Live Load Distribution on Bridge Abutments

Western Bridge Engineers Seminar

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Background

Live Load Distribution on Abutments is a three dimensional phenomenon that is complicated by nonlinear subgrade properties, load configurations and geometric effects. Detailed analytical studies are needed to better understand this phenomenon and propose simple procedures suitable for design.

Scope of the Work

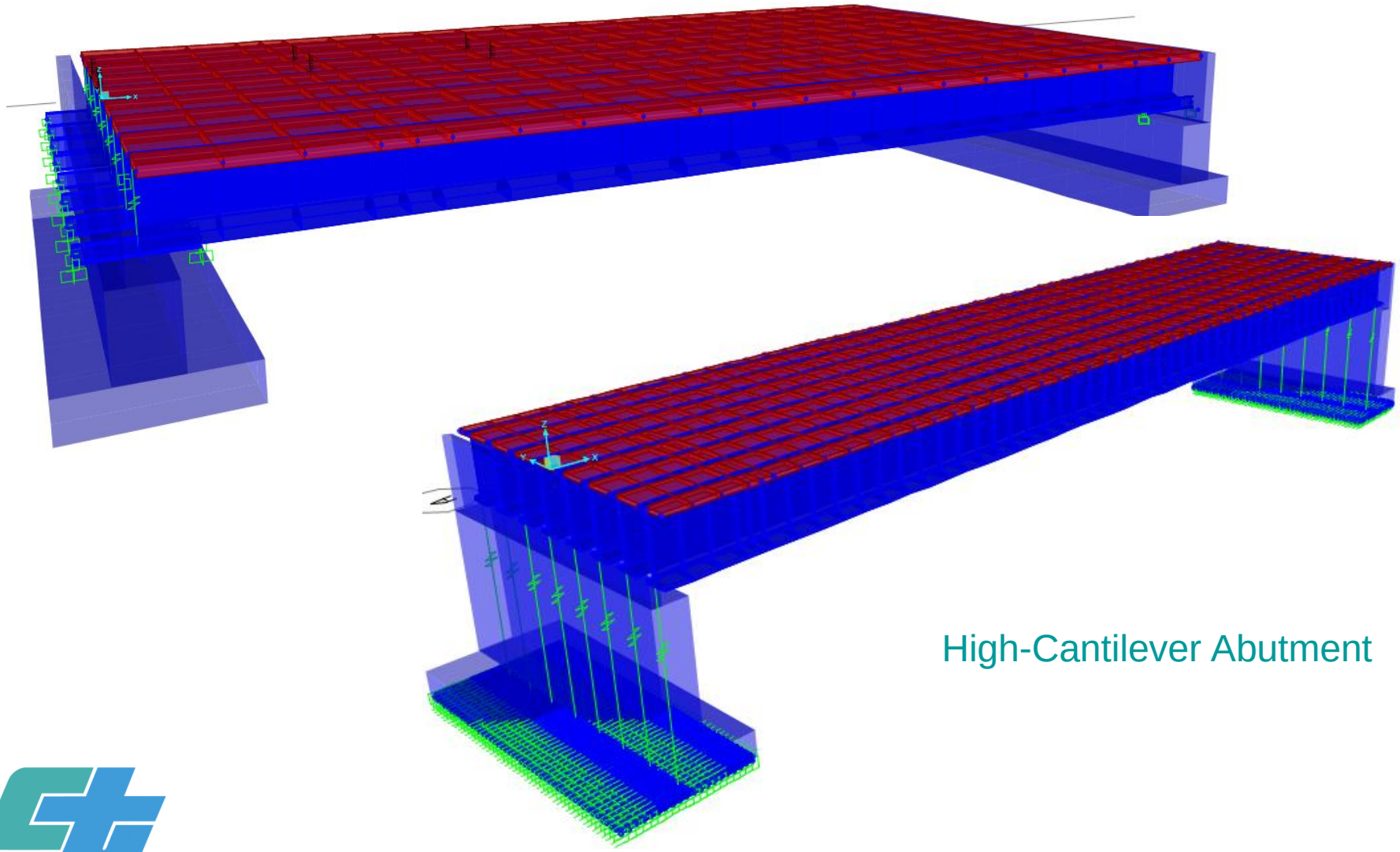
- The scope of the work includes single span bridges with different span lengths (80’ & 200’), widths (24’, 48’, 72’, 96’)
- Precast Girders
- Pile and Spread Footings
- Different soil types
- Short (Seat) and Tall (High-Cantilever) type abutments

Scope of Work (Continued)

- Perform simplified and advanced (3D FE with nonlinear springs) analysis and compare the equivalent number of lanes used for design
- Compare various simplified methods
  - Excel Spreadsheet (45 deg. Distribution)
  - Rigid Footing Analogy
  - Total number of lanes with and without MPF

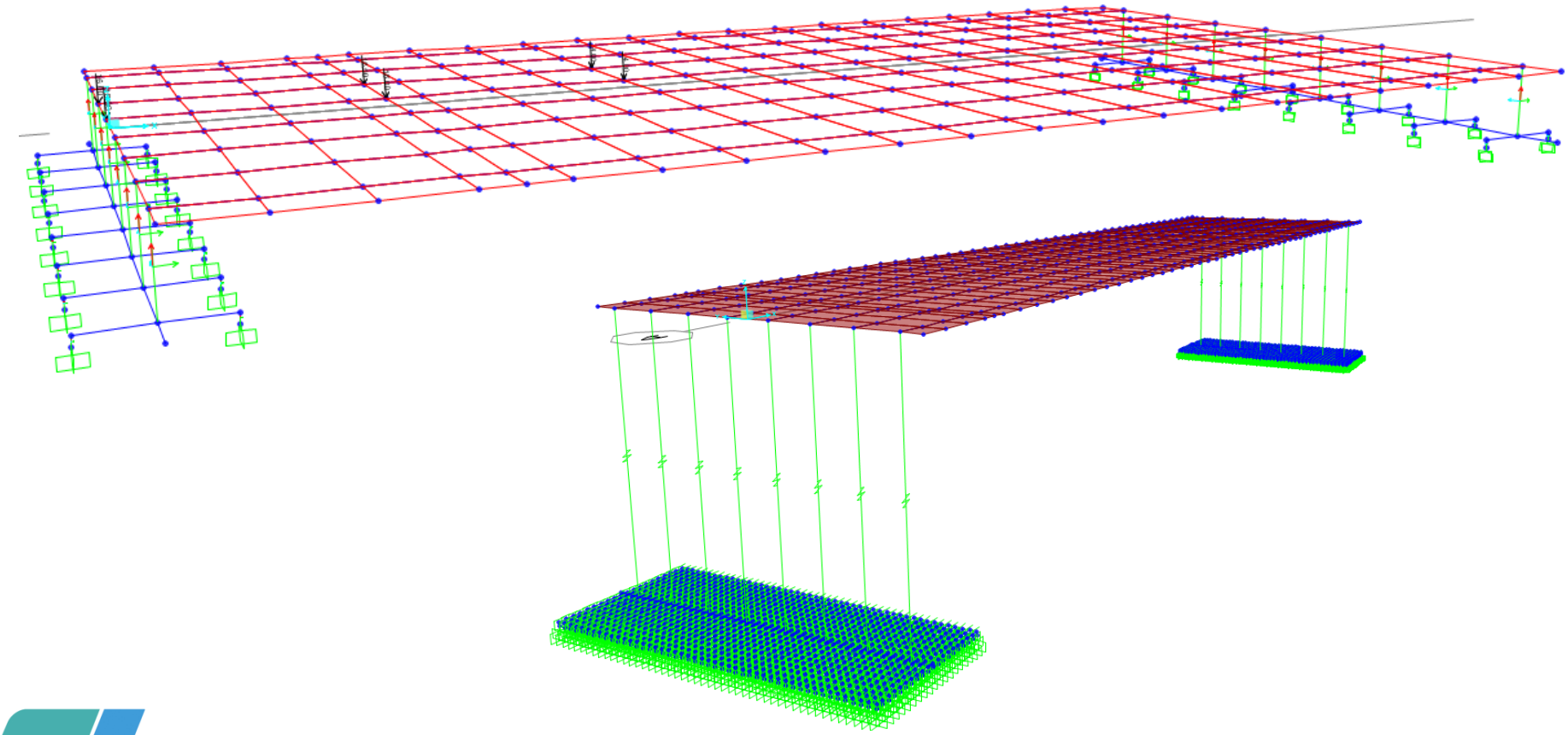
CSI-Bridge

Short-Seat Abutment



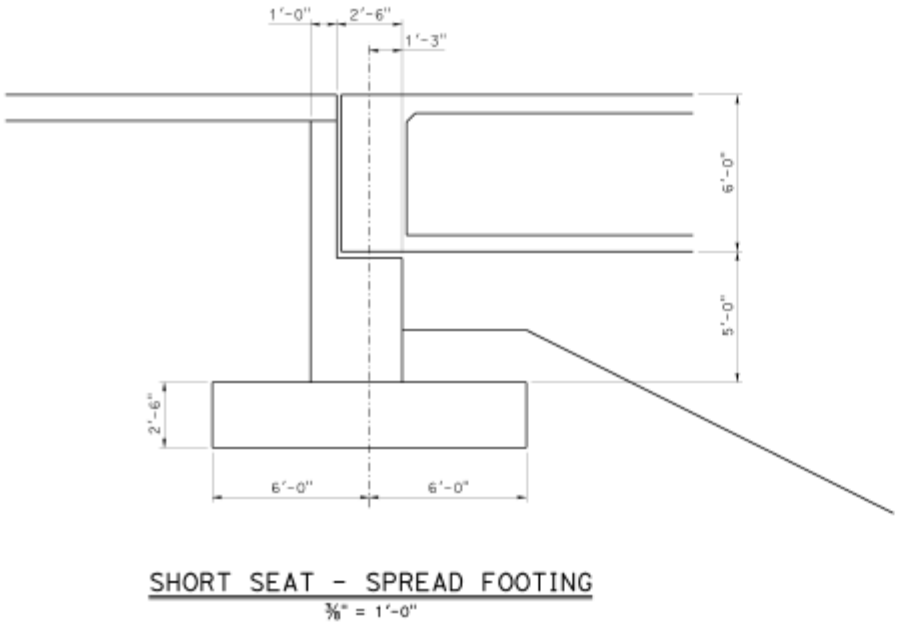
High-Cantilever Abutment

CSI-Bridge: Foundation



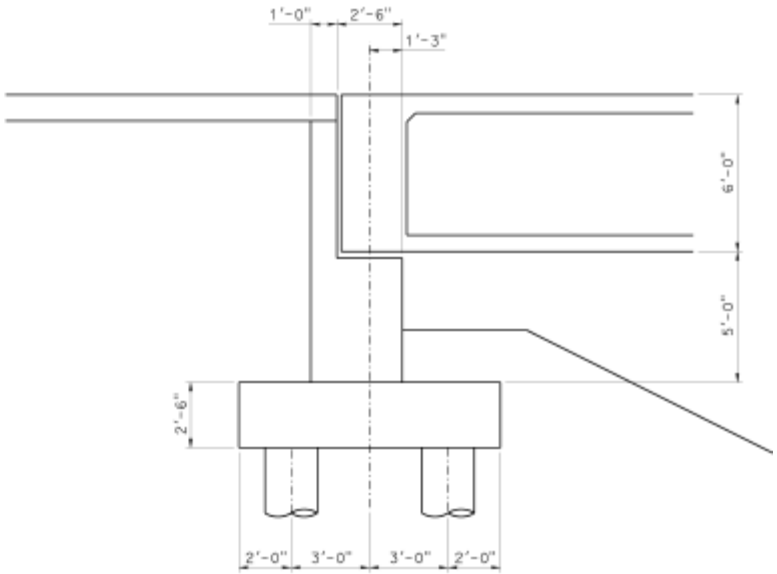
CSI-Bridge: Abutment

Short-Seat Abutments for 80’ span Bridges



SHORT SEAT - SPREAD FOOTING

3/8" = 1'-0"

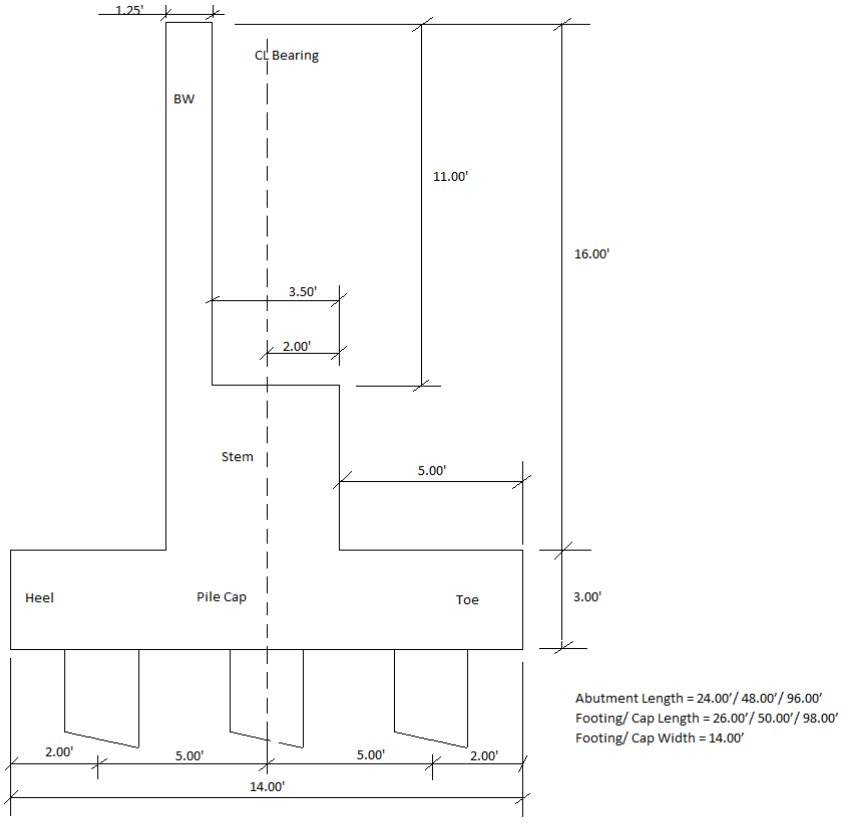


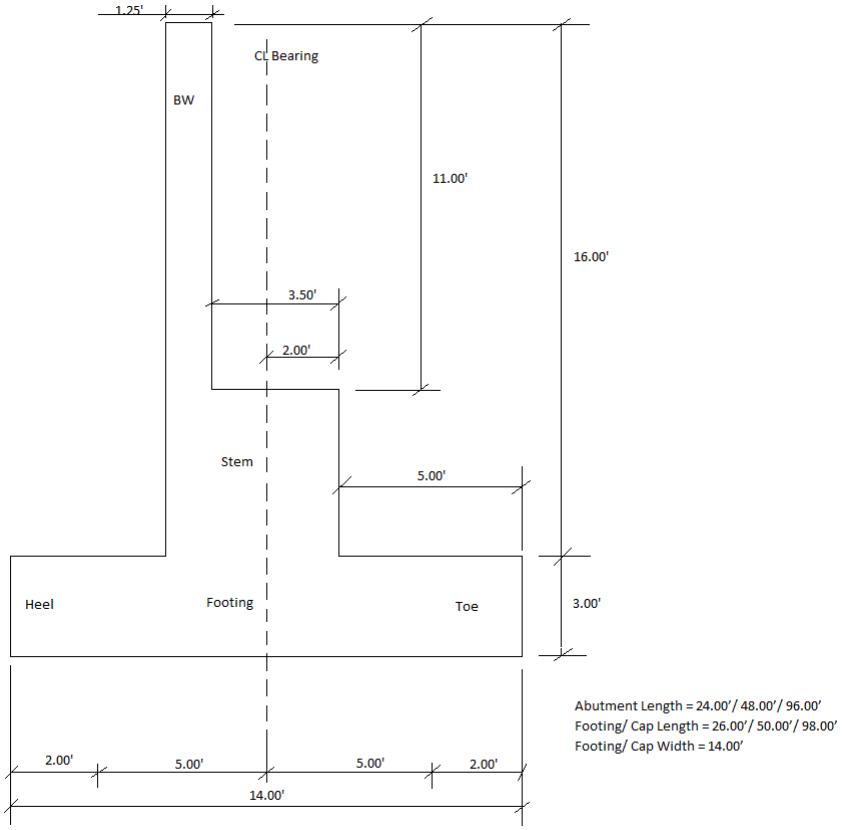
SHORT SEAT - PILE FOOTING

3/8" = 1'-0"

CSI-Bridge: Abutment

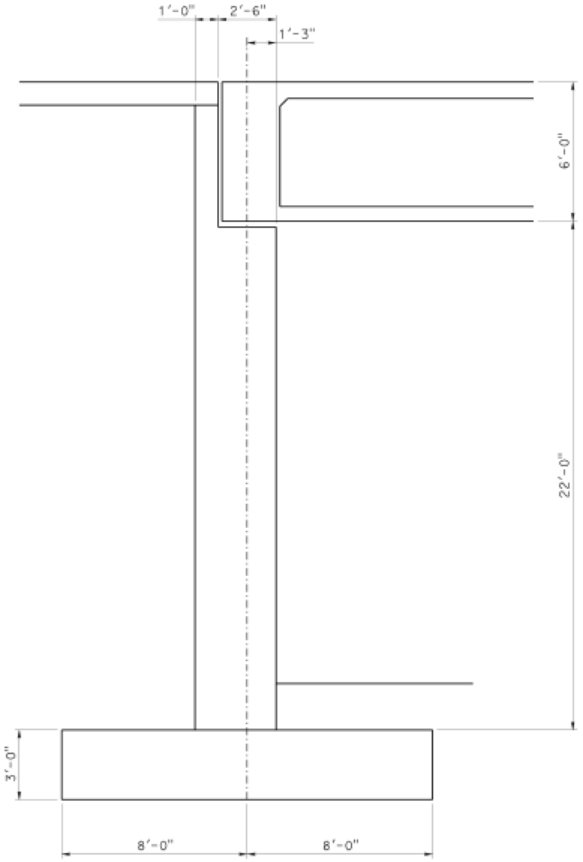
Short-Seat Abutments for 200’ span Bridges



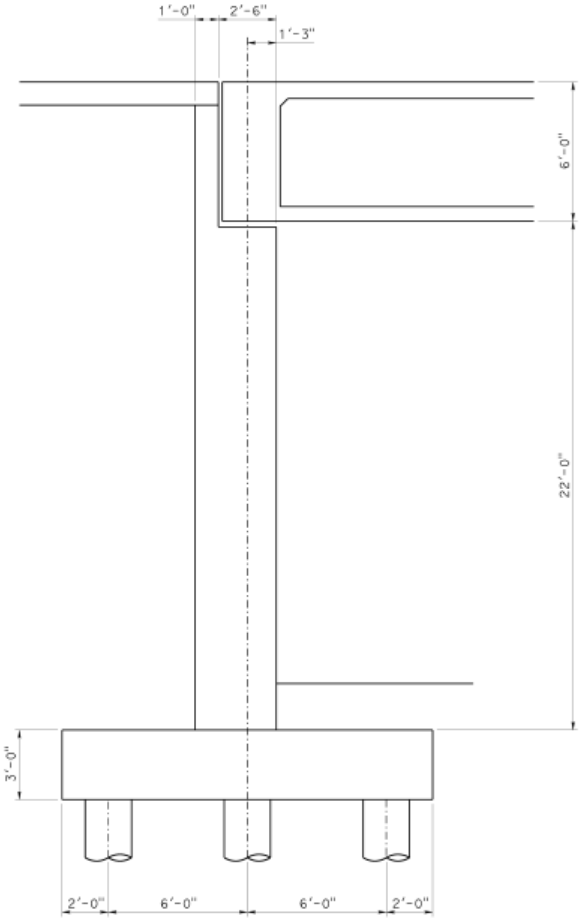


CSI-Bridge: Abutment

High-Cantilever Abutments for 80’ span Bridges



HIGH CANTILEVER - SPREAD FOOTING
3/8" = 1'-0"



HIGH CANTILEVER - PILE FOOTING
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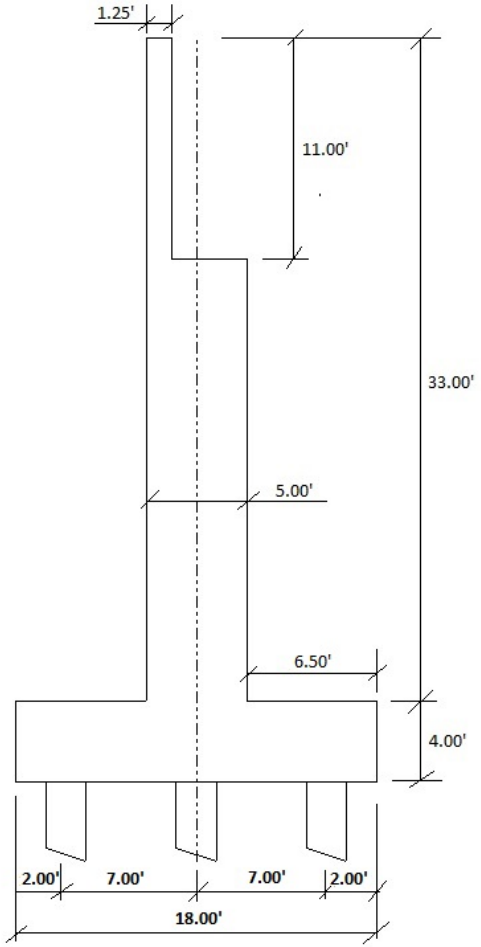
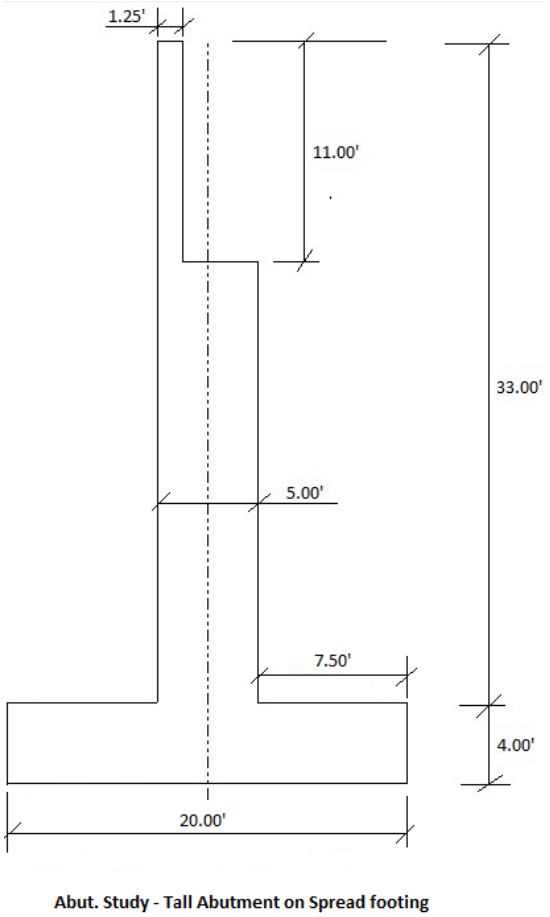
CSI-Bridge: Abutment

High-Cantilever Abutments for 200’ span Bridges



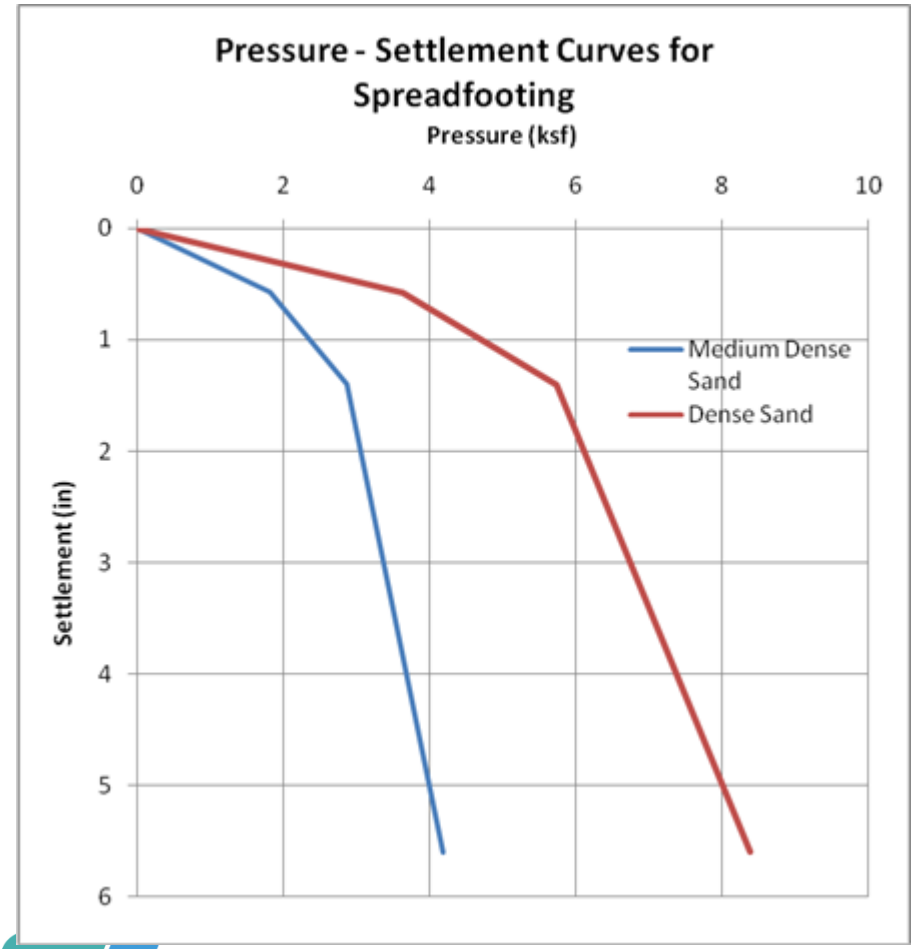
Abut Study Tall Abut Pile

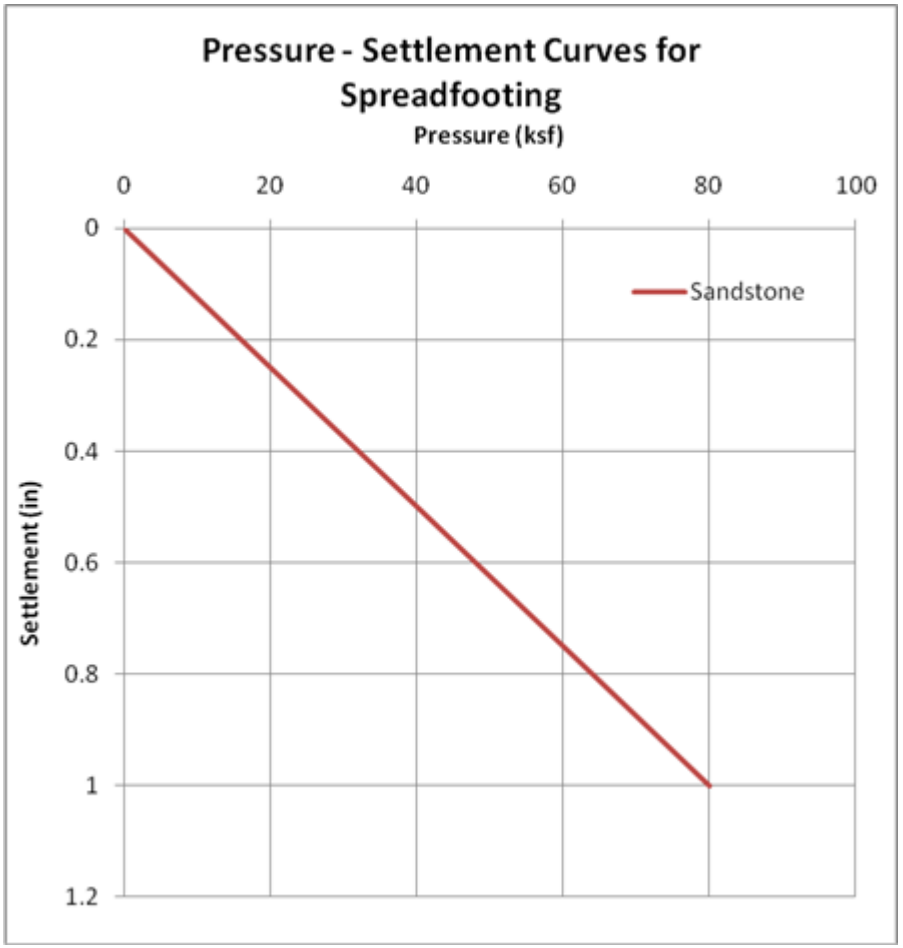


Abut. Study - Tall Abutment on Spread footing

CSI-Bridge: Subgrade

Foundation Stiffness – Spread Footings

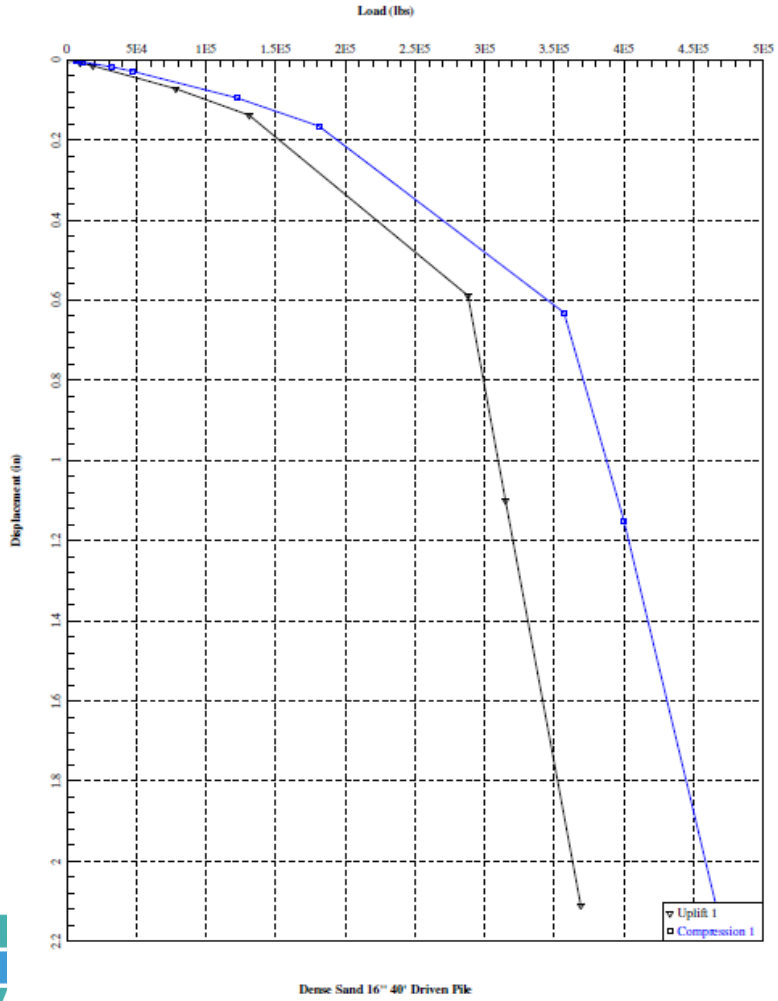




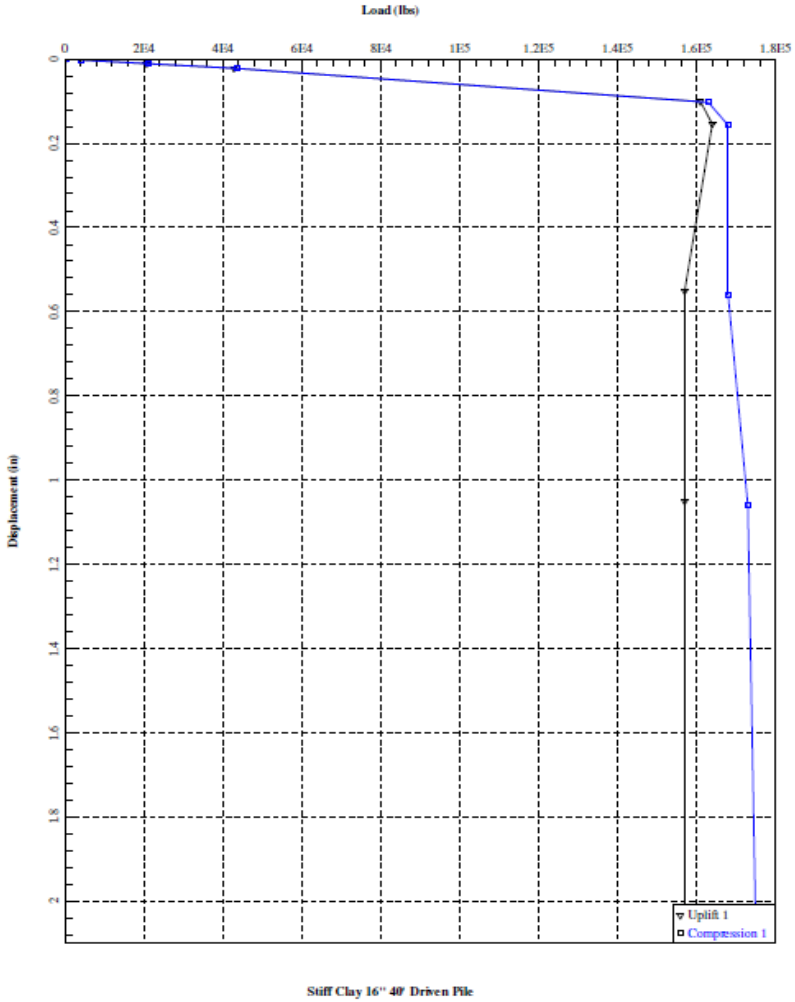
CSI-Bridge: Subgrade

Foundation Stiffness – Pile Footings

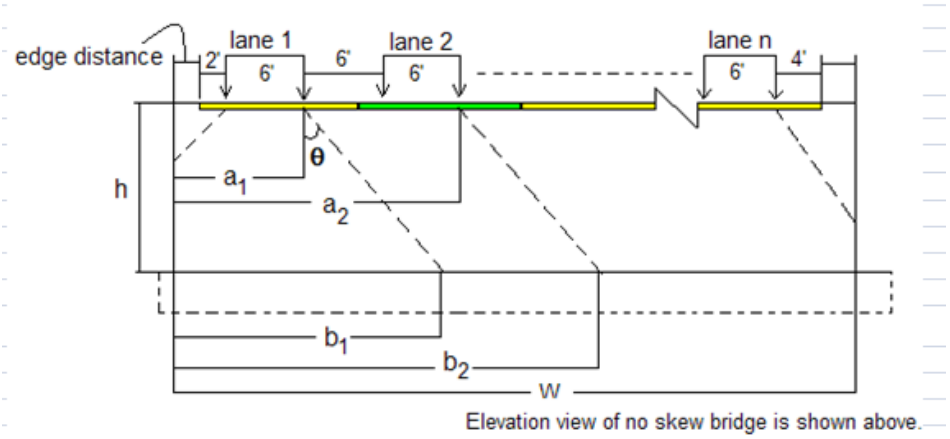
Dense Sand

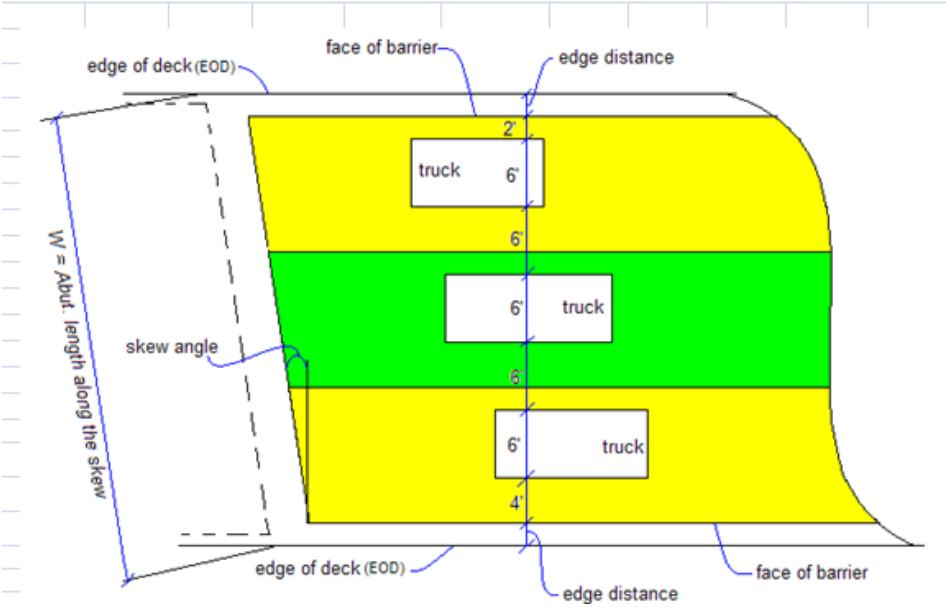


Clay

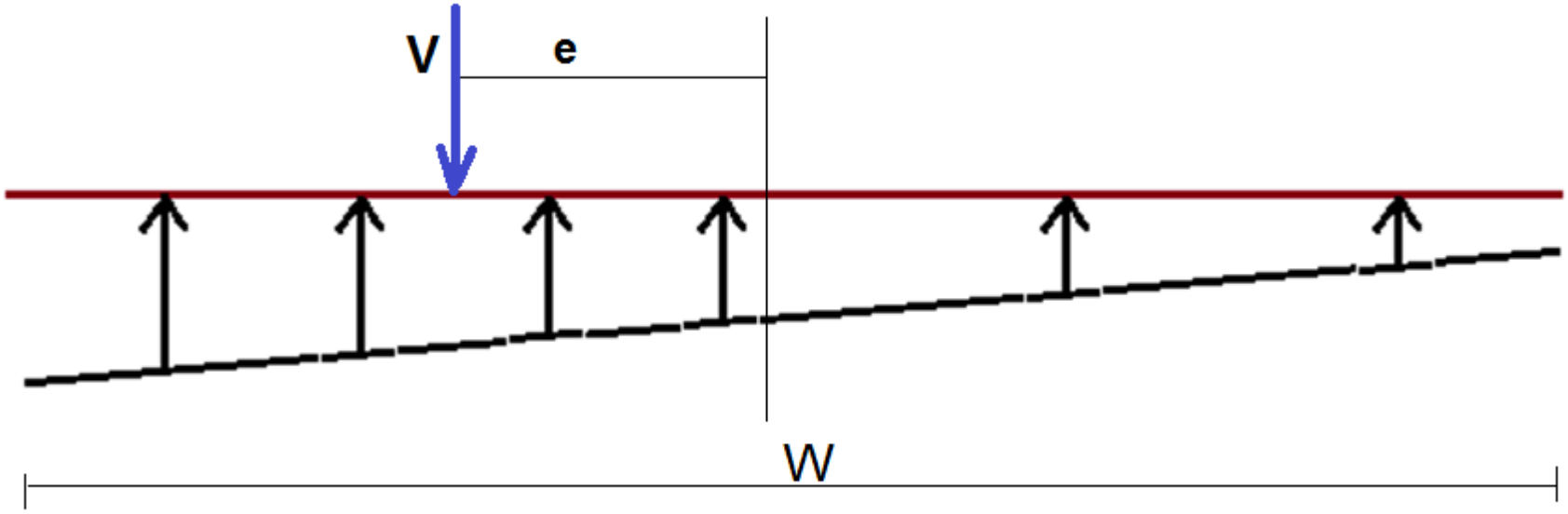


Simplified Analysis - Excel





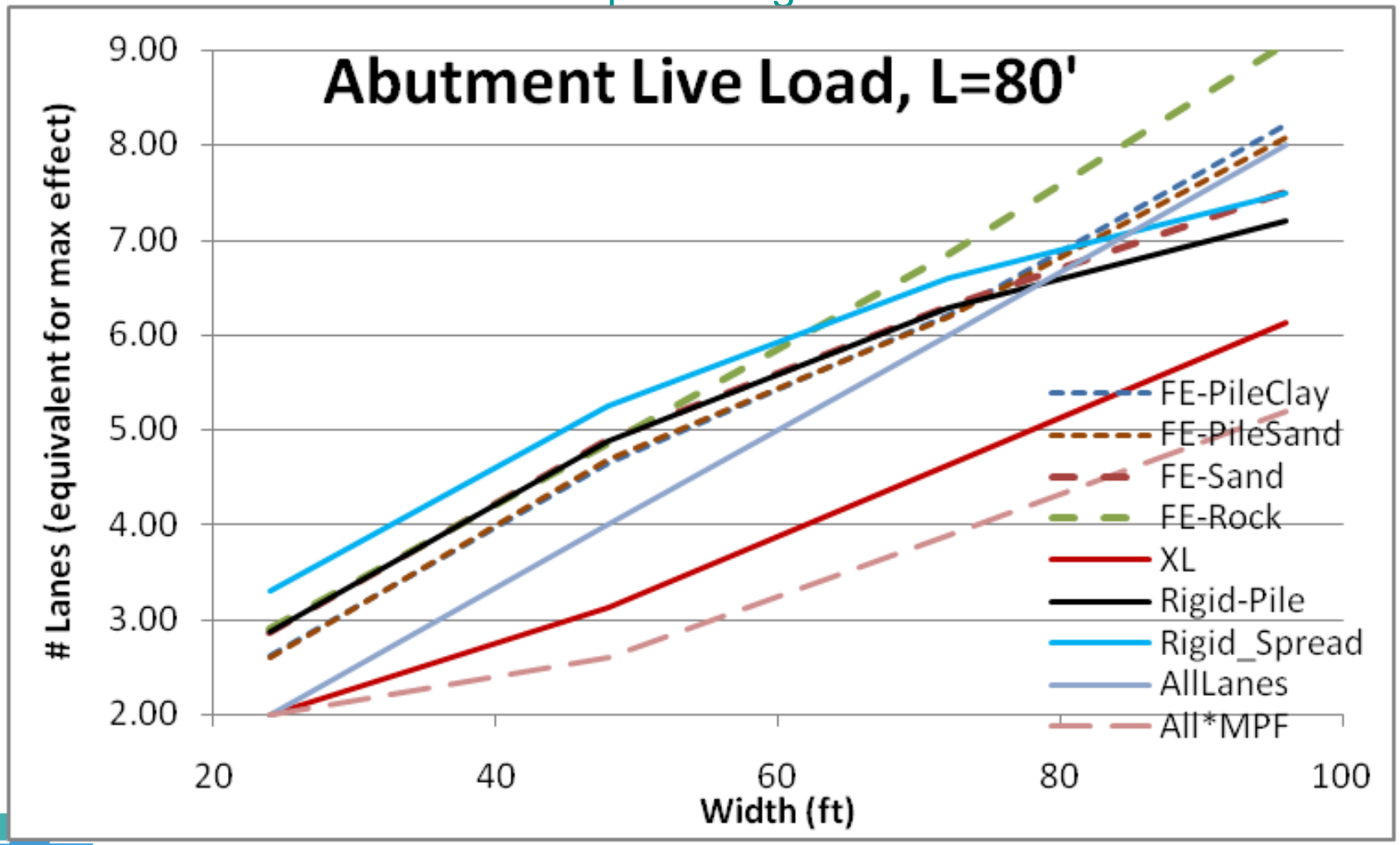
Simplified Analysis – Rigid Ftg



Side Pressure = $V * (\frac{6e}{W^2} + \frac{1}{W})$

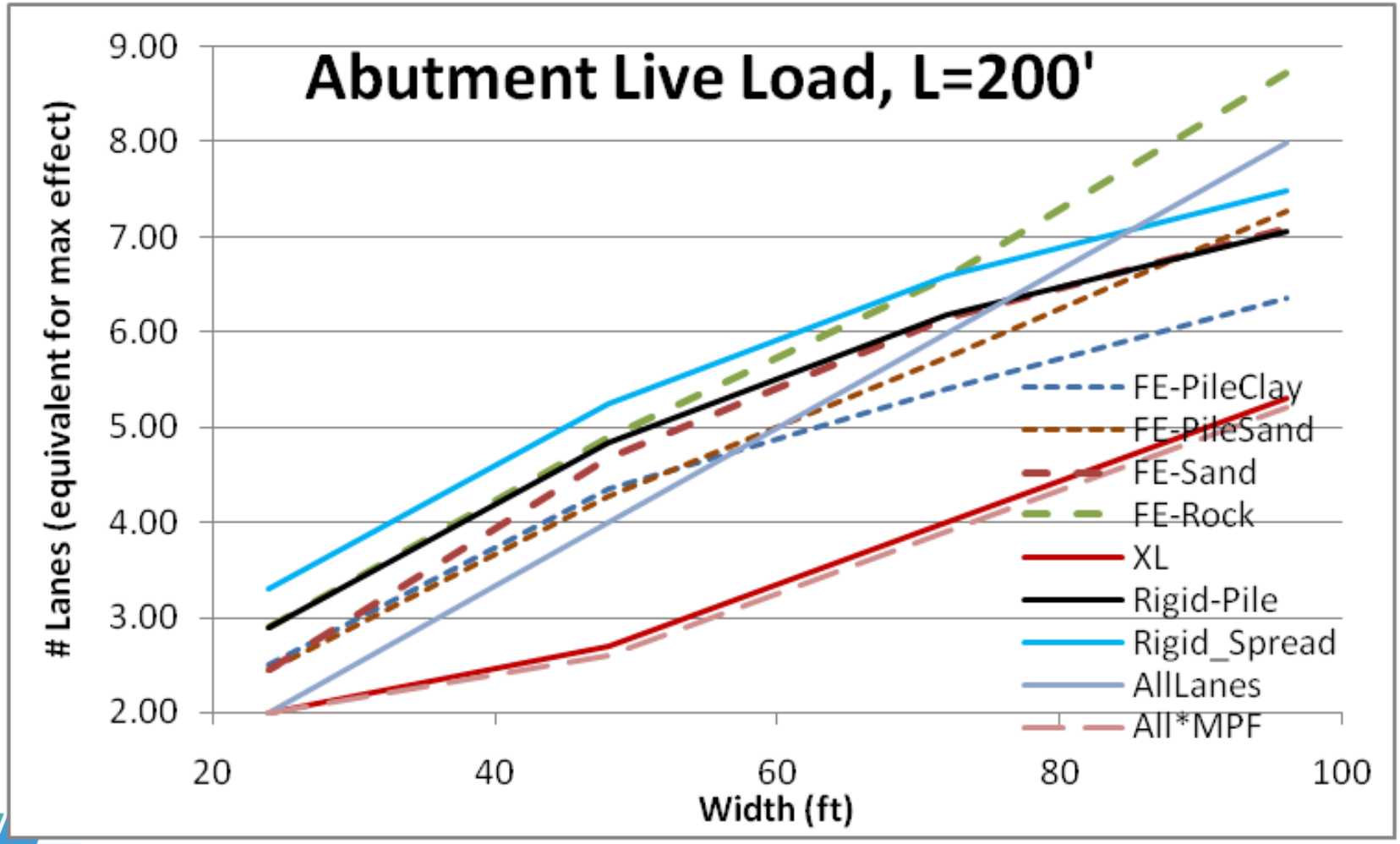
Summary of Results

Short-Seat Abutments for 80’ span Bridges



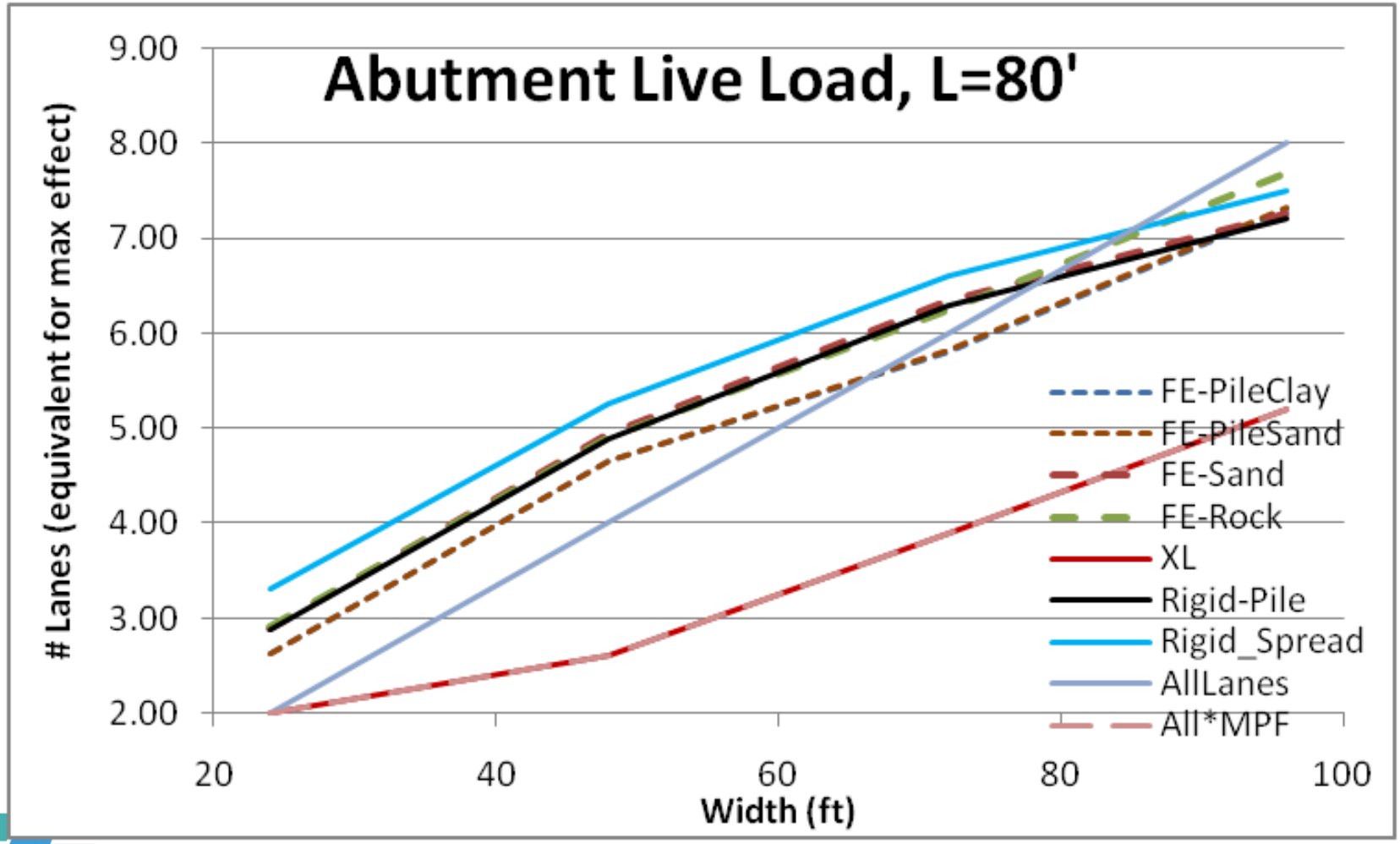
Summary of Results

Short-Seat Abutments for 200’ span Bridges



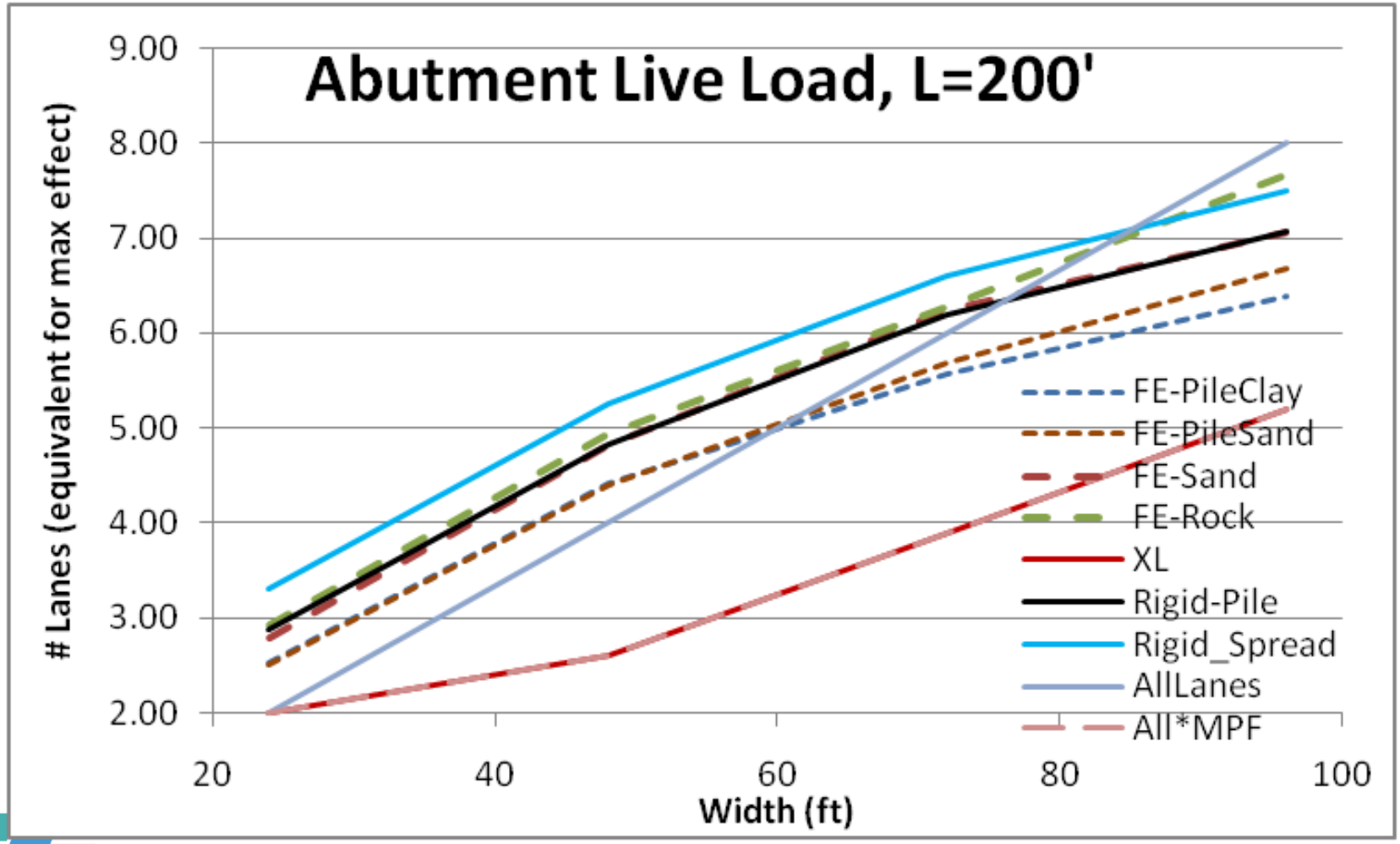
Summary of Results

High-Cantilever Abutments for 80’ span Bridges



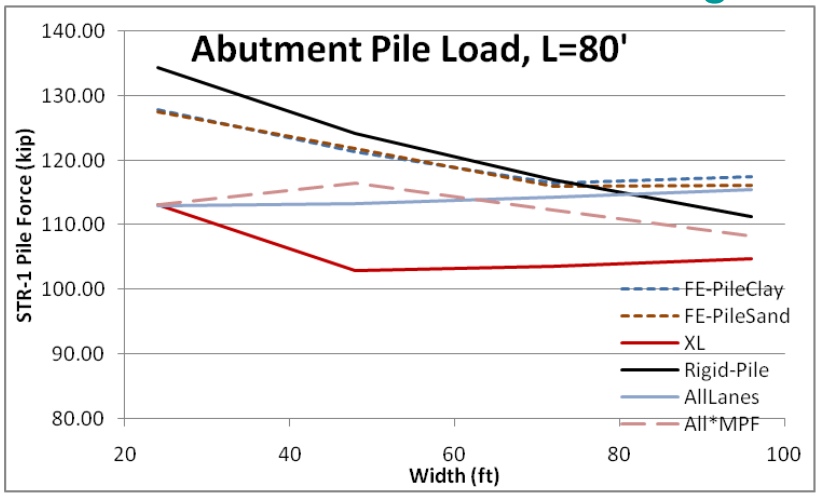
Summary of Results

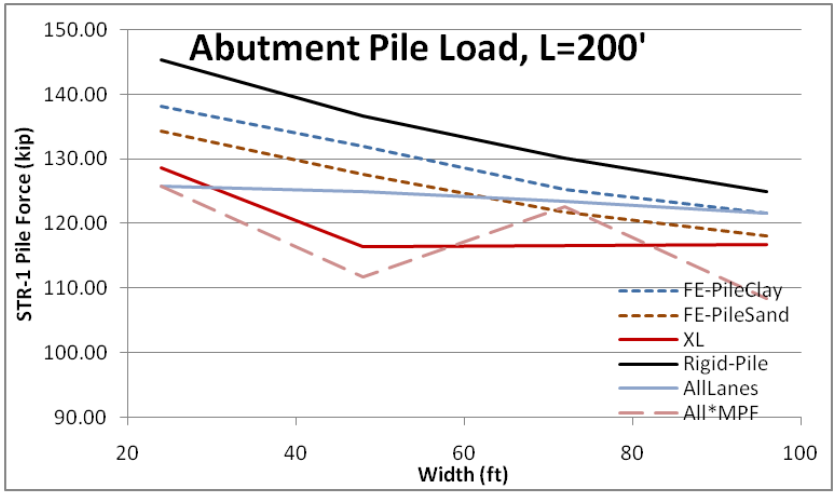
High Cantilever Abutments for 200’ span Bridges

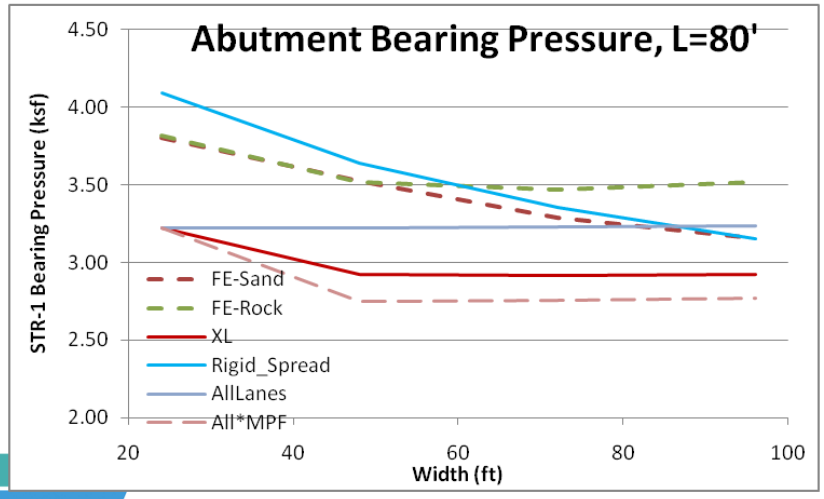


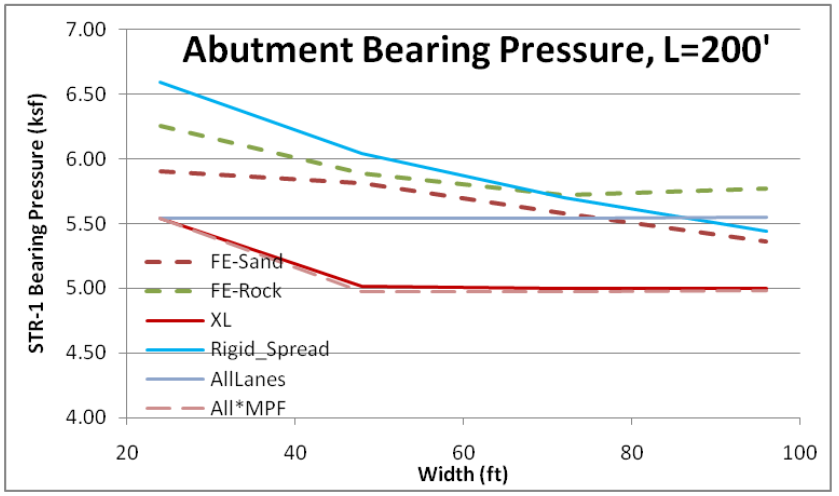
Summary of Results

Short-Seat Abutments: Strength-1 Results









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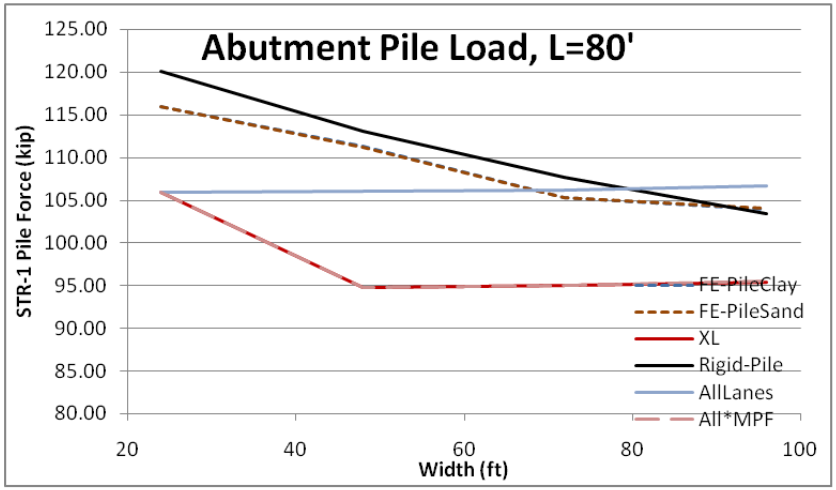
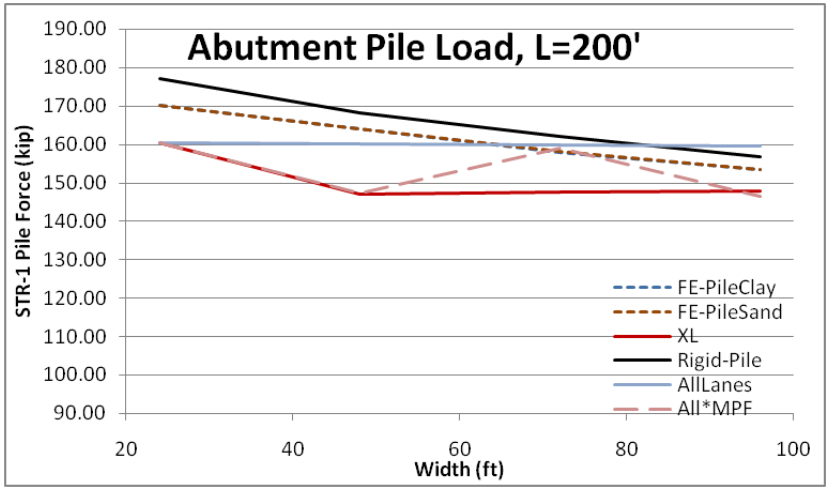
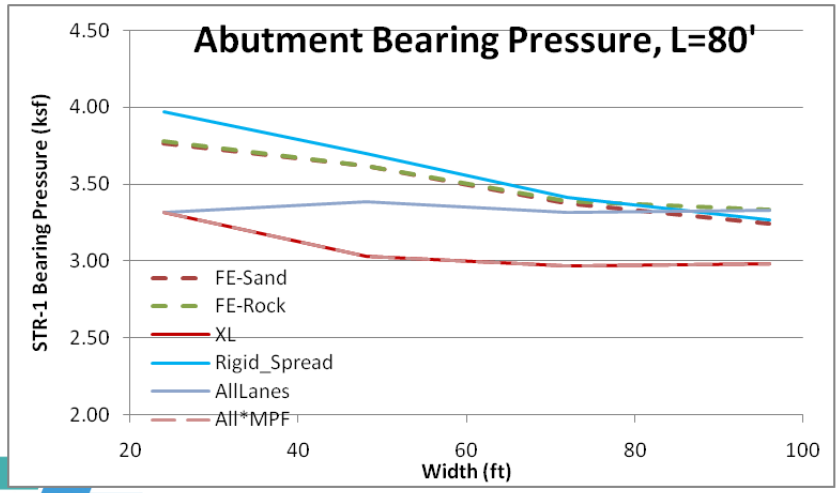
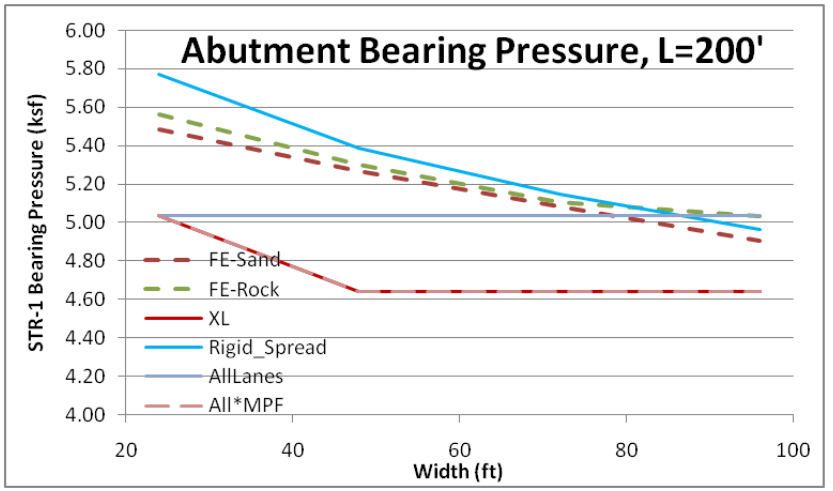


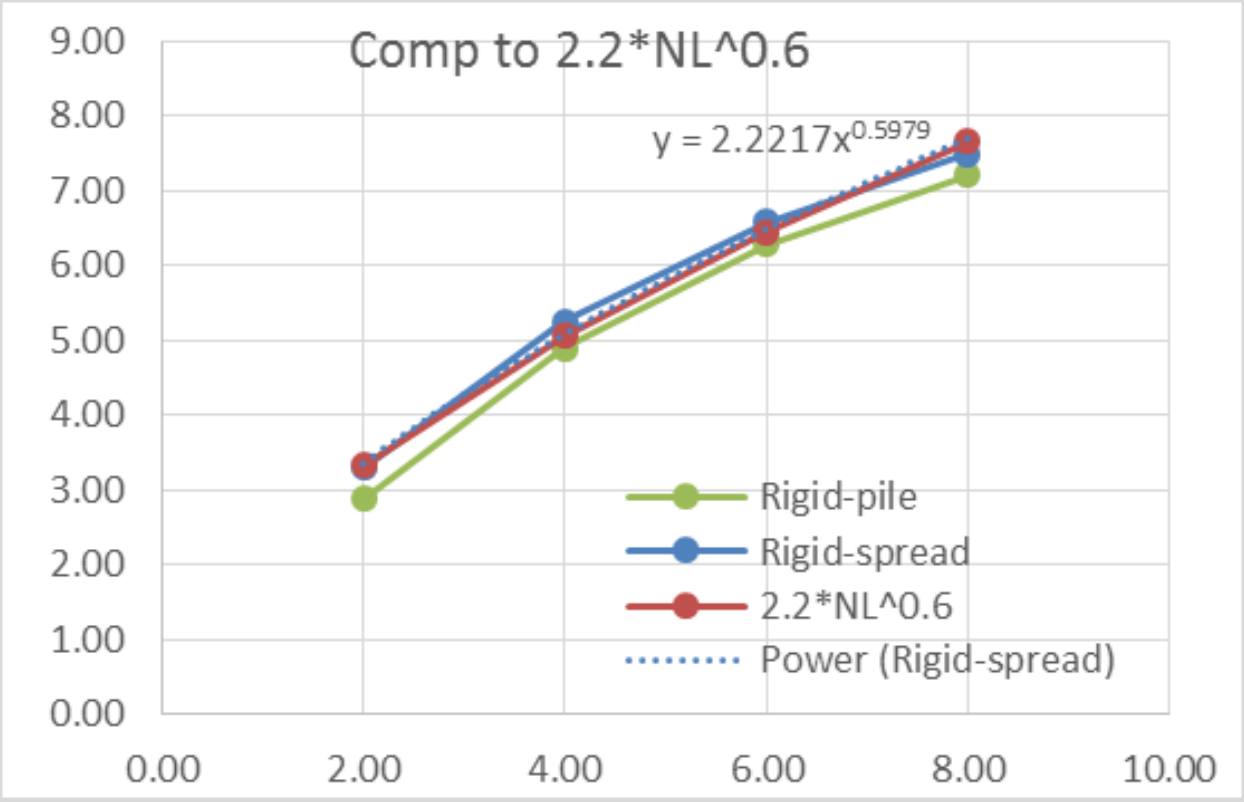






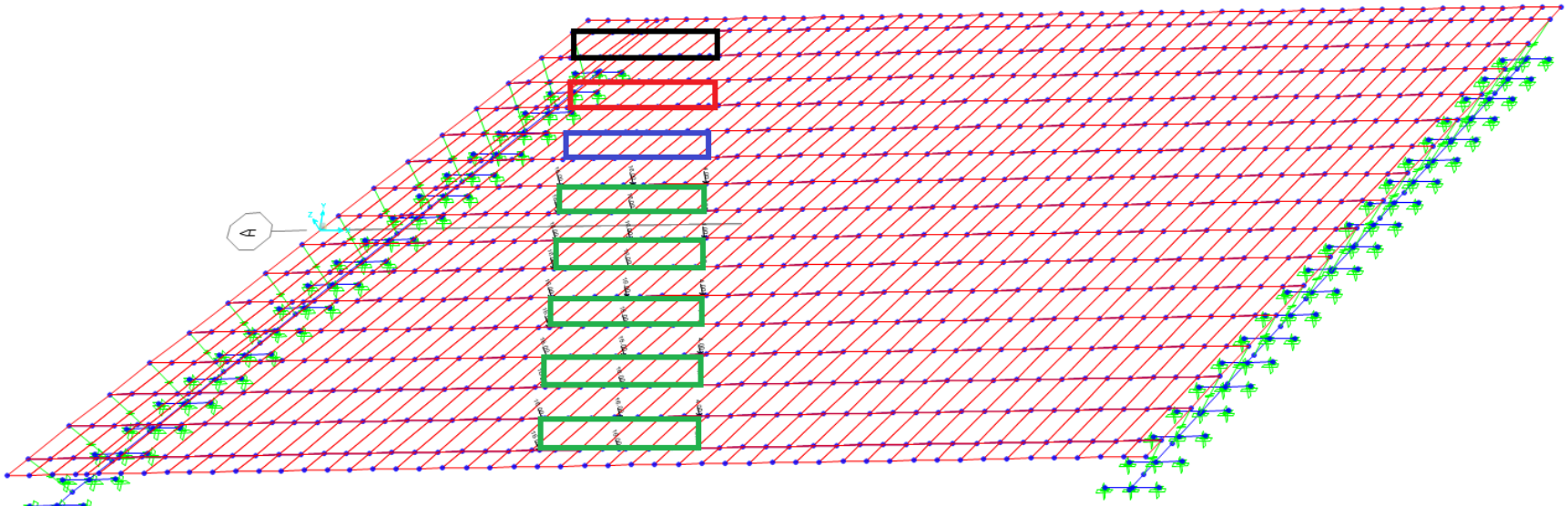
Abutment Live Load Equation Fit

- Number of lanes fro analysis = $2.2*NL^{0.6}$
- NL = Width/12.0 (decimal, not rounded)

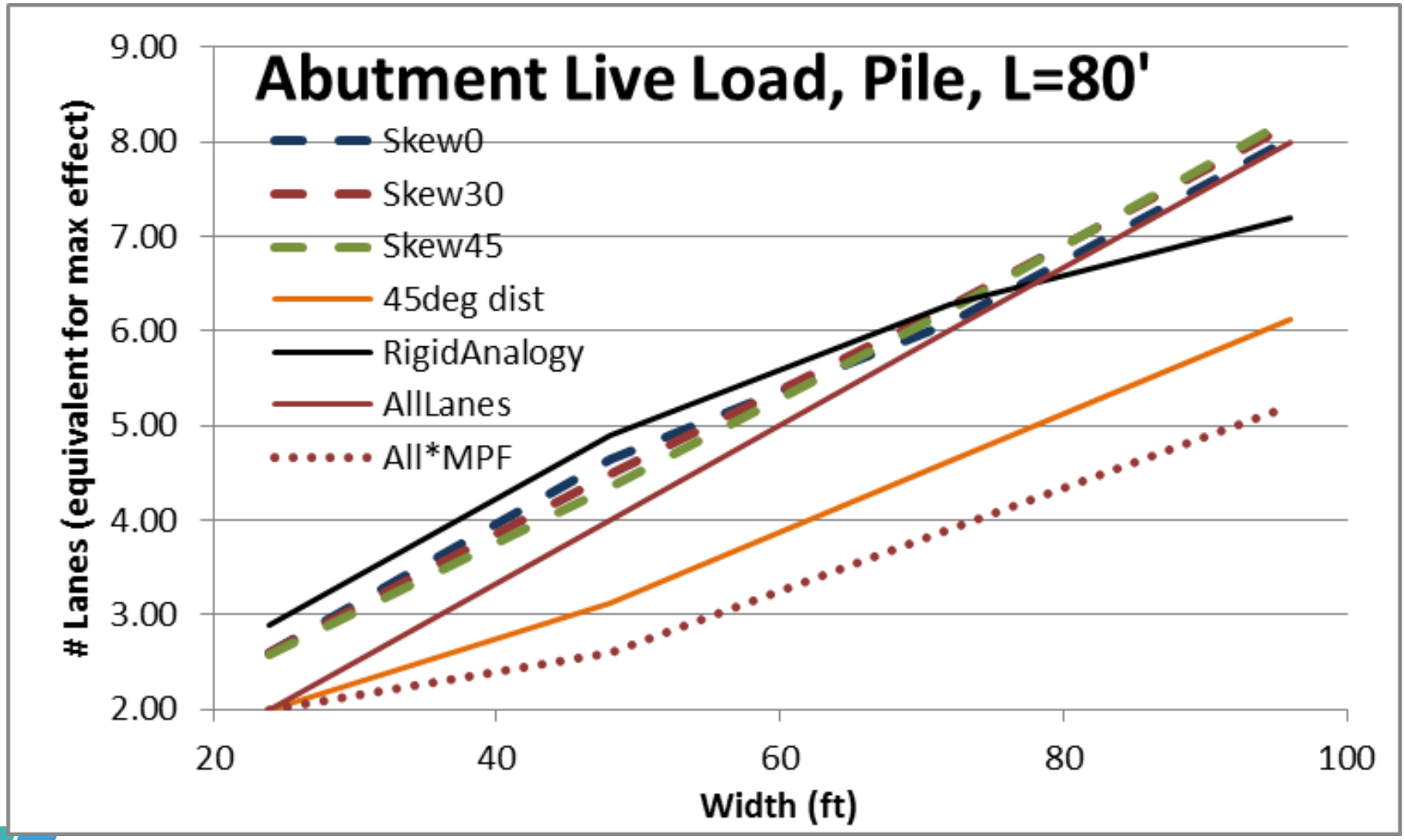


Skew Effect

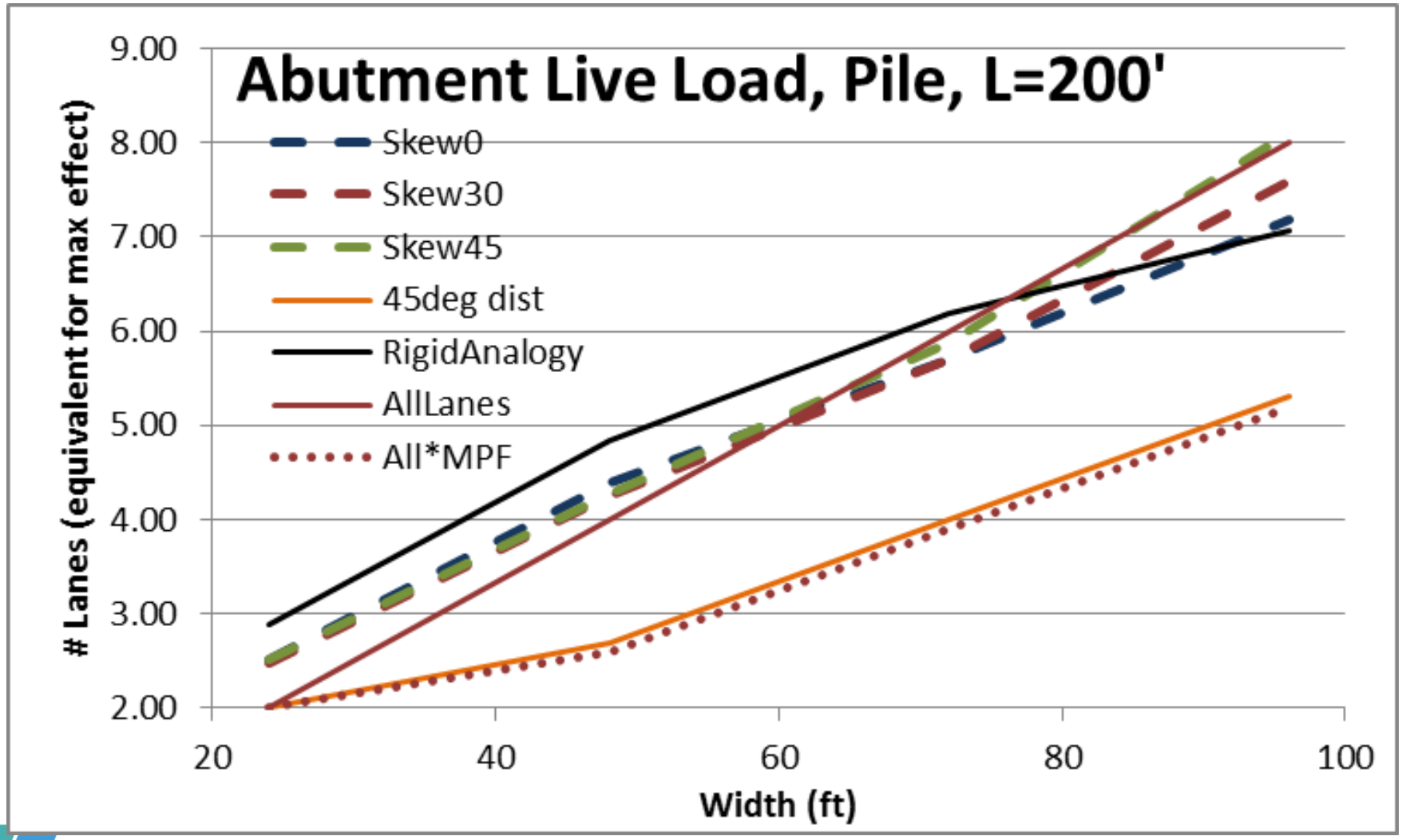
- Short Seat 80’ and 200’ Span Bridge Models
- Pile Supports (NO Spread Footings)
- Equal Skew at both Abutments
- Skewed Supports at 0, 30, and 45 degrees
- Loads placed at same longitudinal location



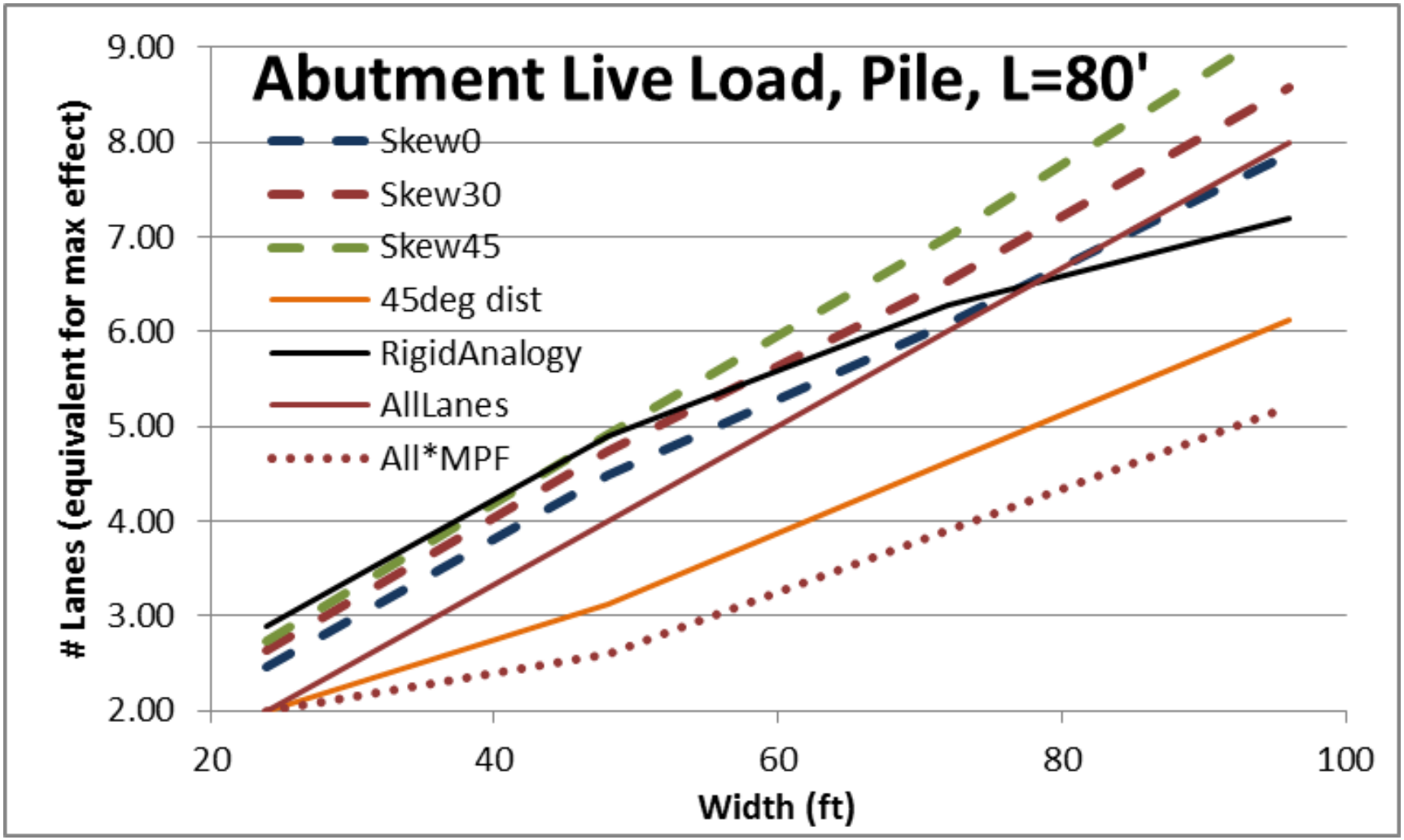
LL Skew Effect (Precast)



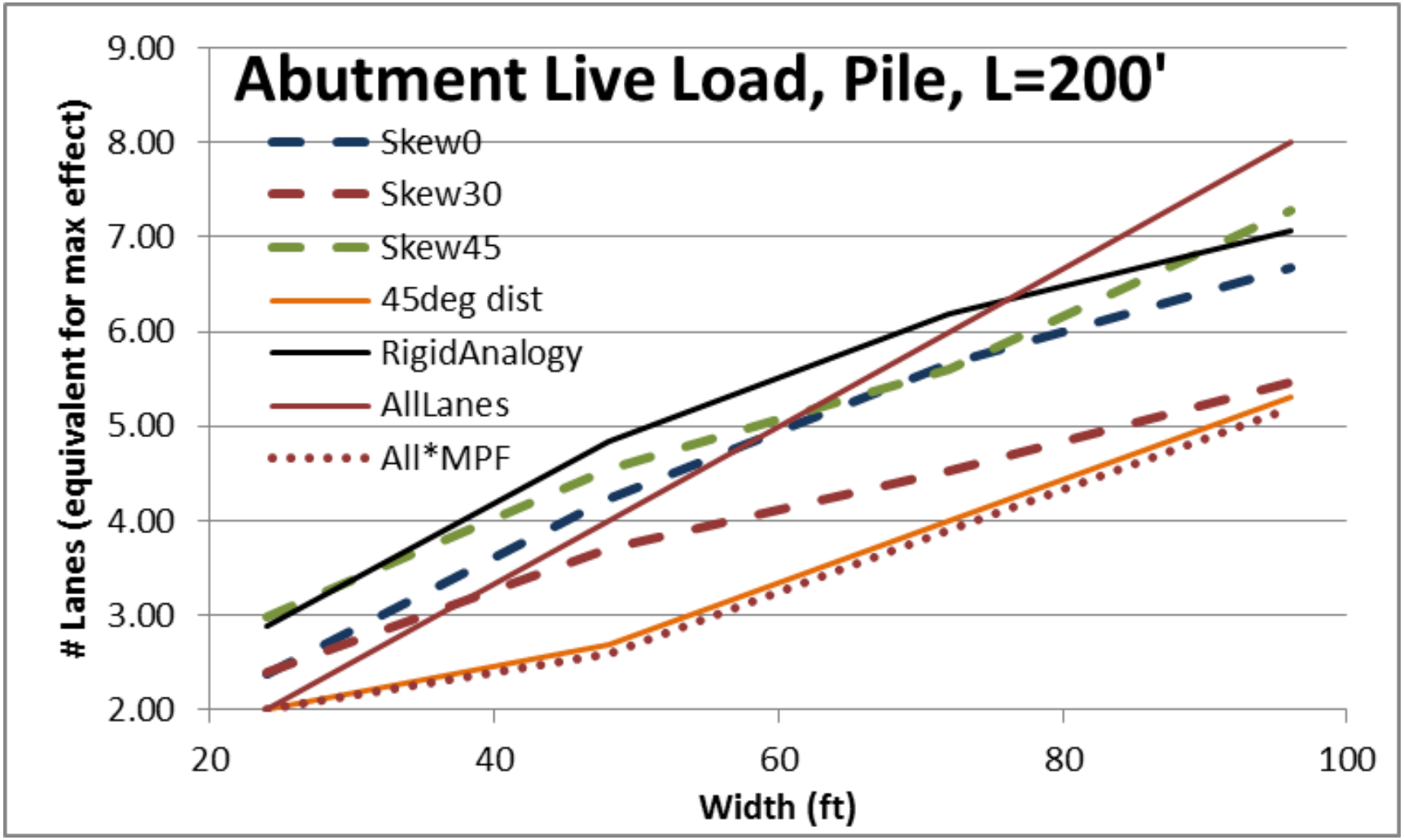
LL Skew Effect (Precast)



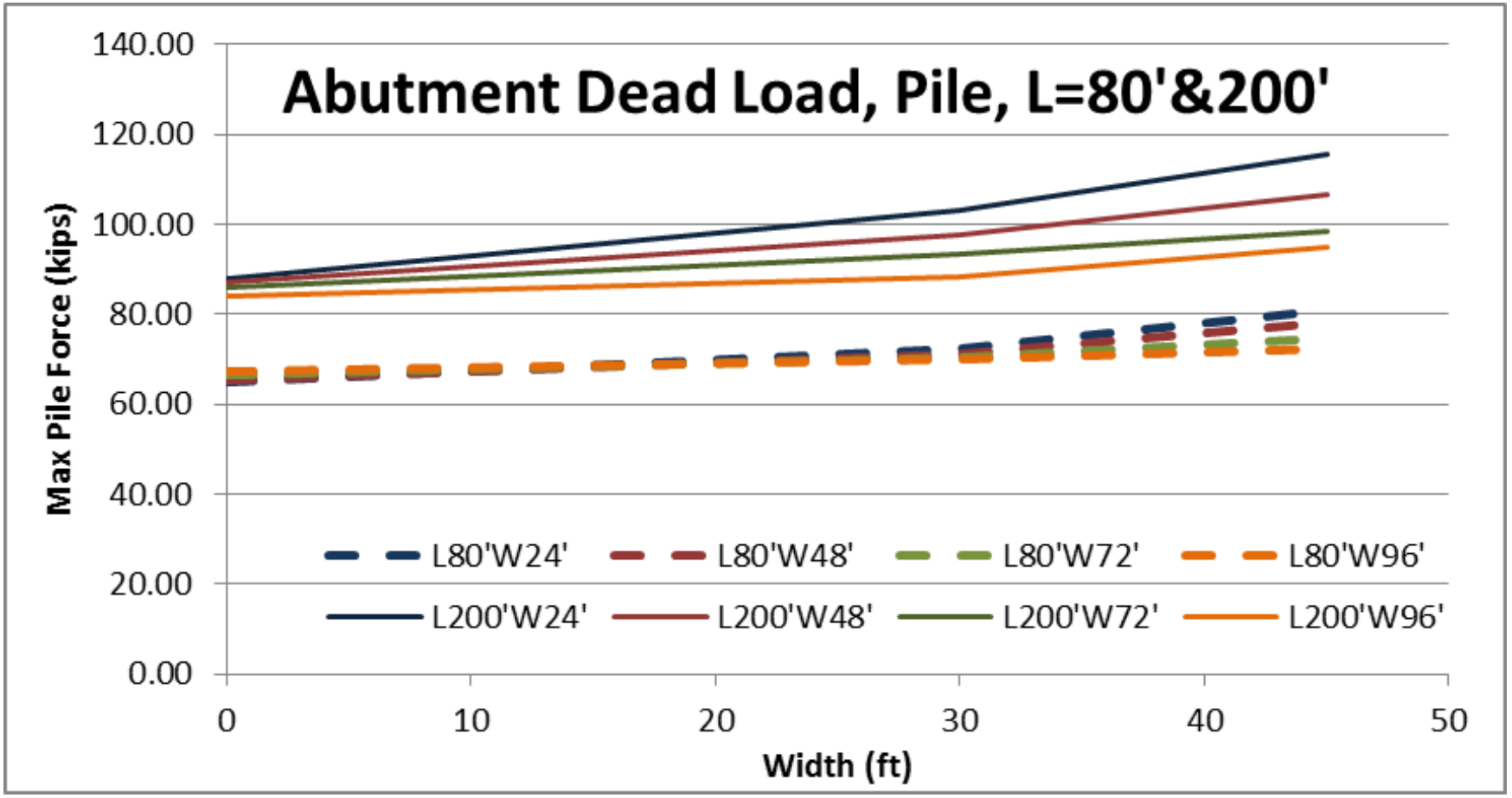
LL Skew Effect (CIP Box Girder)



LL Skew Effect (CIP Box Girder)



DL Skew Effect (Precast)



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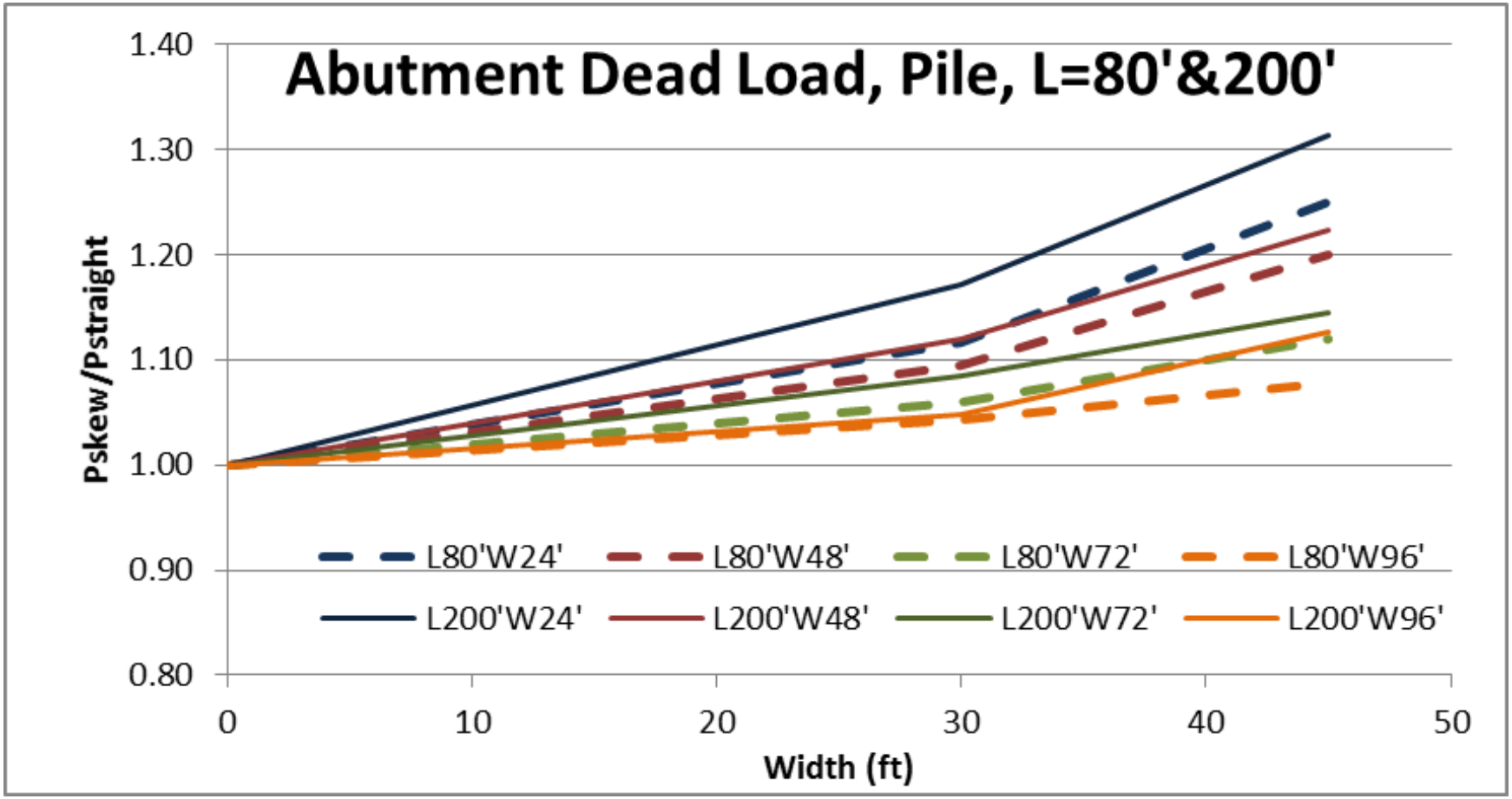

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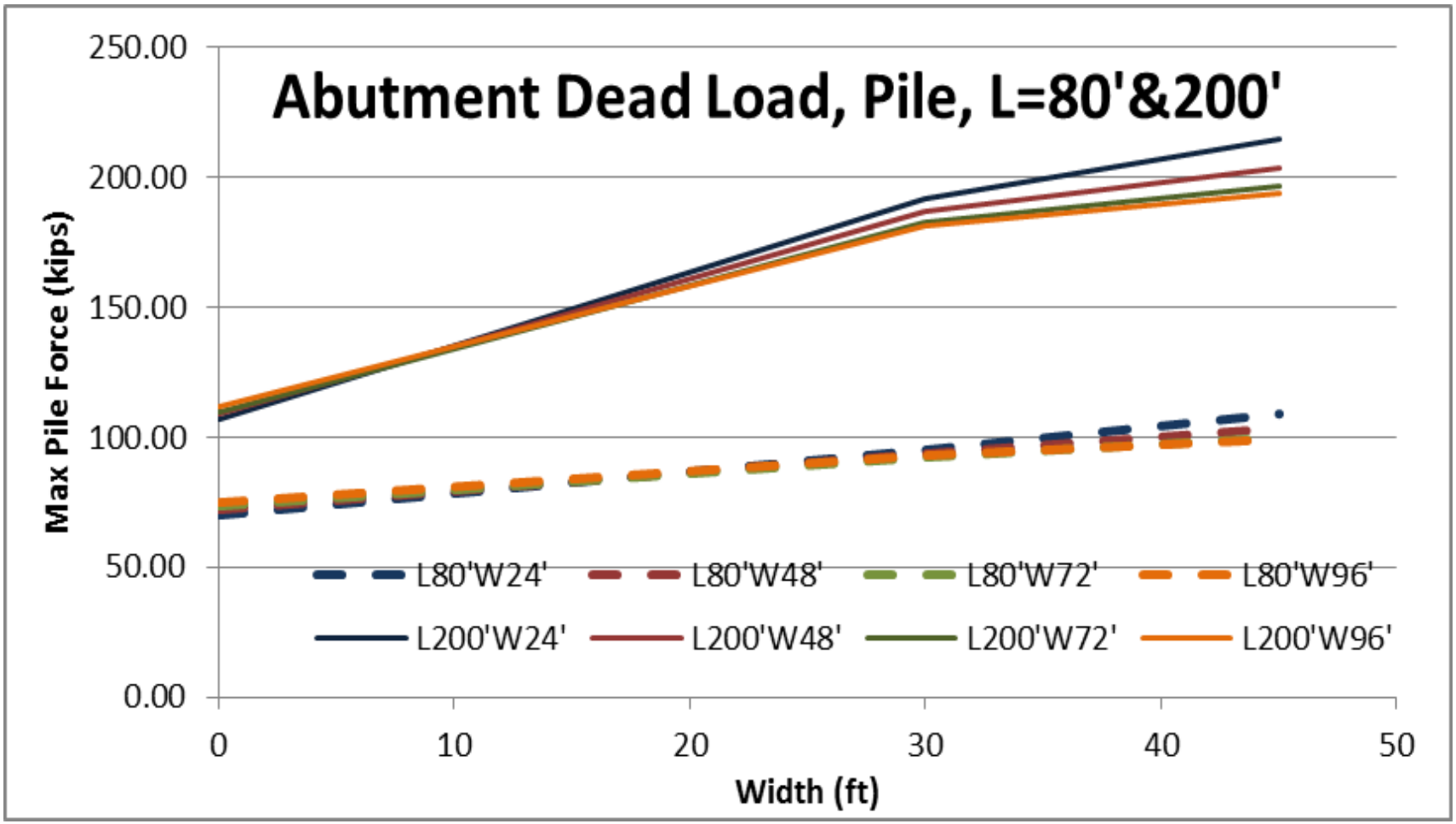

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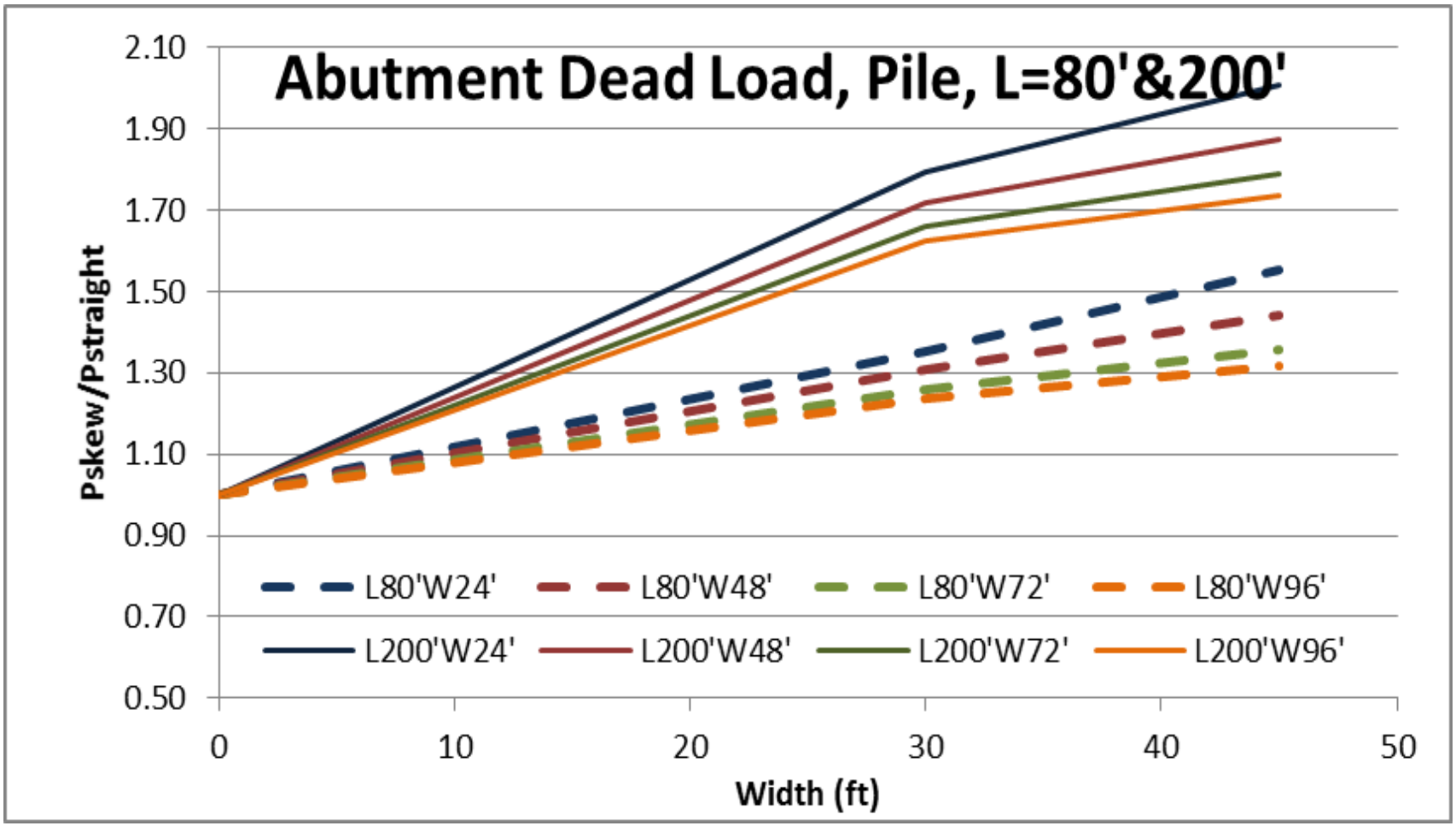

Conclusions

- The spreadsheet (45 degree distribution) method is not always conservative
- Tall (Cantilever) abutment results show similar trends to Short-Seat
- Rigid Analogy is fairly accurate in most cases
- In Softer foundations, load distribution is more uniform and Rigid Analogy tends to be conservative

Conclusions

- Live load response on abutment is not affected by skew angle
- Rigid Analogy works well for live load distribution in skewed abutments
- Curve fit for live load distribution works well:

  $\#Lanes = 2.2*NL^{0.6}$ or

  $\#Lanes = 0.56*W^{0.6}$ (W=Bridge Width, NL=W/12.0)
- Skew affects the dead load response
- Skew effect on DL is more pronounced in box girder bridges

Questions?