



# Methods for IEB Design

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## Design Issues:

- *No single nationally accepted method for analysis and design of integral abutment bridges.*
- *AASHTO Standard Specifications for Highway Bridges 17<sup>th</sup> Edition does not address.*
- *AASHTO LRFD Bridge Design Specifications 3<sup>rd</sup> Ed., Art. 11.6.1.3, recommends following FHWA Technical Advisory T 5140.13 (1980).*
- *Not all states have approved the use of integral bridges.*
- *Active states have developed their own comfort envelope for when to use integral bridges.*

# Methods for IEB Design

Three Main Design Methodologies:

1. No Analysis of Lateral Effects.
2. Simplified Analysis of Lateral Effects.
3. Rigorous Analysis of Lateral Effects.

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# Methods for IEB Design

## 1. No Analysis of Lateral Effects.

- Design bridge using conventional approach and neglect any additional potential loading.
- $(DL_{TOTAL} + LL_{TOTAL}) / \text{Allowable Pile Load} = \# \text{ of Piles}$
- Lateral forces and movements are neglected.
- Some engineers use this approach when the bridge is within the DOT's established comfort envelope for length, skew, etc.
- Most often occurs when the DOT has a long history of using integral bridges and has standardized the detailing of the abutments.
- Incorporate the DOT's standard detailing practices at the abutments.

# Methods for IEB Design

## Three Main Design Methodologies:

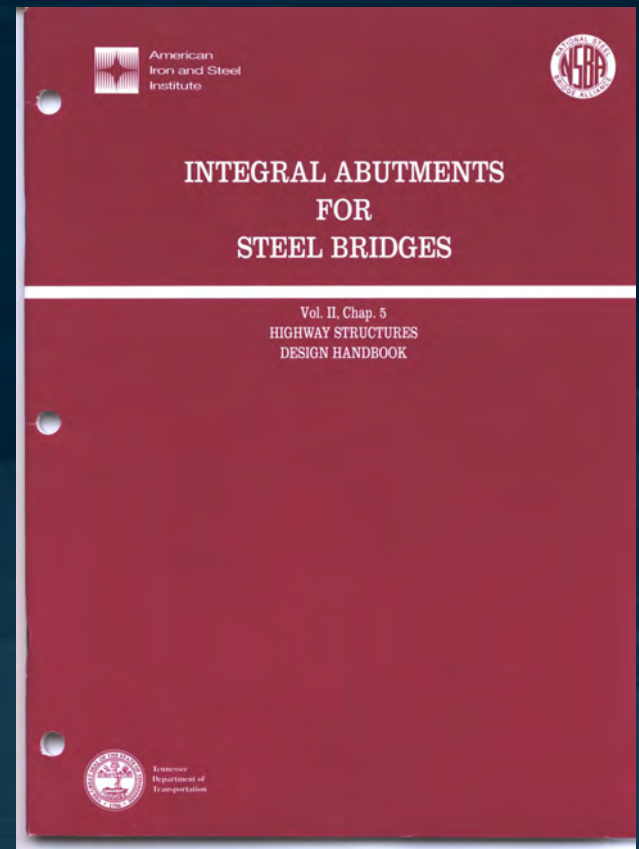
1. No Analysis of Lateral Effects.
2. Simplified Analysis of Lateral Effects.
3. Rigorous Analysis of Lateral Effects.

# Methods for IEB Design

## 2. Simplified Analysis of Lateral Effects.

### General Approach:

- Models end bents independently from the bridge.
- Approach follows the method outlined by Wasserman, et al. (see reference no. 47 on provided list) which can be found in the AISI/NSBA Highway Structures Design Handbook, Volume II, Chapter 5.



# Methods for IEB Design

## 2. Simplified Analysis of Lateral Effects.

### Determine Pile Loading:

- Calculate vertical loads in piles using engineering judgment.
  - Assume equal distribution
  - Model cap as a continuous beam
  - Other.....
- Additional Loading
  - Moments caused by eccentricities of loads applied to the deck.
  - Forces, moments, and deflections caused by the construction sequence.
- Calculate the required thermal movement.
- Requires an assumed number of piles.

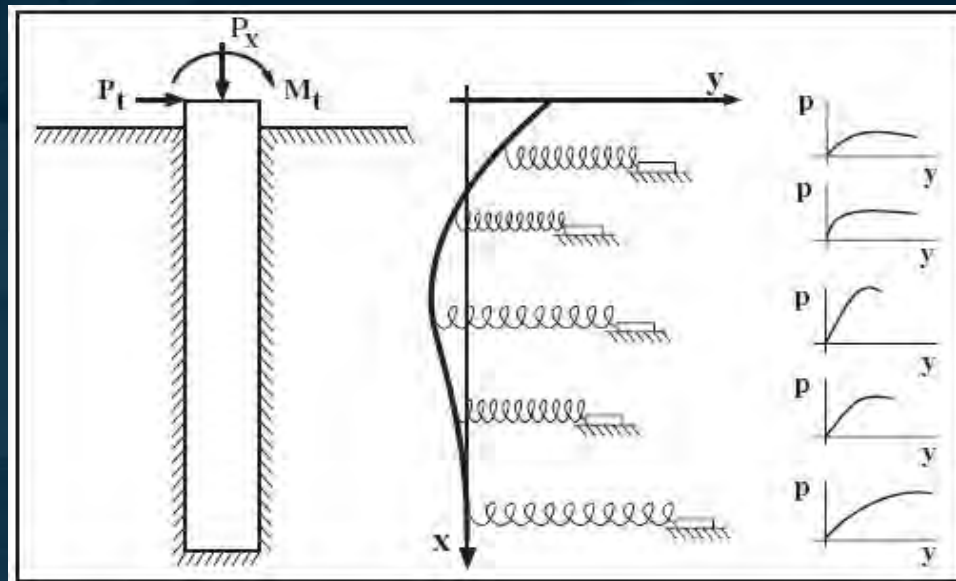


# Methods for IEB Design

## 2. Simplified Analysis of Lateral Effects.

### Determine Soil Response:

- Soil response is a non-linear function of the pile deflection.
- One method of determining response is the P-Y Method.
- Geotechnical Engineer can assist in developing P-Y (soil resistance vs. pile deflection) curves.

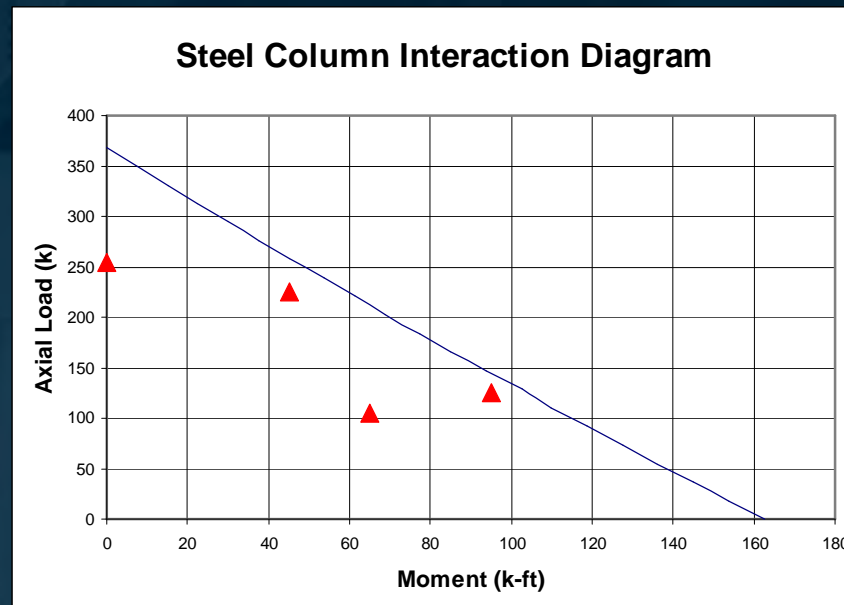


# Methods for IEB Design

## 2. Simplified Analysis of Lateral Effects.

### Determine Pile Response:

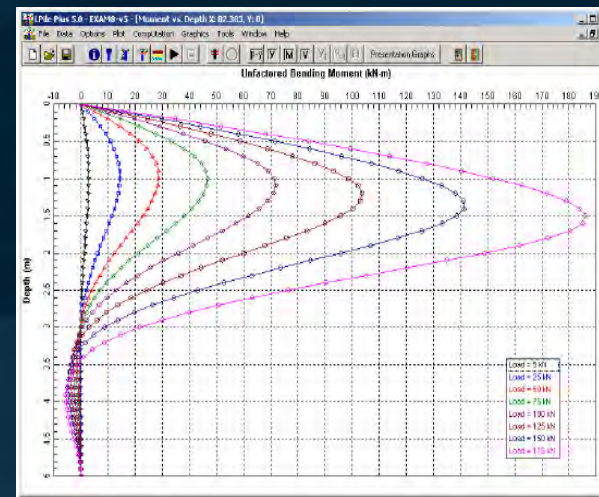
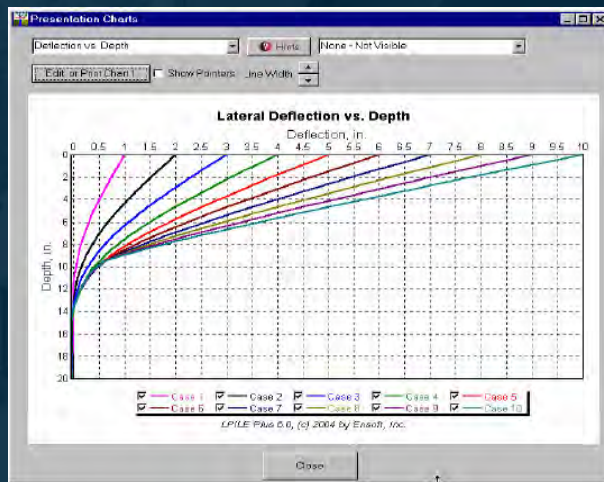
- Develop deflected shape of pile under loading and determine POF.
- Develop interaction diagram for pile (plot of axial load vs. moment).
  - Use AASHTO column equations to determine the allowable envelope.
- Check pile loads for each AASHTO Loading Group against the interaction diagram.



# Methods for IEB Design

## 2. Simplified Analysis of Lateral Effects.

- Two software packages available are:
  - **LPile Plus** – developed and distributed by Ensoft, Inc. ([www.ensoftinc.com](http://www.ensoftinc.com))



- **COM624P** – Report No. FHWA-5A-91-048  
Distributed by FHWA, McTrans, or PC-TRANS  
([www.fhwa.dot.gov/engineering/geotech/software/softwaredetail.cfm](http://www.fhwa.dot.gov/engineering/geotech/software/softwaredetail.cfm))

# Methods for IEB Design

## 2. Simplified Analysis of Lateral Effects.

### Summary:

- Models abutment separately from bridge superstructure.
- Requires that vertical and lateral pile loads be calculated along with expected thermal movement of cap.
- Soil response is obtained through P-Y curves.
- Resulting pile capacity is checked.
- Can require iteration between Geotechnical Engineer and Structural Engineer.

# Methods for IEB Design

## Three Main Design Methodologies:

1. No Analysis of Lateral Effects.
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3. Rigorous Analysis of Lateral Effects.

# Methods for IEB Design

## 3. Rigorous Analysis of Lateral Effects.

### General Approach:

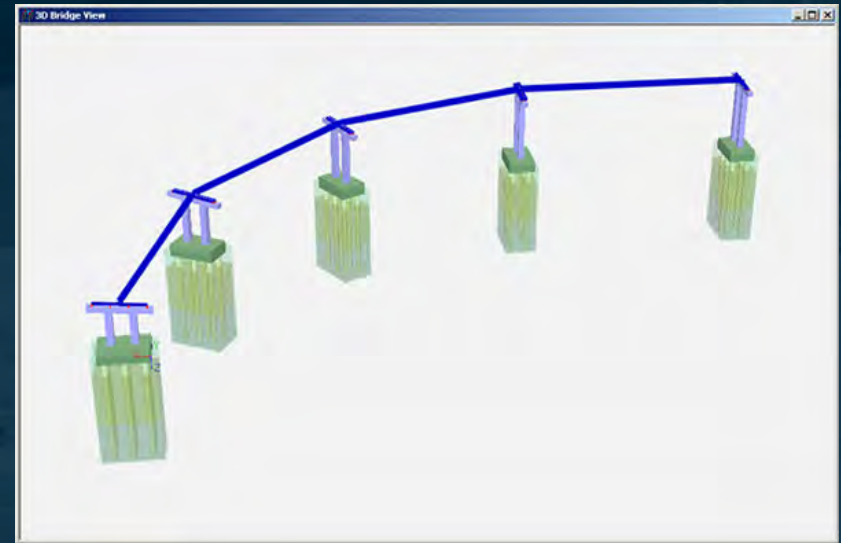
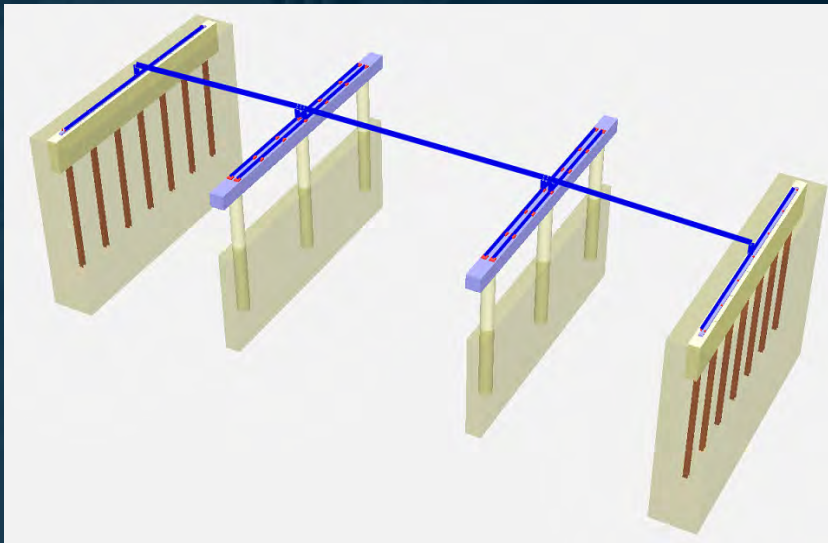
- Involves modeling the entire bridge (abutment to abutment) along with the foundation and soil in either 2-D or 3-D.
- Requires versatile FE program with soil interaction capabilities.
- Advantage is that it provides the Engineer a very detailed evaluation of the internal loads in each pile.
- Example approach is discussed in article by Christou, et al., titled “Soil Structure Analysis of Integral Abutment Bridges” (see reference no. 15 on provided list).

# Methods for IEB Design

## 3. Rigorous Analysis of Lateral Effects.

### Develop Model:

- Bridge is broken down into discrete elements.
- Superstructure can be simplified to a single line of 3-D elements.
- Abutments (caps, columns, and footings) are modeled as 3-D elements.

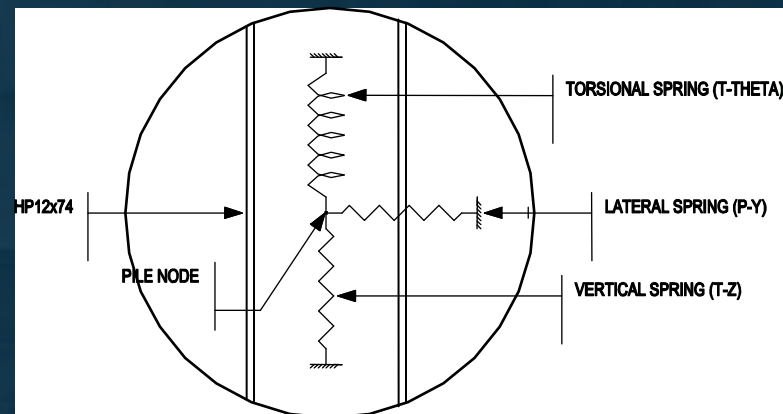


# Methods for IEB Design

## 3. Rigorous Analysis of Lateral Effects.

### Develop Soil Response:

- Soil response is nonlinear and a function of the pile displacements.
- Soil is described by three sets of curve data:
  - P-Y Curve (lateral response)
  - T-Z Curve (vertical response)
  - Tau- $\theta$  Curve (torsional response)
- Soil behavior is modeled by using multiple non-linear soil springs.
- Information obtained from Geotechnical Engineer.





# Methods for IEB Design

## 3. Rigorous Analysis of Lateral Effects.

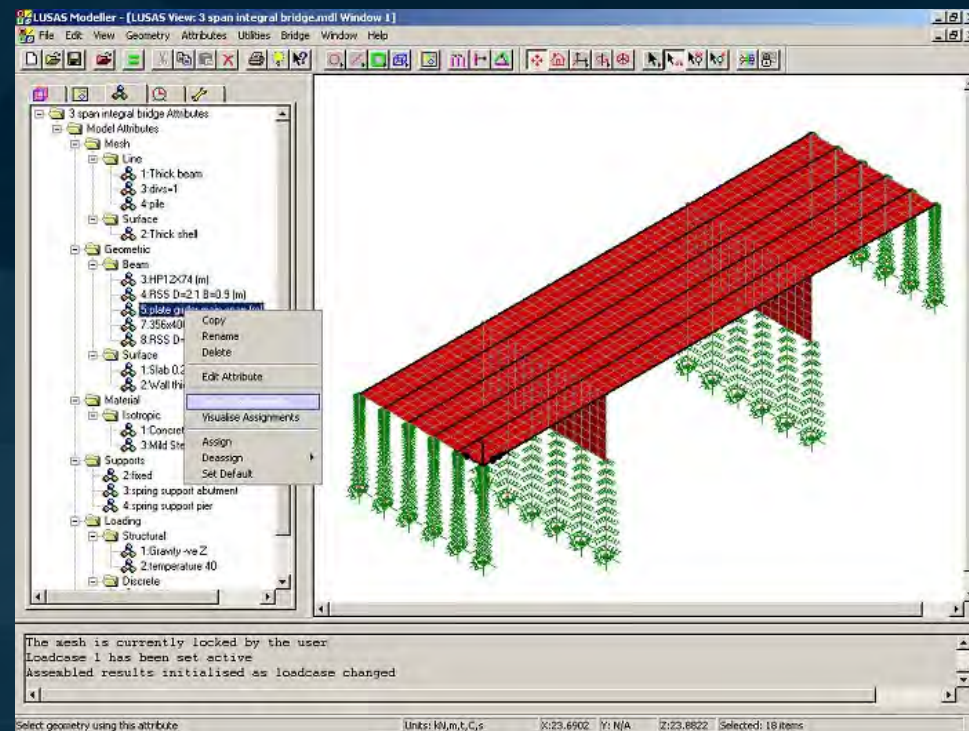
### Process Output:

- Using program output, Engineer can easily evaluate the piles.
- Once model has been developed, and validated, alternative foundation types or layouts can easily be checked and optimized.

# Methods for IEB Design

## 3. Rigorous Analysis of Lateral Effects.

- Two software packages available are:
  - **LUSAS Bridge Module** – developed specifically for modeling and analysis of jointless and integral abutment bridges. ([www.lusas.com](http://www.lusas.com))



# Methods for IEB Design

## 3. Rigorous Analysis of Lateral Effects.

- **FB-MultiPier** –nonlinear FE program capable of analyzing multiple pier bridges. ([bsi-web.ce.ufl.edu](http://bsi-web.ce.ufl.edu))

**Bridge Wind Load Generation**

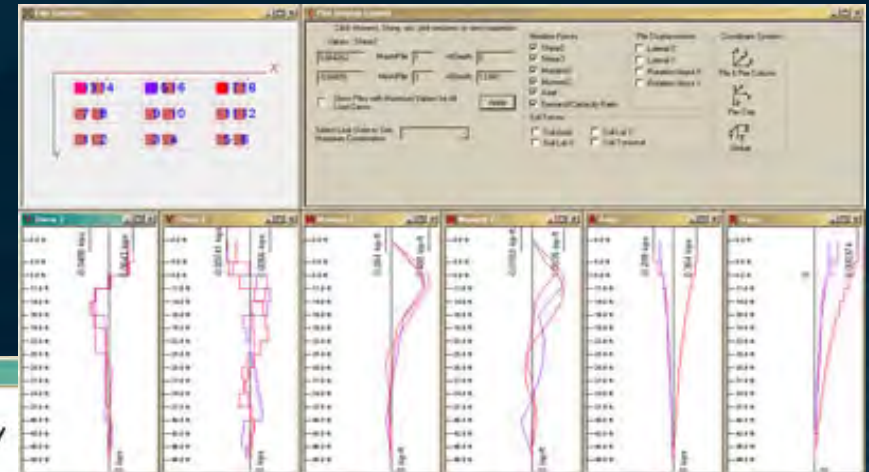
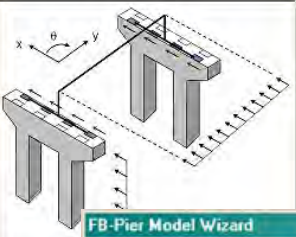
Num. of Cases: 3

Angle 1: 0 Angle 2: 30 Angle 3: 60 Angle 4: 0 Angle 5: 0

The wind load generator will apply the wind to the pier, superstructure, and live load. The resulting loads will be converted to loads at the bearing locations. Overturning due to vertical wind pressure is not modeled and should be added in the load table.

Wind Pressures

Angle Deg	Superstructure		Pier (Pile Bent)		Live Load	
	Trans KSF	Long KSF	Trans KSF	Long KSF	Trans KLF	Long KLF
0	0.0500	0.0000	0.0400	0.0000	0.1000	0.0000
15	0.0440	0.0060	0.0390	0.0100	0.0880	0.0120
30	0.0410	0.0120	0.0350	0.0200	0.0820	0.0240
45	0.0330	0.0160	0.0280	0.0280	0.0660	0.0320
60	0.0170	0.0190	0.0200	0.0350	0.0340	0.0380
75	0.0110	0.0220	0.0100	0.0390	0.0140	0.0420



**FB-Pier Model Wizard**

**Pile Group Geometry**

Select a pile type and enter the pile group geometry...

Pile Type -> 24" Square FDOT Standard prestressed

Pile in x-direction: 2

Pile in y-direction: 3

Pile spacing: 3d

Pile Length: 50 ft

Pile Cap Thickness: 5 ft

Click Next to continue.

# Methods for IEB Design

## 3. Rigorous Analysis of Lateral Effects.

### Summary:

- Method allows the Engineer to get the “Big Picture” view.
- Rigorous method can be complicated and time consuming.
- Beware of the “Black Box” syndrome (Garbage In → Garbage Out)
  
- Advantages:
  - Get a detailed quantitative evaluation of the internal loads in each pile.
  - Can easily run “what-if” type scenarios.
- Disadvantages:
  - Results are only as good as the soil response parameters.
  - Can generate large volumes of output.