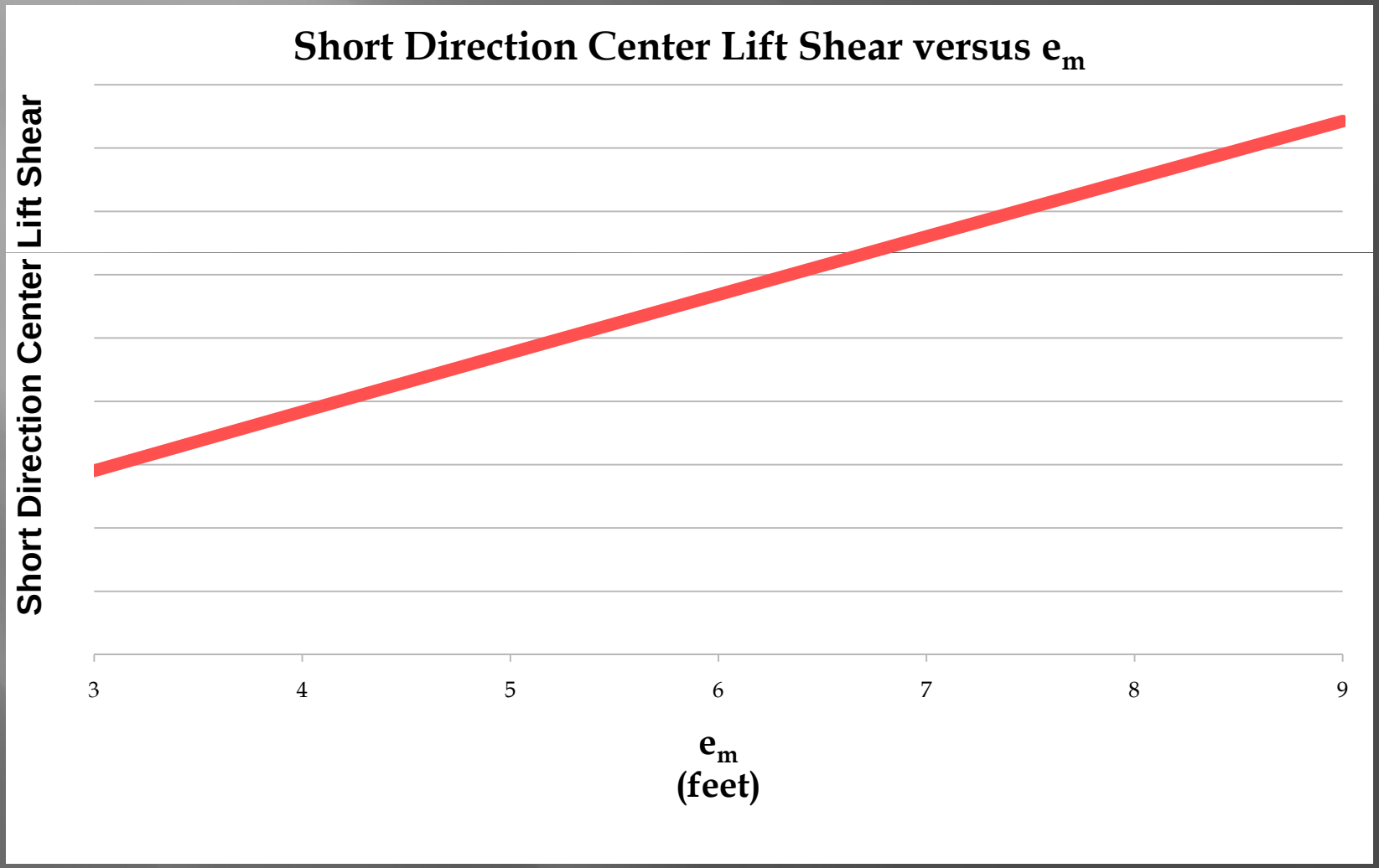

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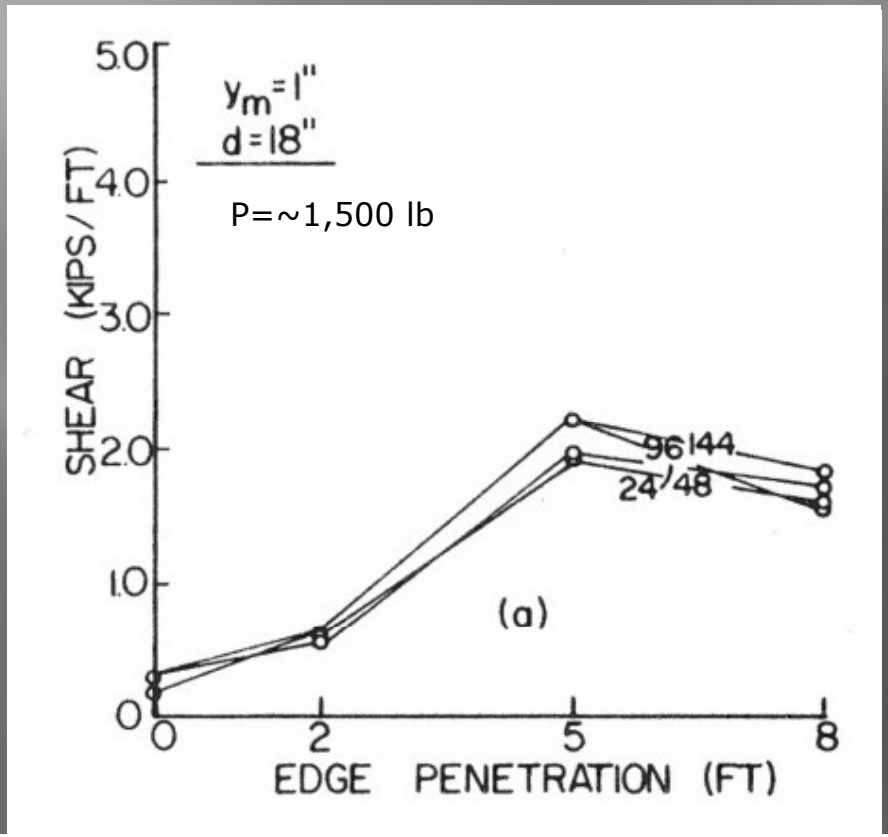

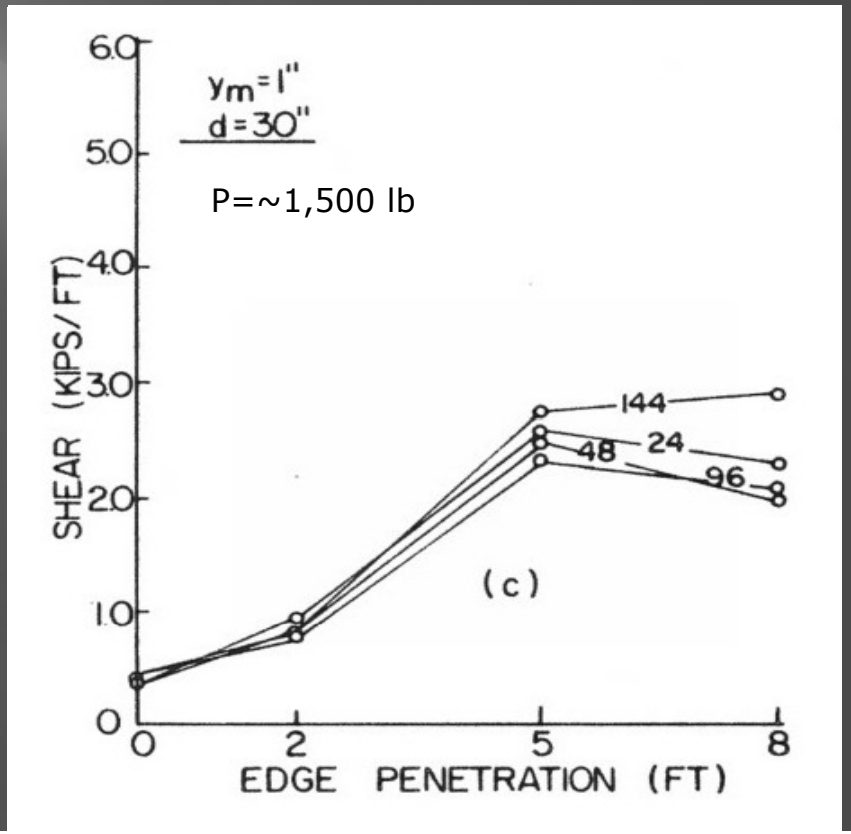

PROPOSED CENTER LIFT SHEAR

Short Direction