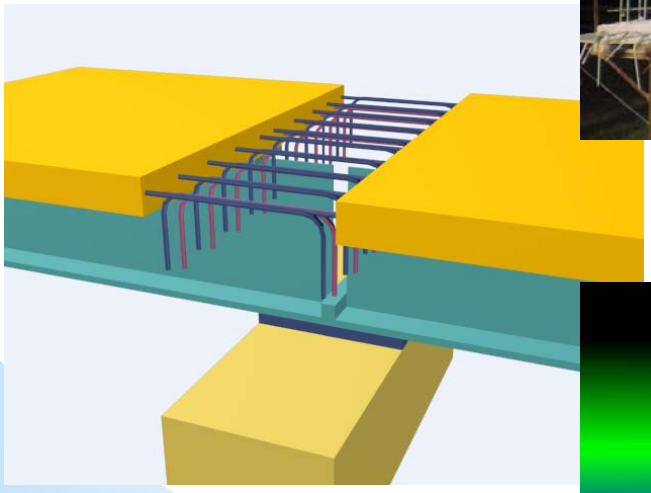
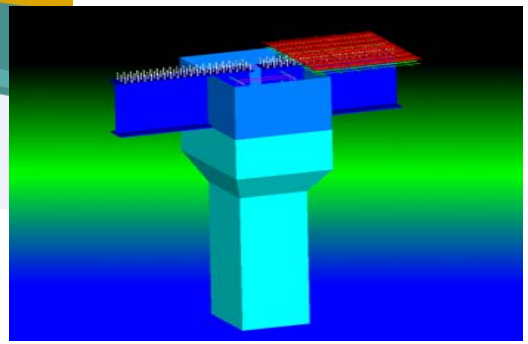
Simple for Dead load and Continuous for Live loads (SDCL)- Steel Bridges ABC Application





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Summary of more than ten years of research, field application and monitoring

Aaron Yakel- University of Nebraska-Lincoln
Reza Farimani, Thornton Tomasetti
Saeed Javidi, Associated Engineering, CA
Derek Kowalski, NUCOR
Nazanin Mossahebi, Bureau Veritas North America
Nick Lampe, HDR

Results of the study are summarized in five journal paper and submitted to special issue of AISC EJ for possible publications

Summary of more than ten years of research, field application and monitoring

Nebraska Department of Roads

Federal Highway Administration

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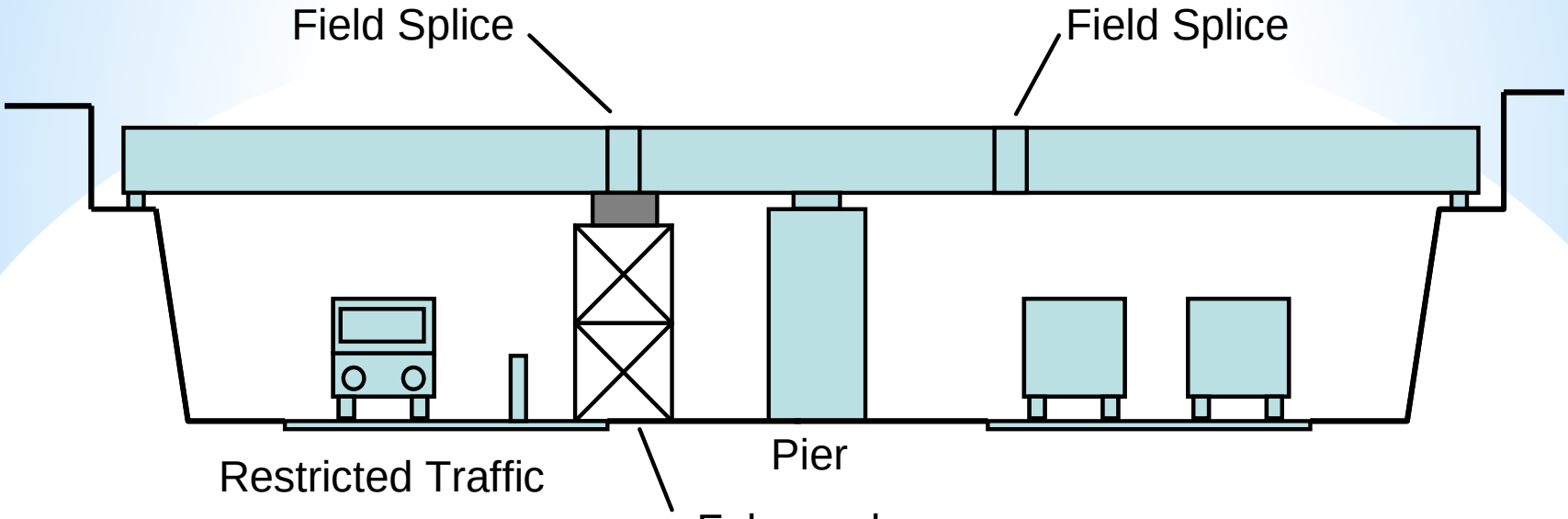
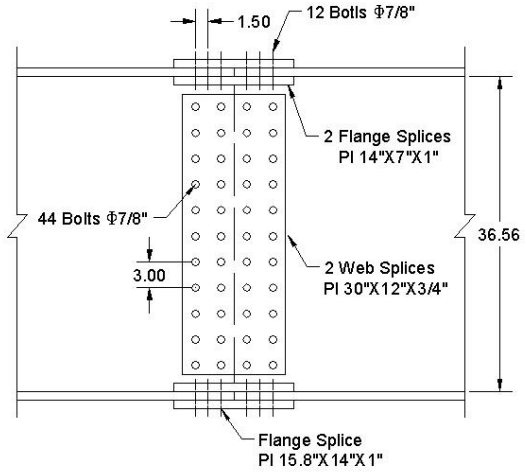
Typical Construction of Steel Bridges

Continuous for Dead and Live Loads





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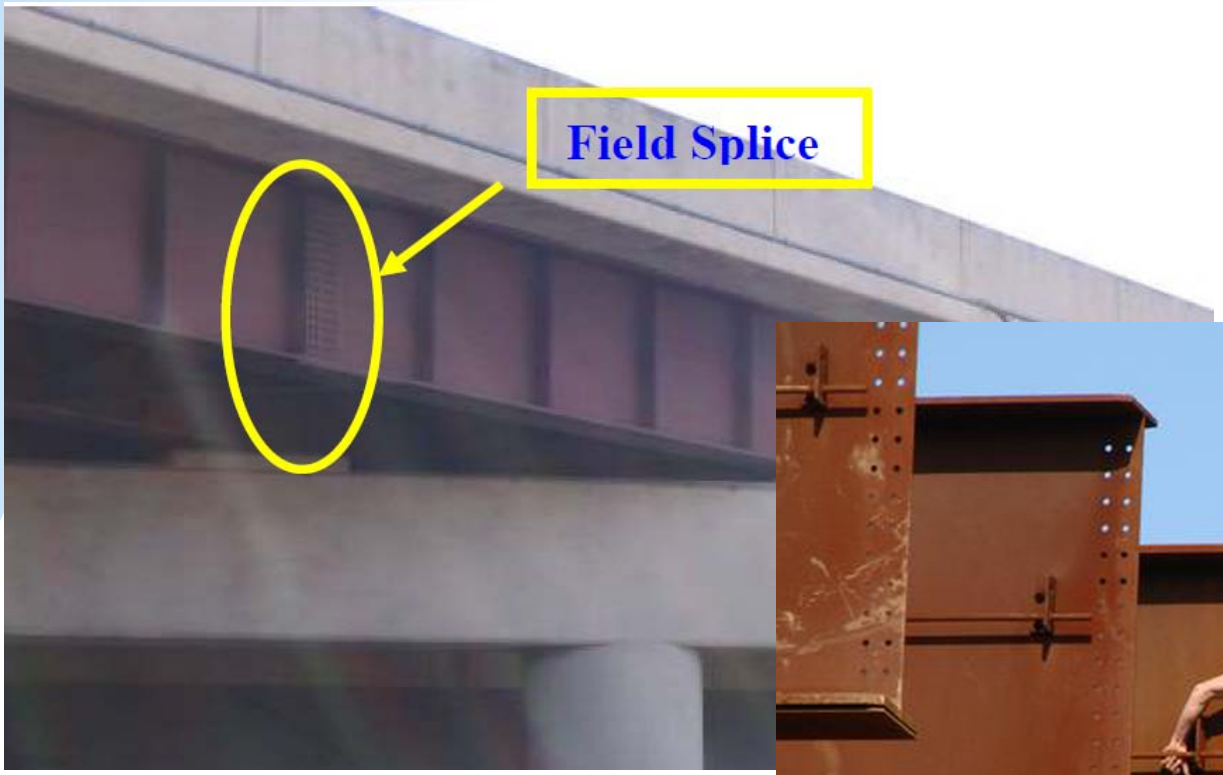
Typical Steel Construction - Continuous for Dead and Live Loads



In the slides to follow:

SDCL

Simple for Dead load and

Continuous for Live loads

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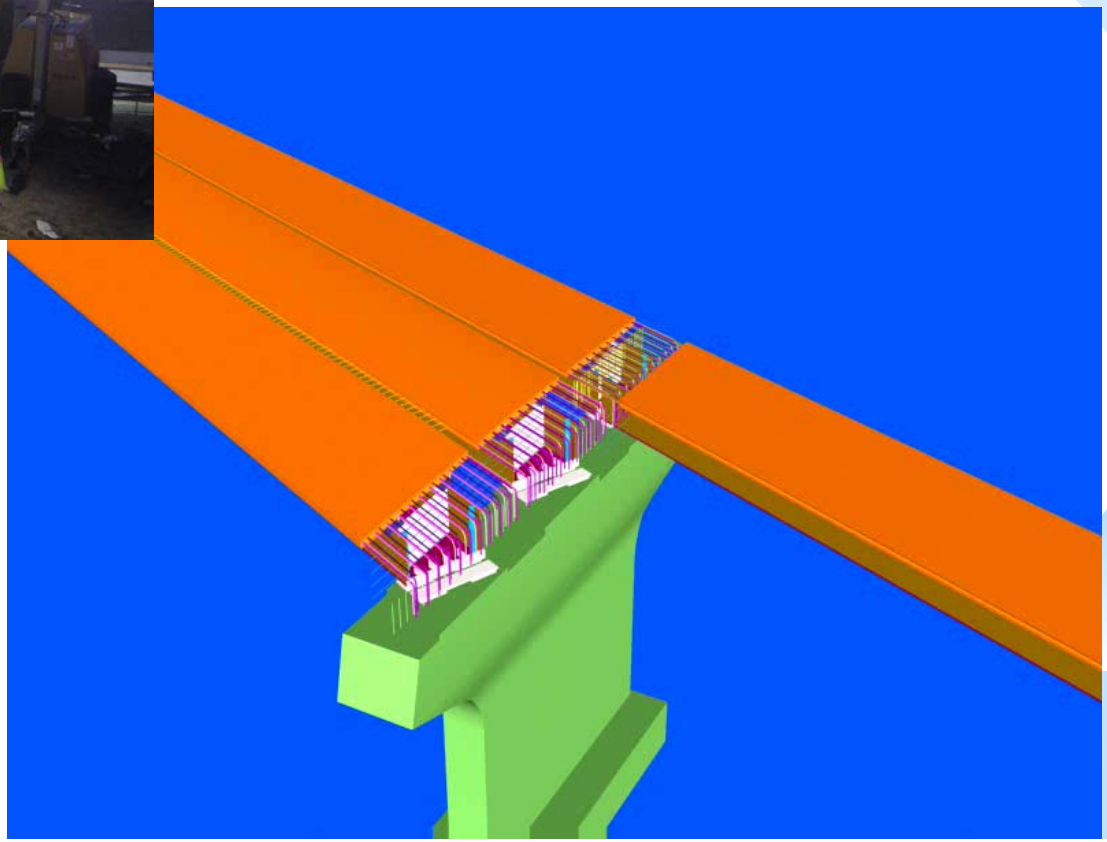
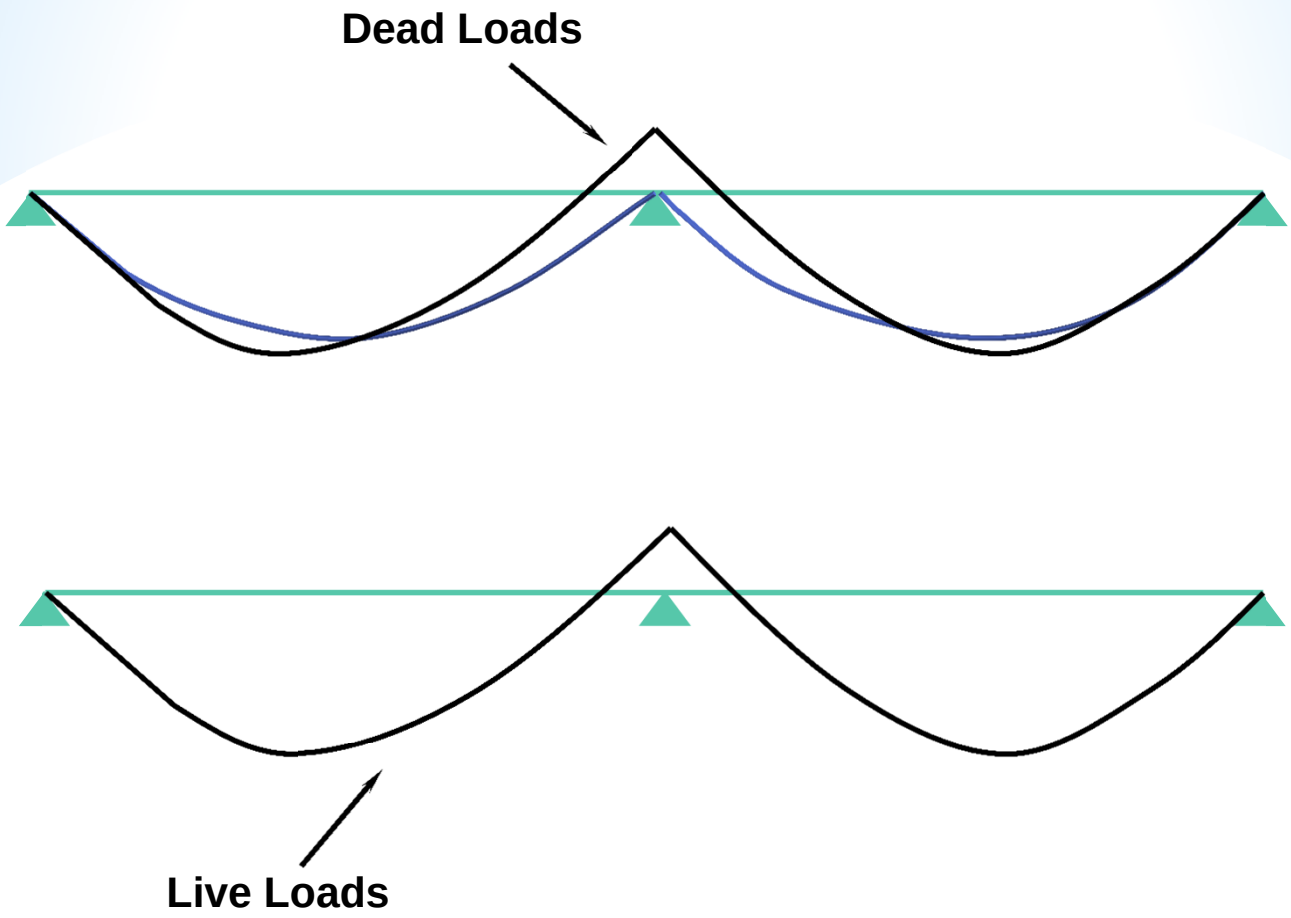
SDCL- Conventional Case- cast in place deck

SDCL- ABC Case- Modular approach



Cont. for Dead and Live Load vs SDCL

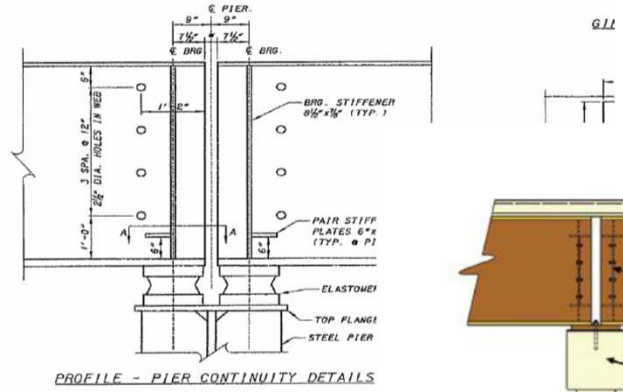


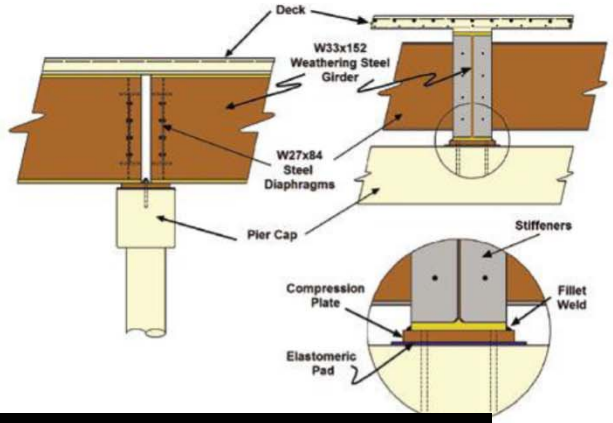
Cont. for Dead and Live Loads

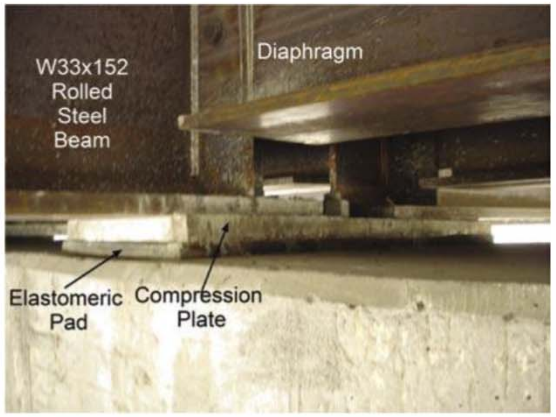
SDCL System

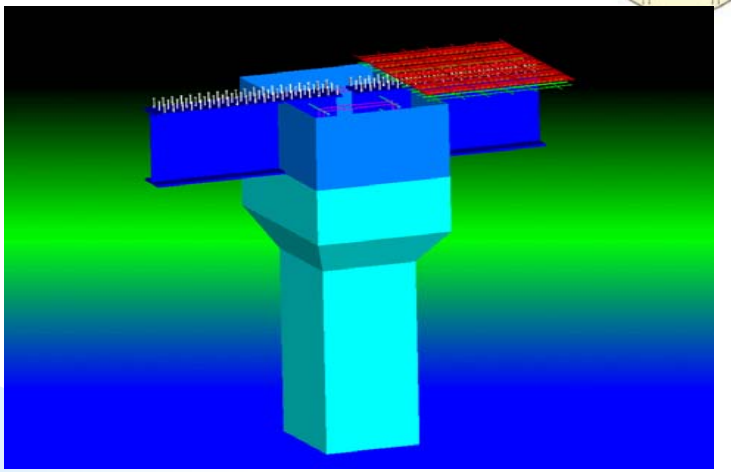
SDCL Steel Bridge System

More than one way to provide continuity for live loads









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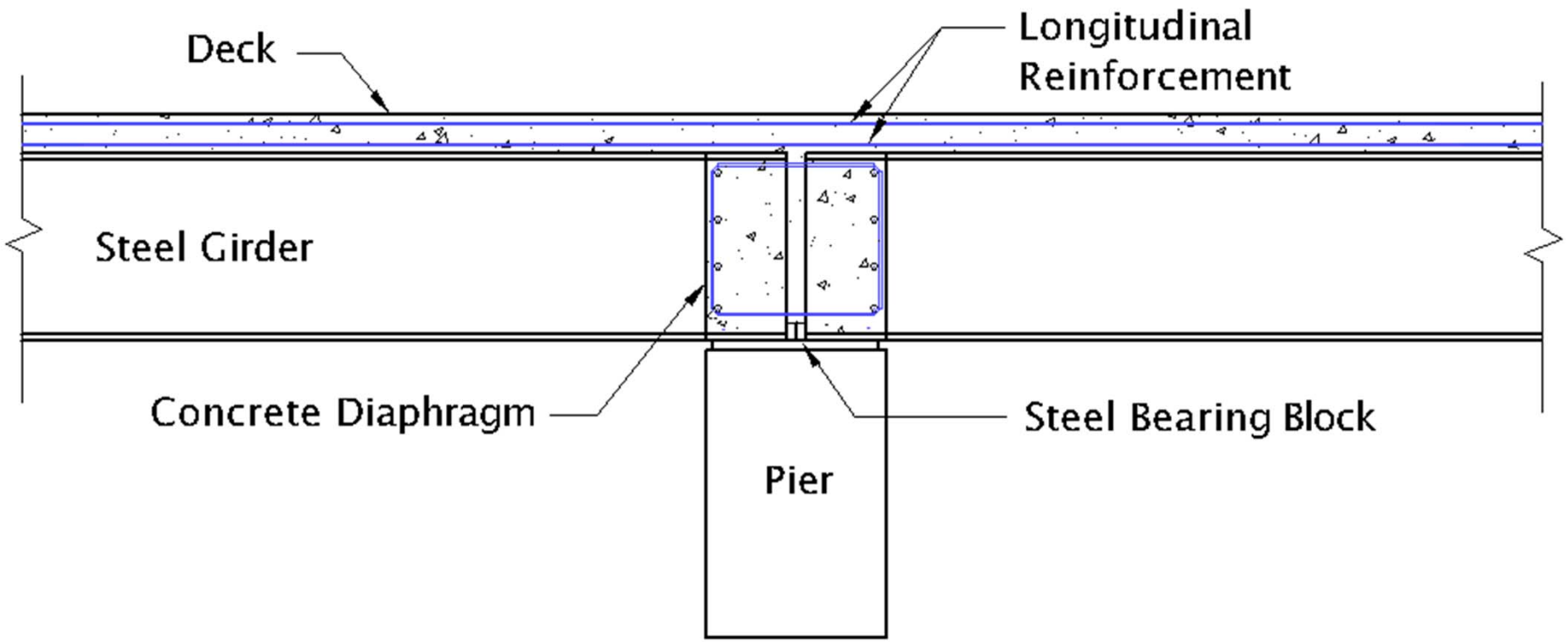
SDCL Bridge System using Concrete Diaphragm



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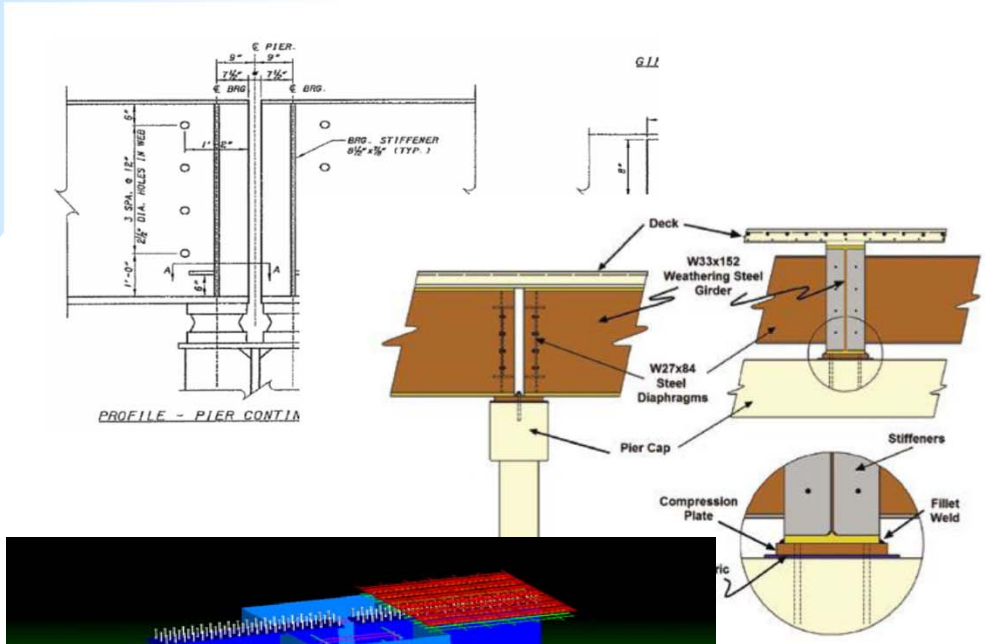
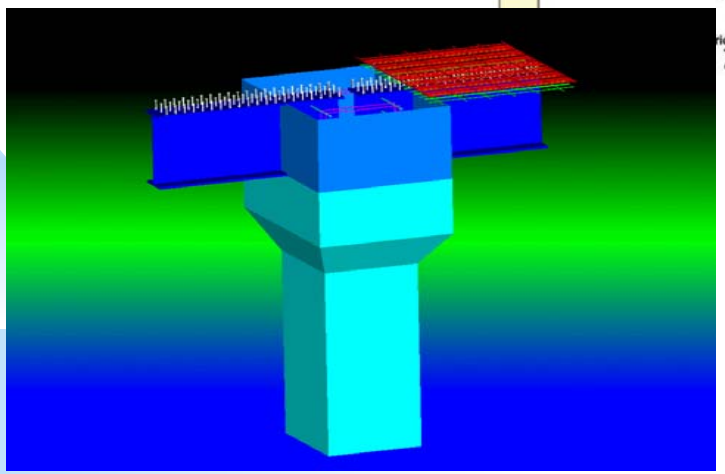
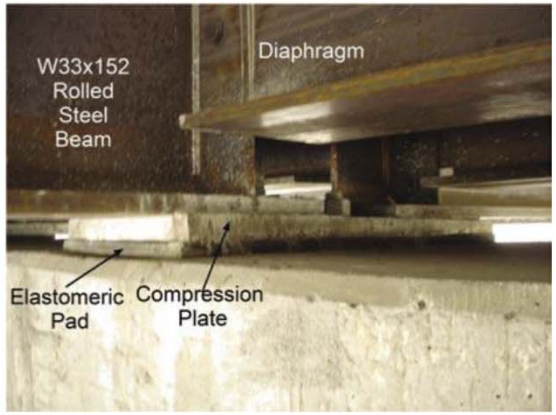
For most part connections that works for cast in place deck methods of construction, also works for ABC applications







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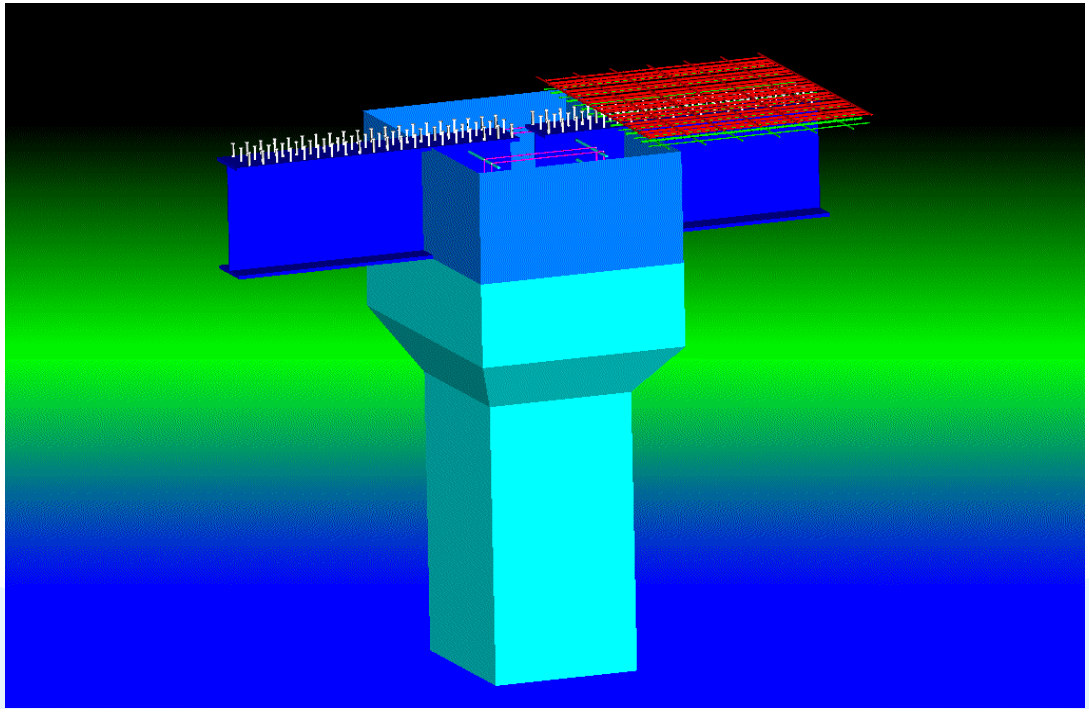
Using Concrete Diaphragm

Creep and shrinkage is not an issue

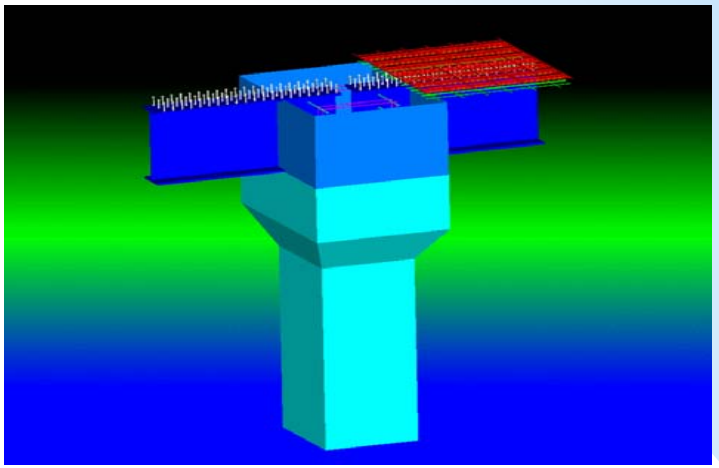


Advantages of Concrete Diaphragm

Protects the ends of the girders and enhances service life

Challenges using Concrete Diaphragm

Large Bottom Flange



Small Bottom Flange

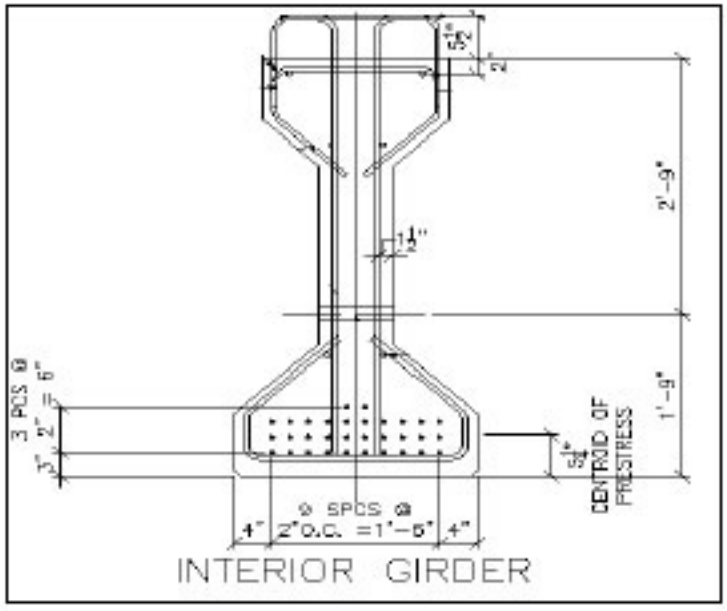
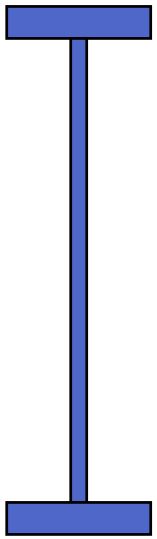


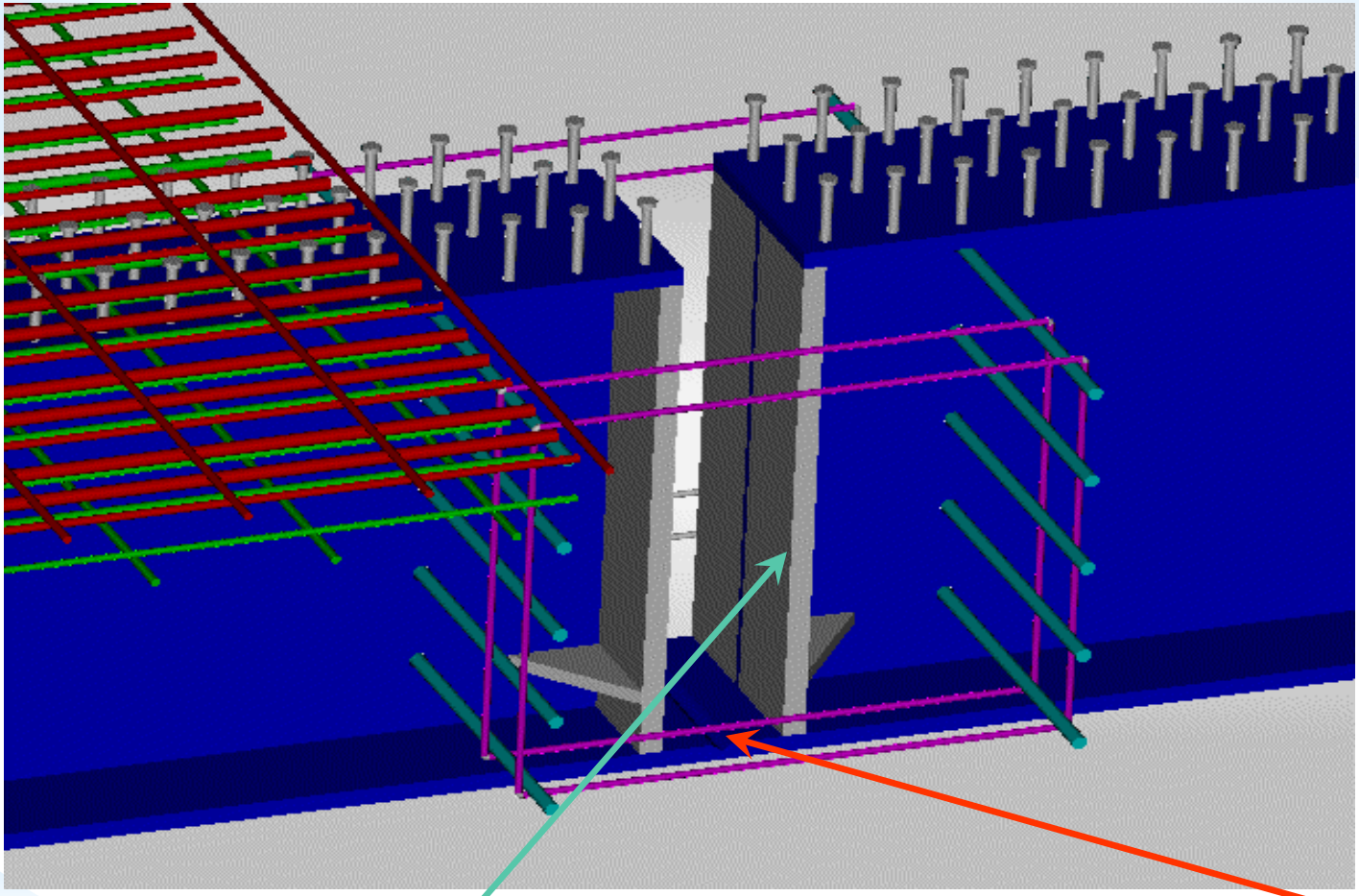
FIGURE 1.

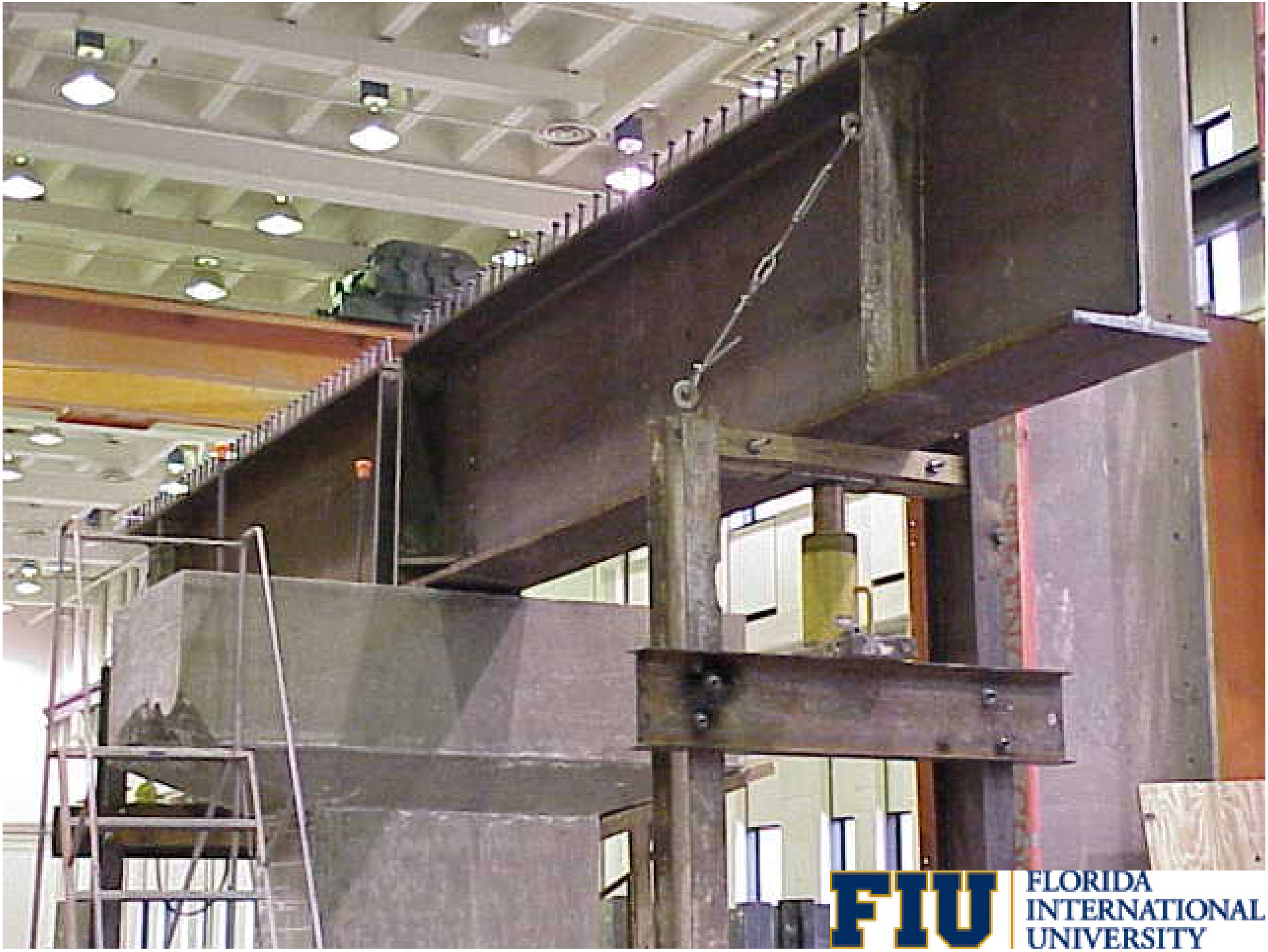
Prestressed Concrete



Steel

Bottom flange continuous plus end plate

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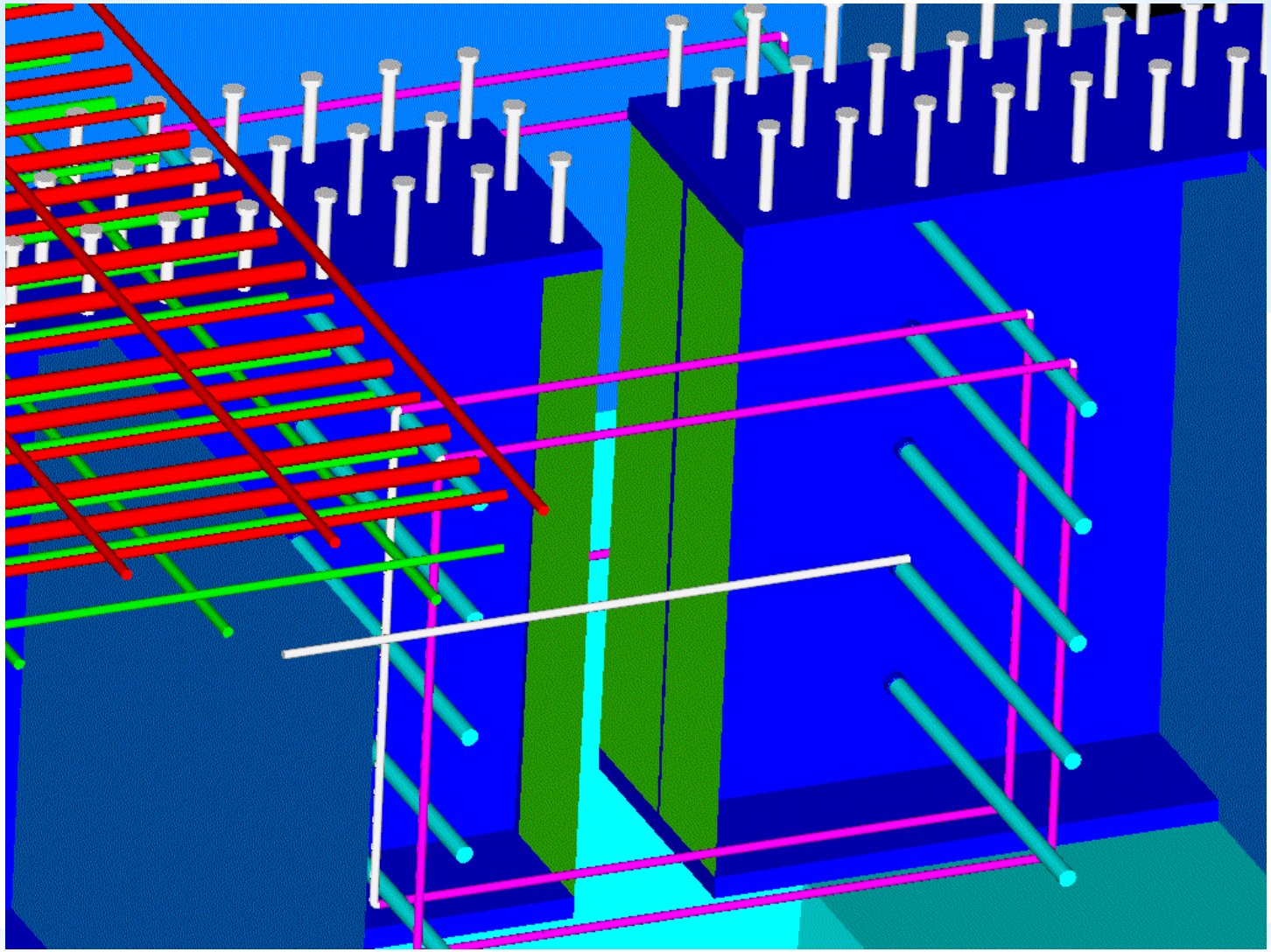
ULTIMATE LOAD TEST

End Plate only



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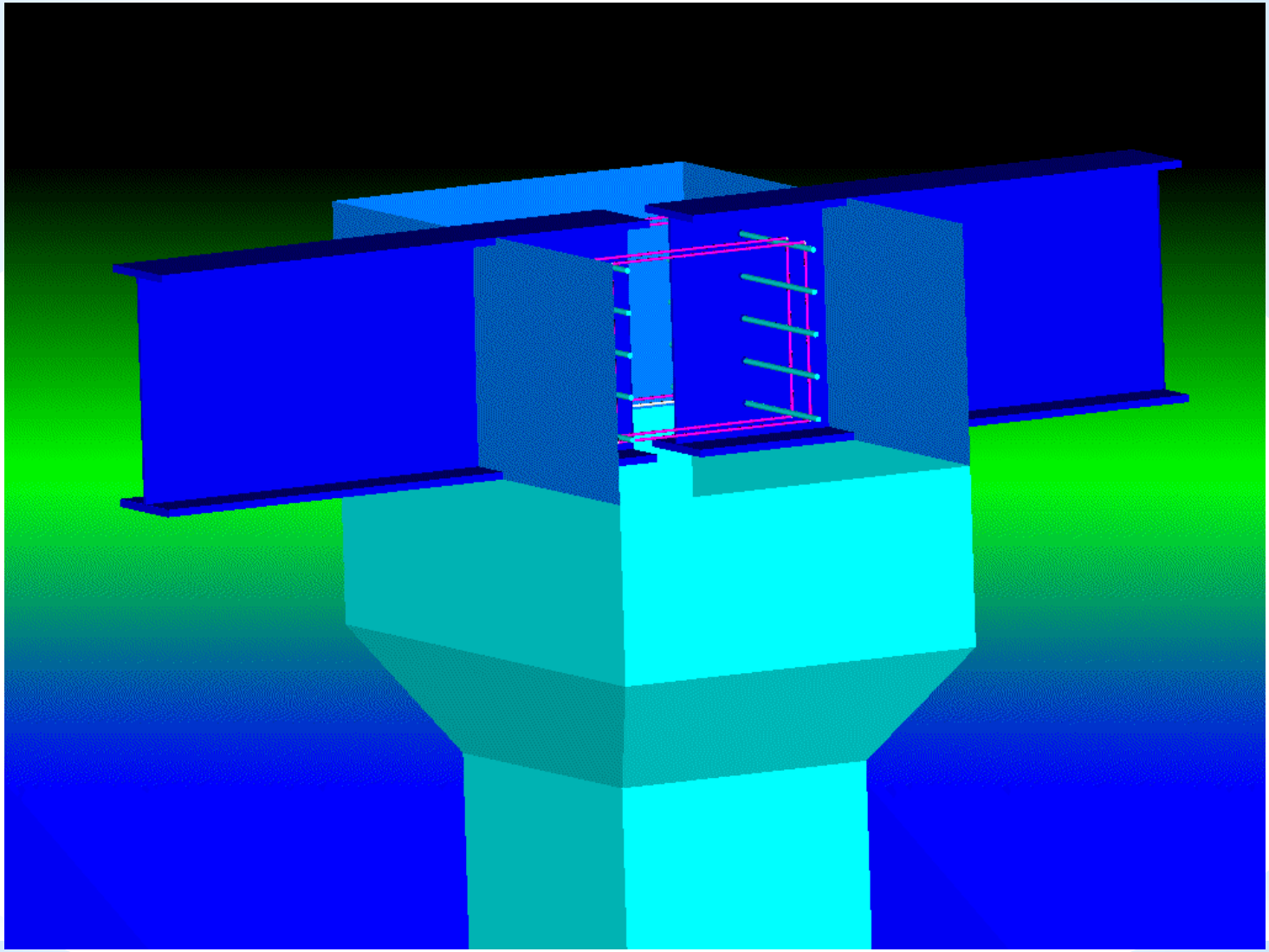
No End Detail



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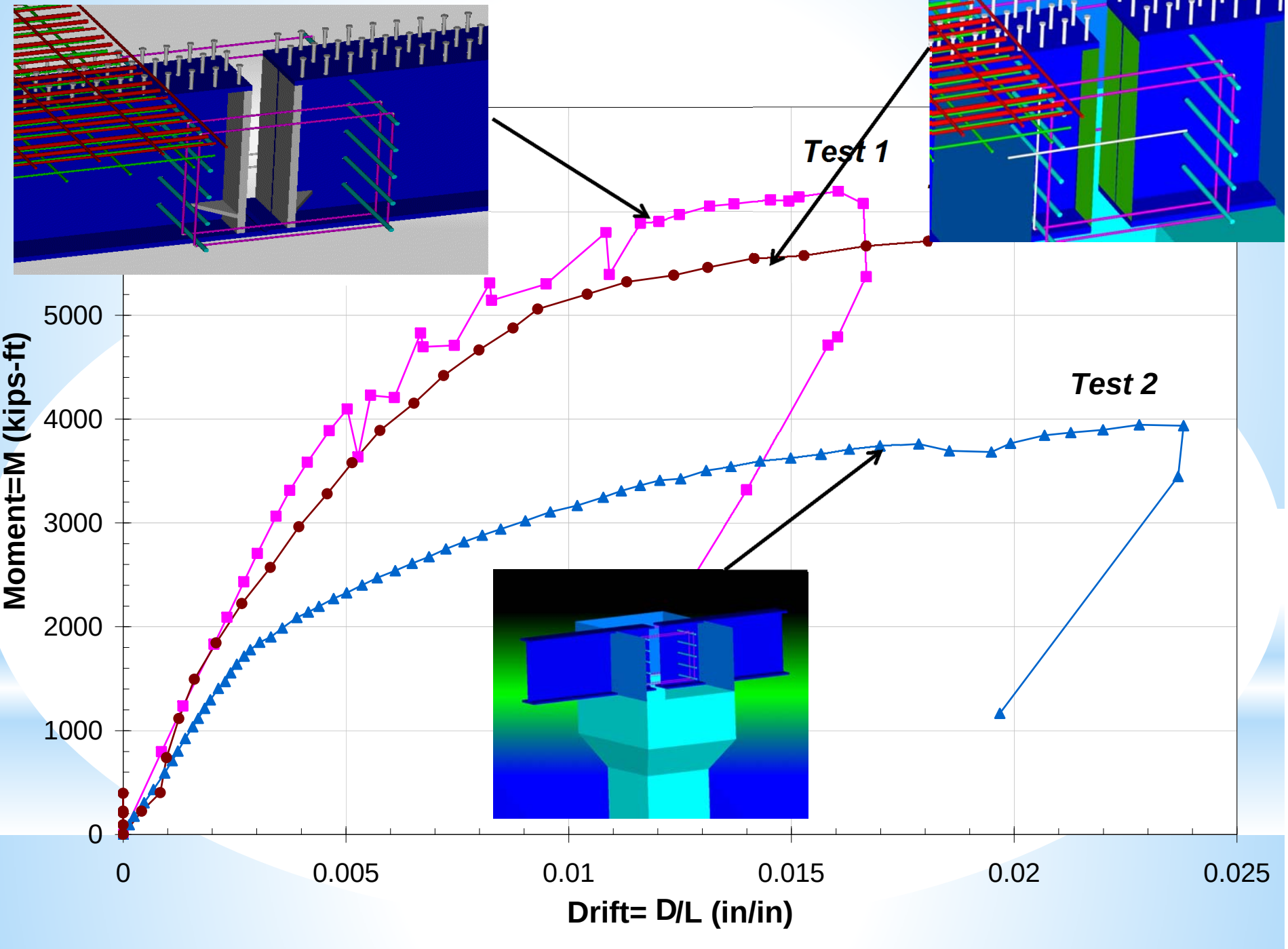
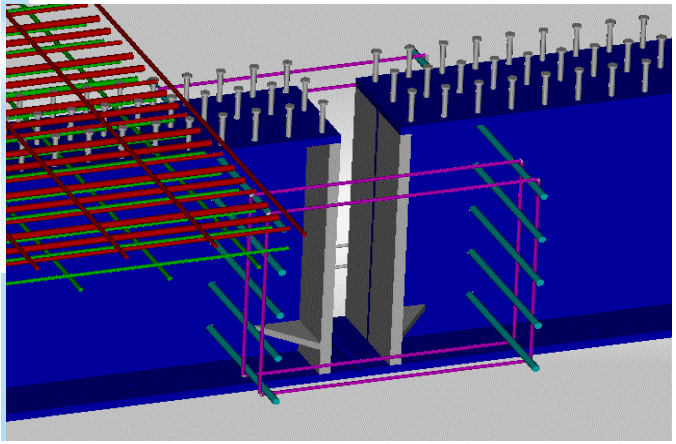

Test 1
Test 2
Moment=M (kips-ft)
5000
4000
3000
2000
1000
0
0
0.005
0.01
0.015
0.02
0.025
Drift= D/L (in/in)

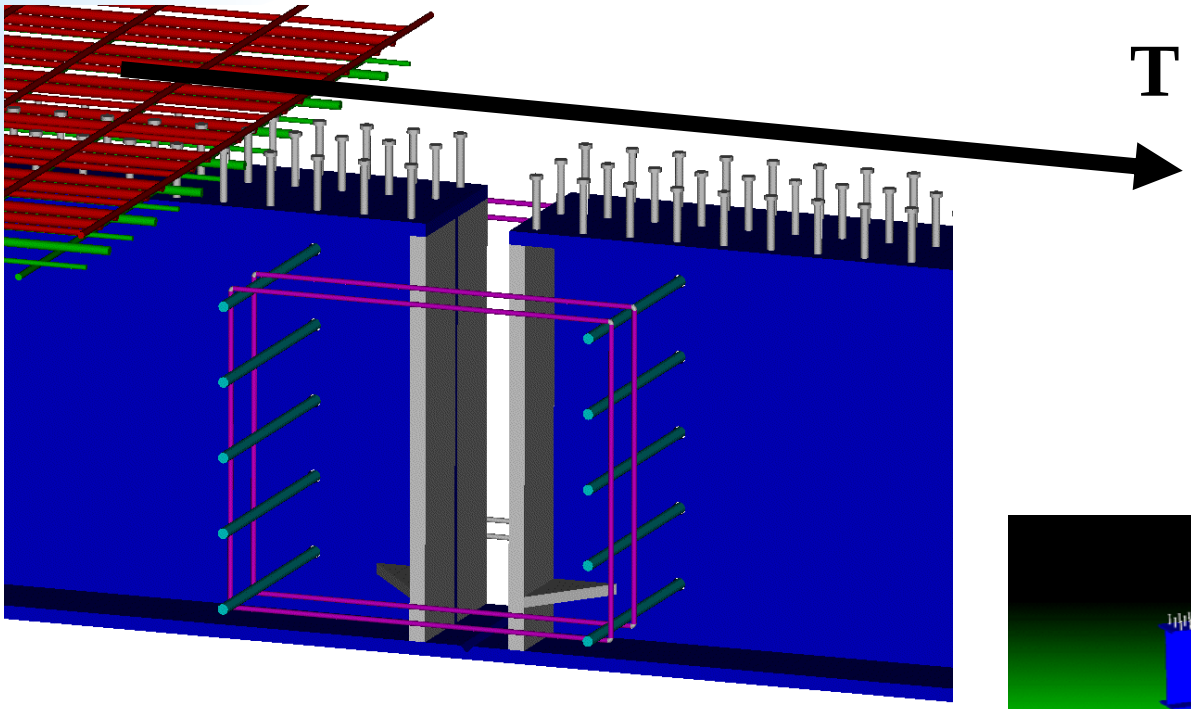
Important consideration when

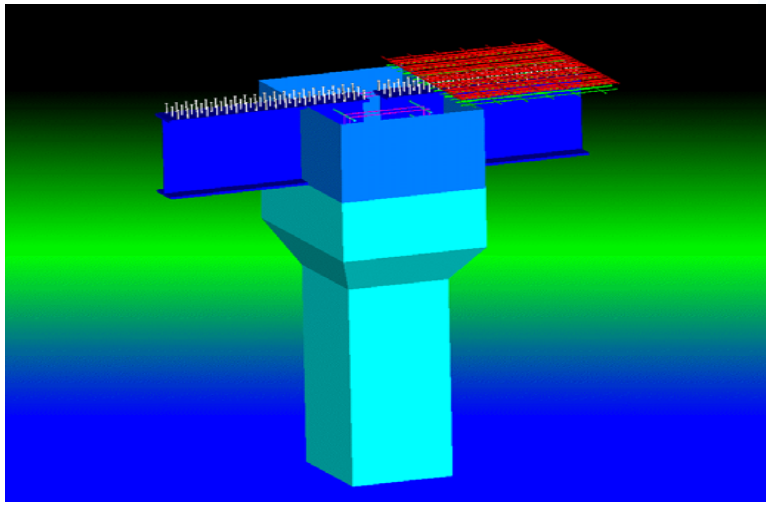
Using concrete diaphragm

It is important to provide continuous load path for transferring the compression force from one flange to the next flange, without the possibility of crushing the concrete in the diaphragm.

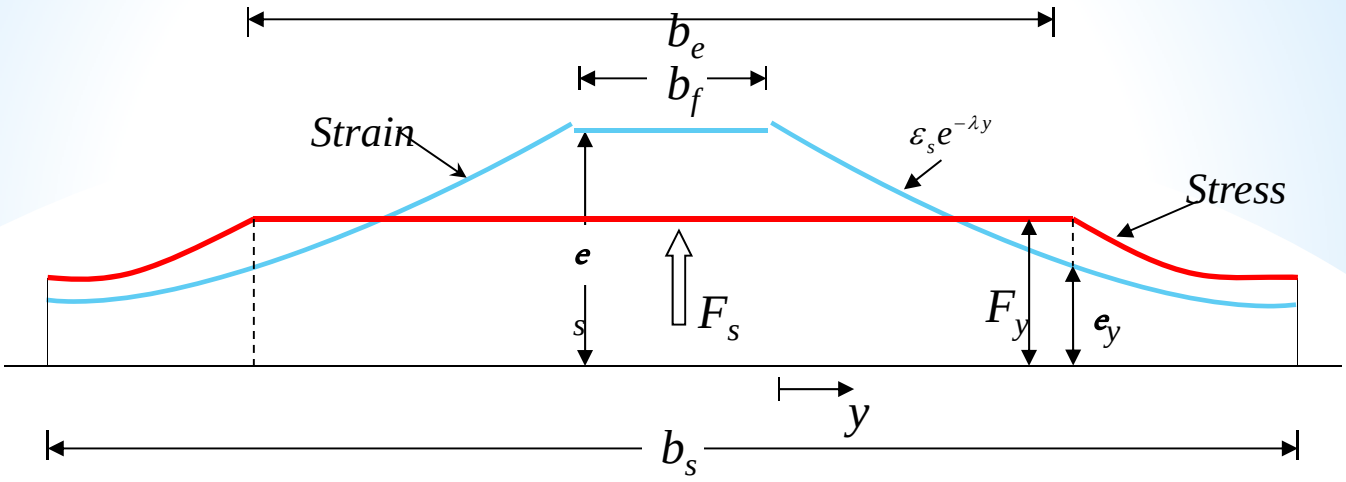


Calculating the tension reinforcement

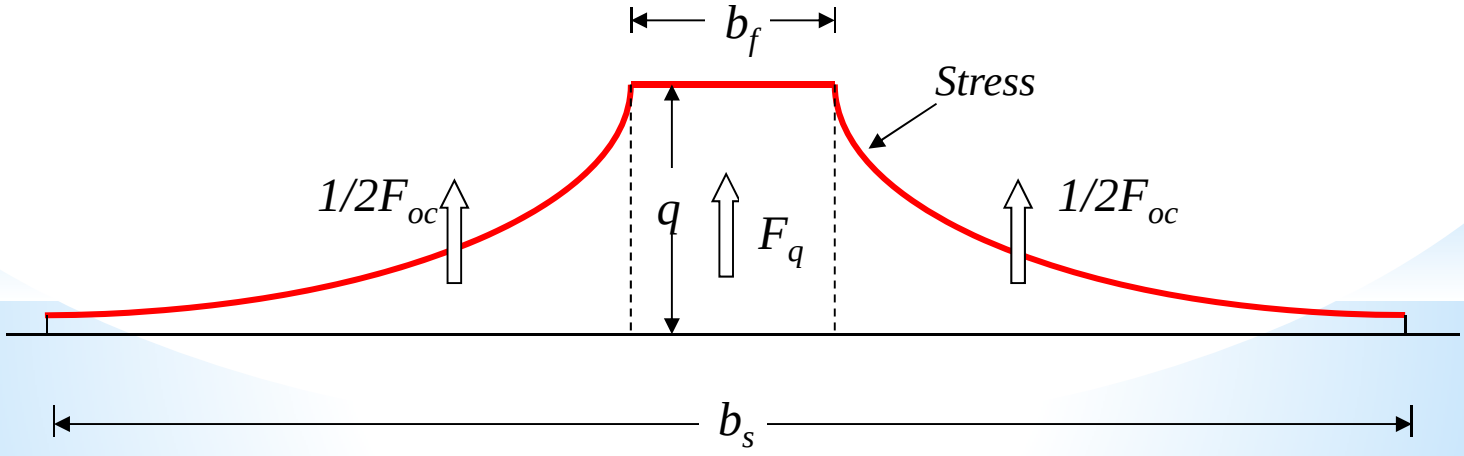


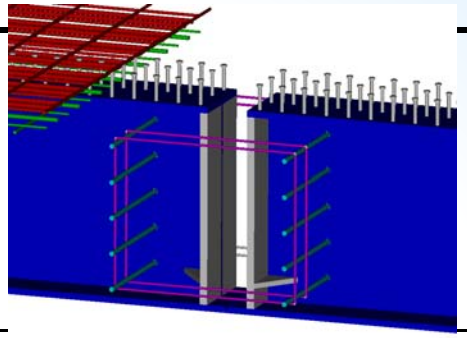
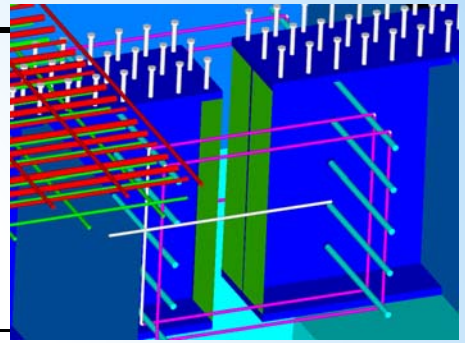


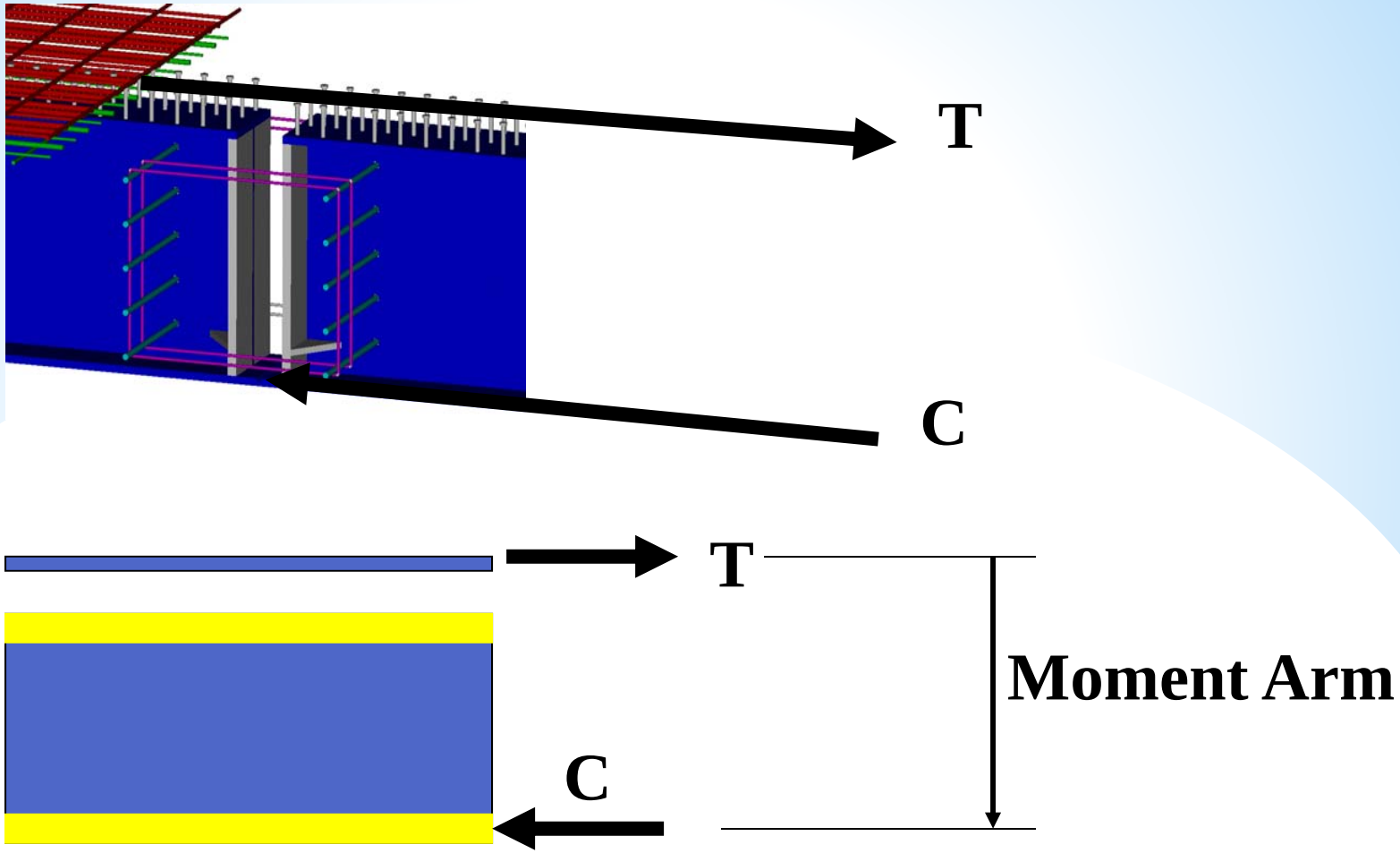
Strain and Stress in Slab



Stress in Concrete Diaphragm



Resisting Elements		
Slab Rebar	60.82%	66.77%
Stirrups in tension	5.09%	5.42%
Concrete in tension	4.35%	6.03%
Stirrups in compression	0.00%	1.58%
Concrete in compression	12.37%	20.20%
Bottom plate in compression	17.37%	NA
Total	100.00%	100.00%



$$M_n = A_s f_y \text{ (moment Arm)}$$

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Example: Two span steel bridge using SDCL system- Each span 95 ft.

Live load moment Mu (LL)= 34770 in-kip

Girder size **W40x249**

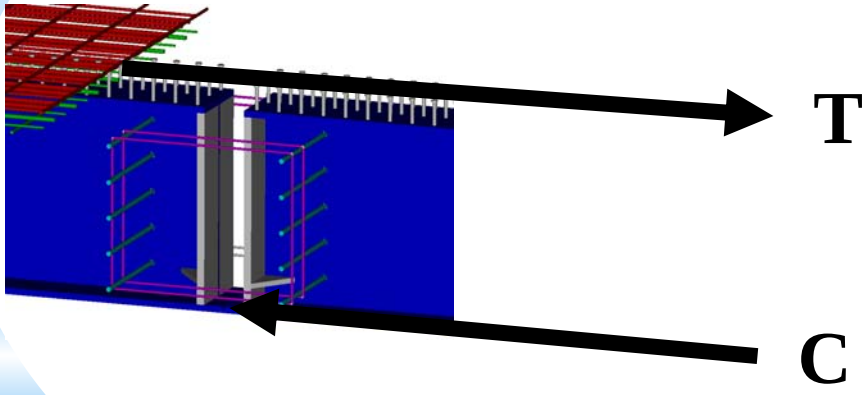
Depth of girder **43.375”**

$$A_s = M_n / (f_y (d - H/2))$$

$$A_s = 34770 / (60 * (43.375 – 4 / 2)) = 14 \text{ in}^2$$

Use of recommended detail for SDCL

Cast in place deck vs ABC



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SDCL- Cast in Place Deck

End of girders needs to be restrained against twist before casting deck

SDCL- Cast in Place Deck

Recommendation is to fill the concrete diaphragm about ½ to 2/3 of the height and let it cure

SDCL- Cast in Place Deck

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SDCL – Cast in Place Dec

SDCL- Cast in Place Deck

To minimize the cracking

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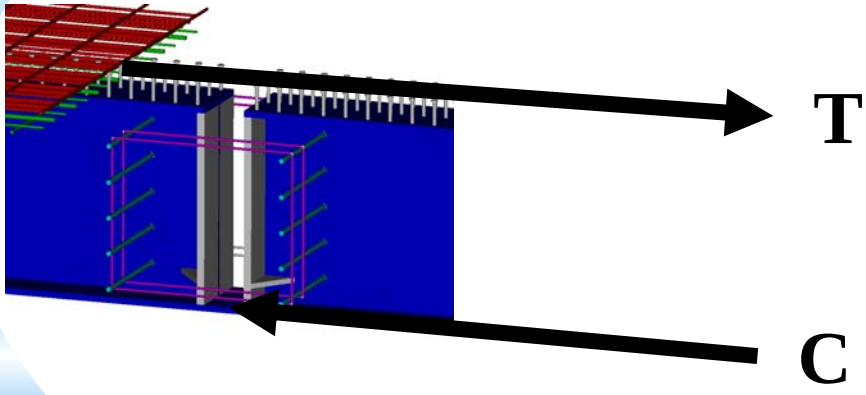
SDCL – Cast in Place Deck

Recommendation- Assume 20% continuity for dead load

Use of the recommended detail

Case of ABC



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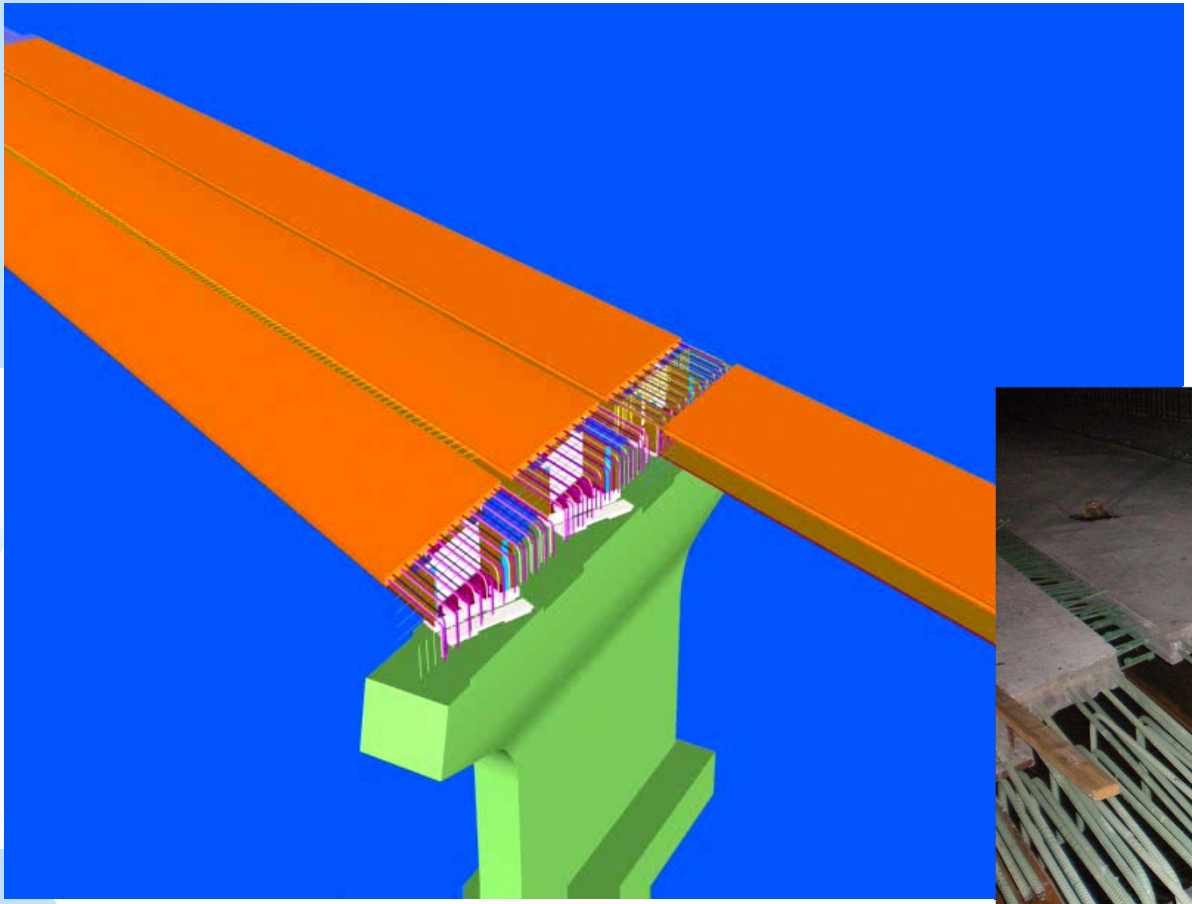
SDCL- Case of ABC



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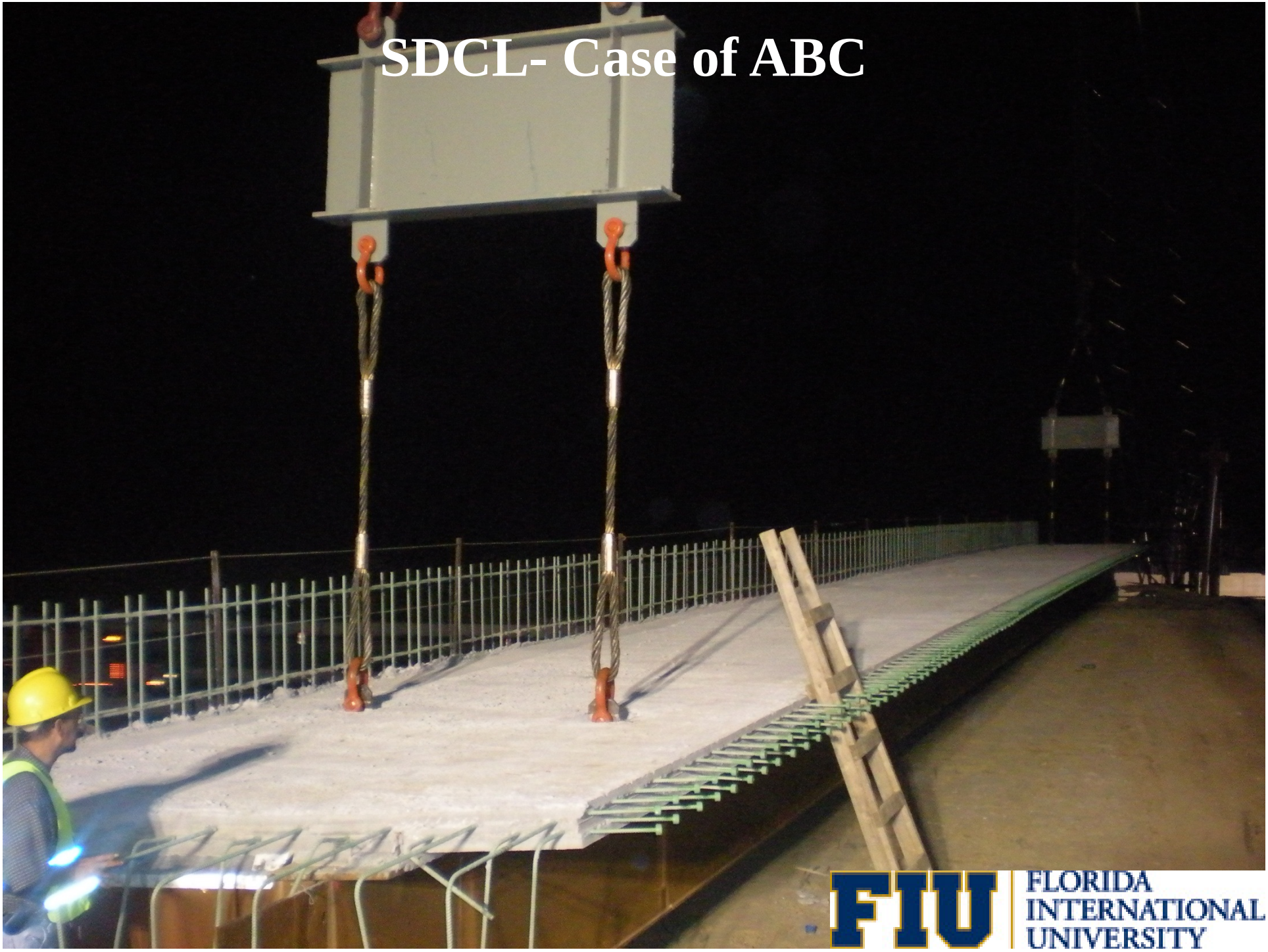
SDCL- Case of ABC



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SDCL- Case of ABC

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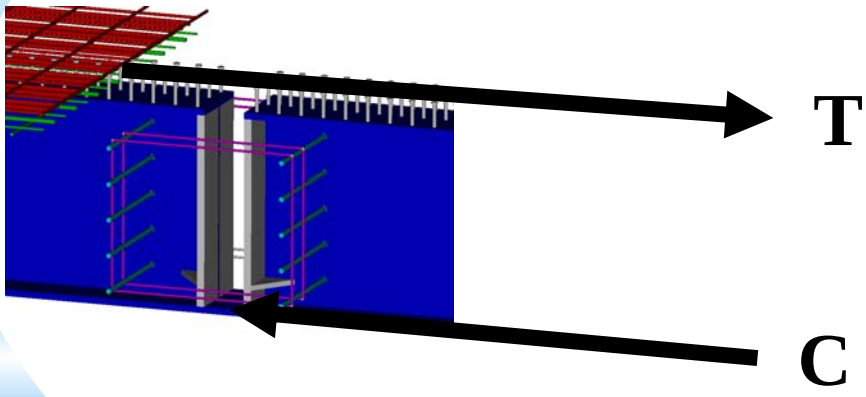
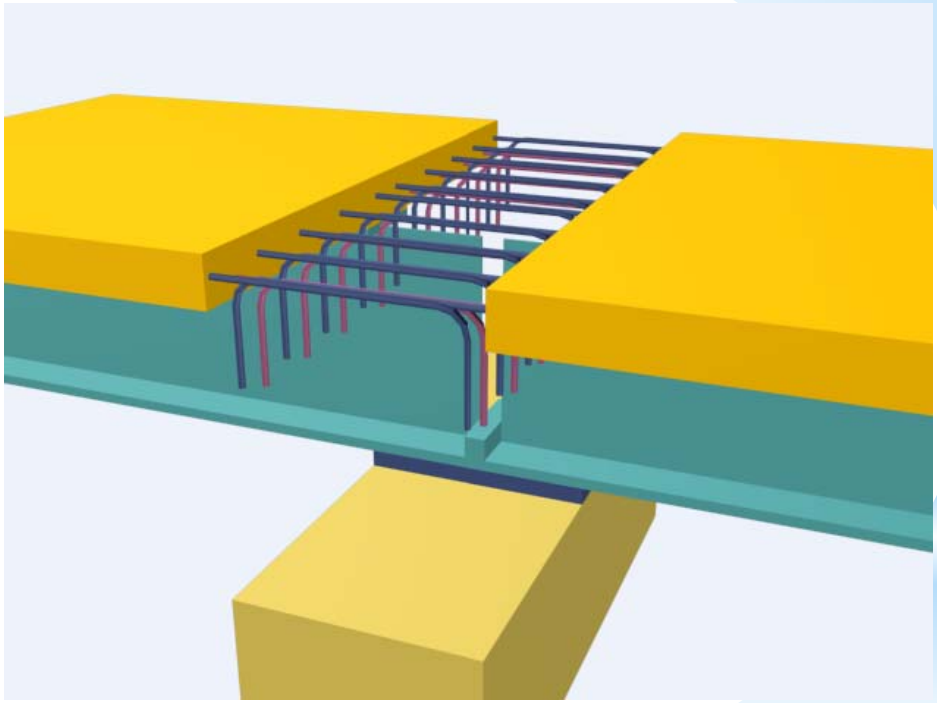
SDCL- Case of ABC





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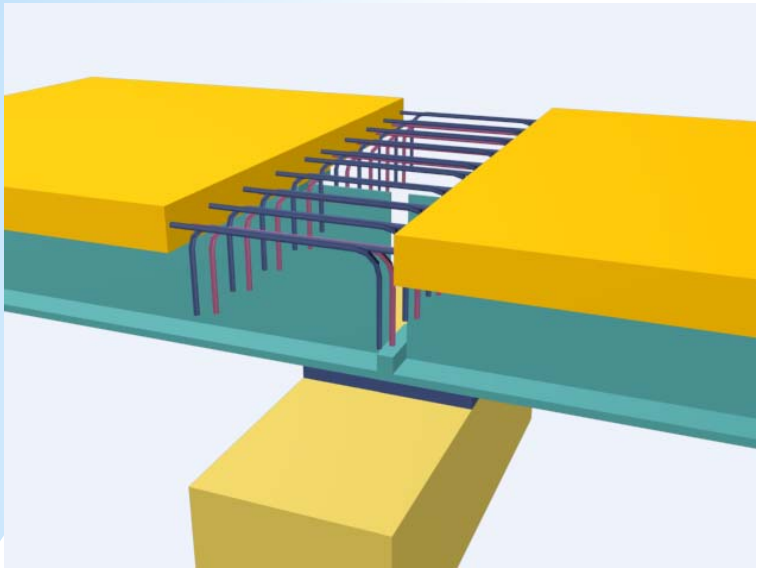
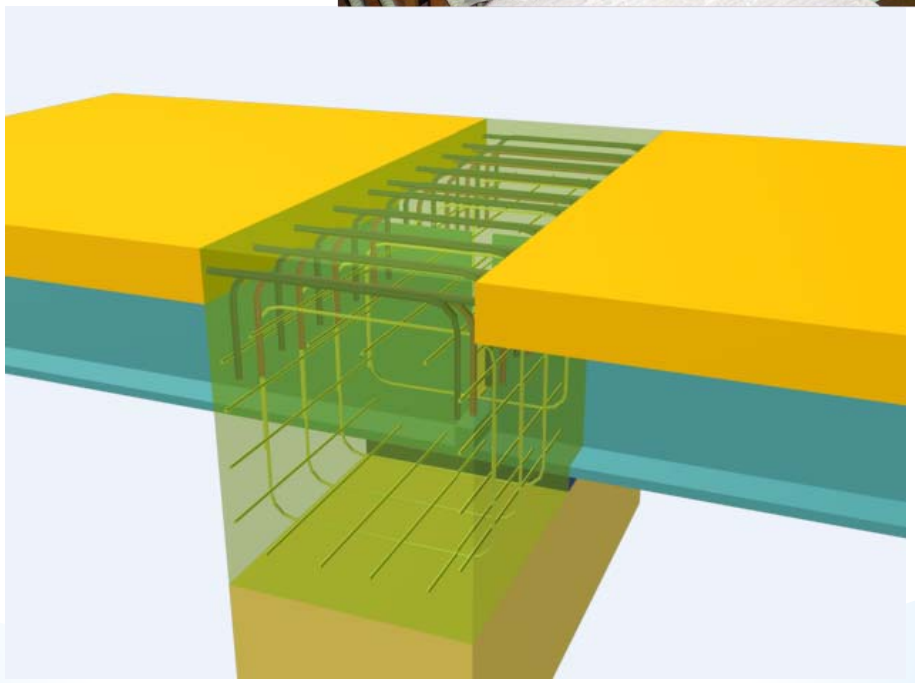
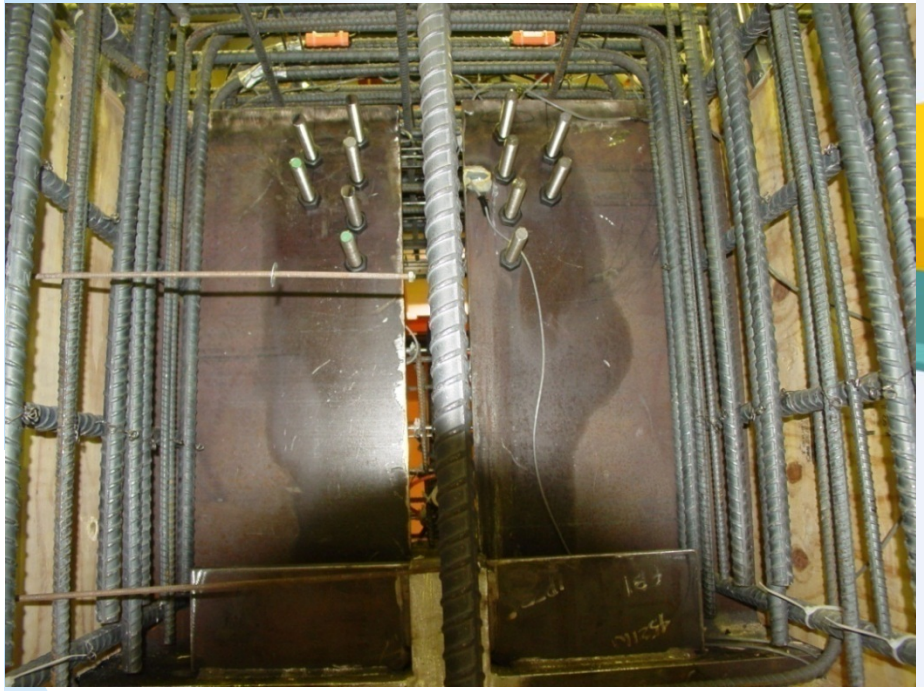
SDCL- Case of ABC

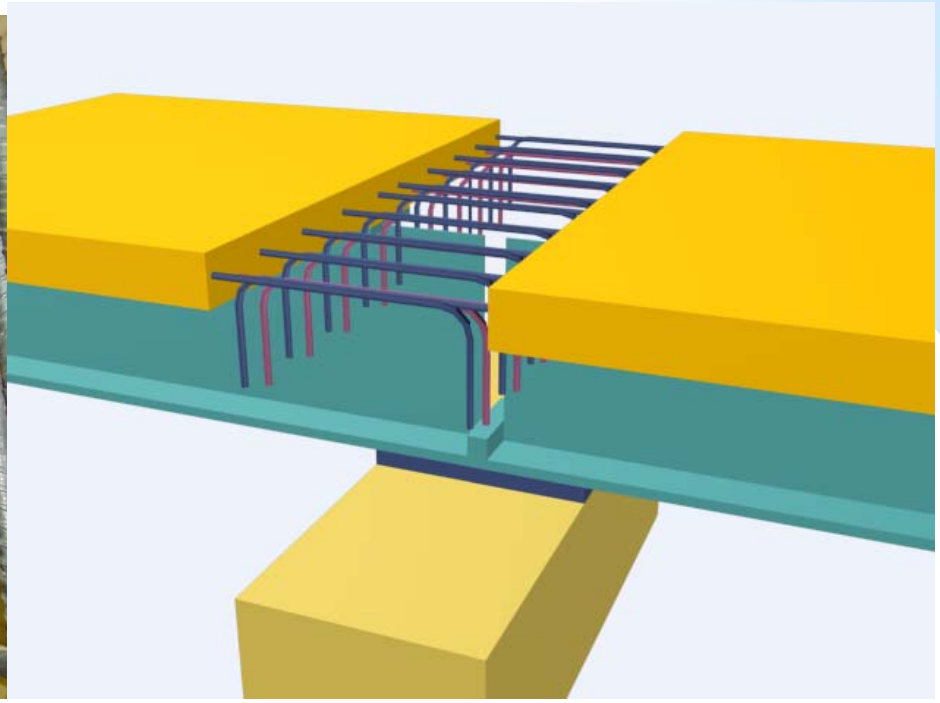




Full Scale Testing

SDCL- ABC recommended detail





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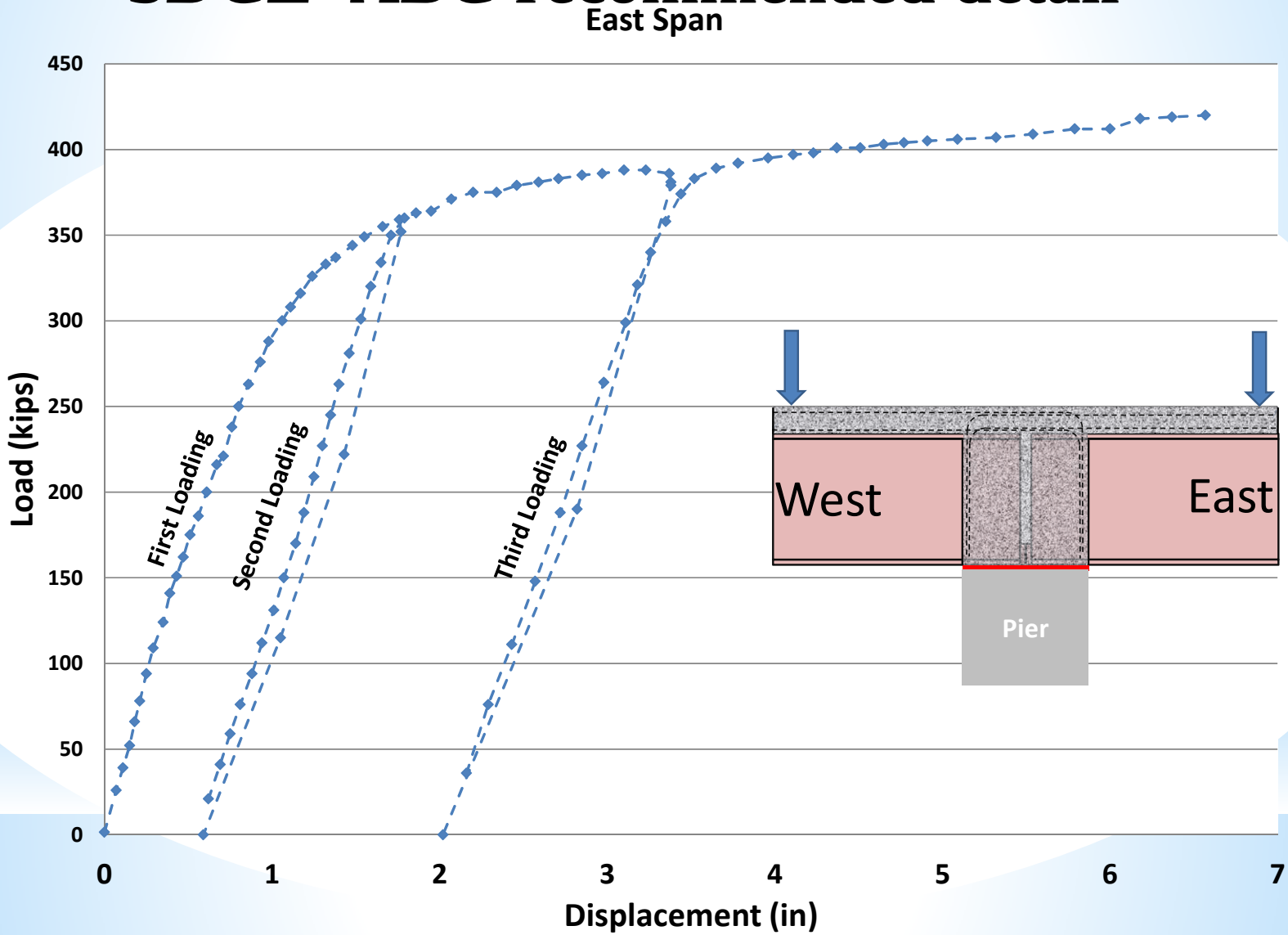
Full Scale Testing

SDCL- ABC recommended detail

Full Scale Testing

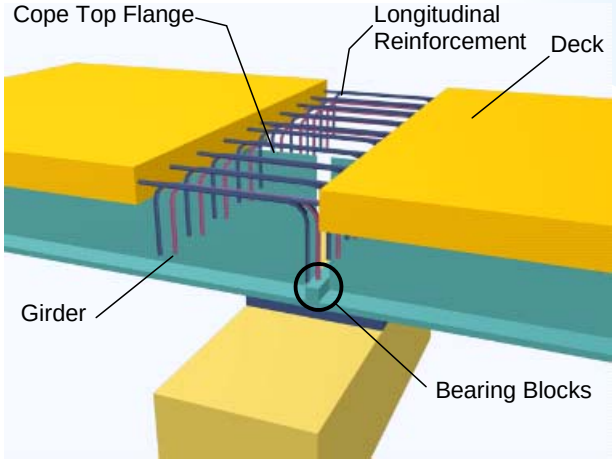
SDCL- ABC recommended detail



SDCL- Recommended Detail

Cast in Place Deck

ABC



Fill Diaphragm

½ to 2/3

Recommended Design – Tension Reinforcement

Cast in Place Deck

ABC

$$M_n = A_s f_y \ (moment\ Arm)$$

Future Applications of SDCL- Seismic Application

Steel bridges are lighter (about 40% of concrete bridges)

1995 Hyogoken-Nanbu earthquake in Kobe lesson: Protect end of steel girder and have a good path to transfer lateral loads from superstructure to substructure.

Hanshine Expressway, was closed for more than a year

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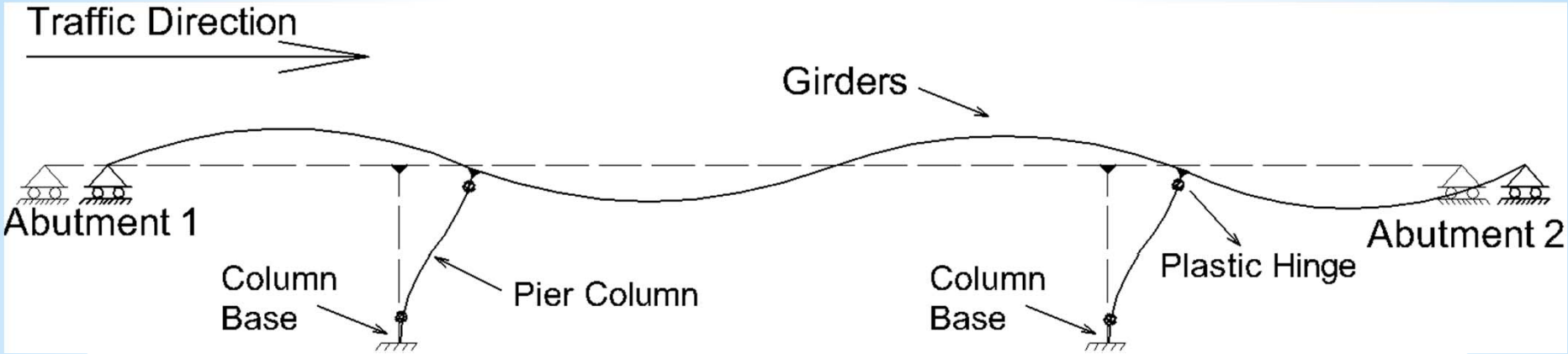
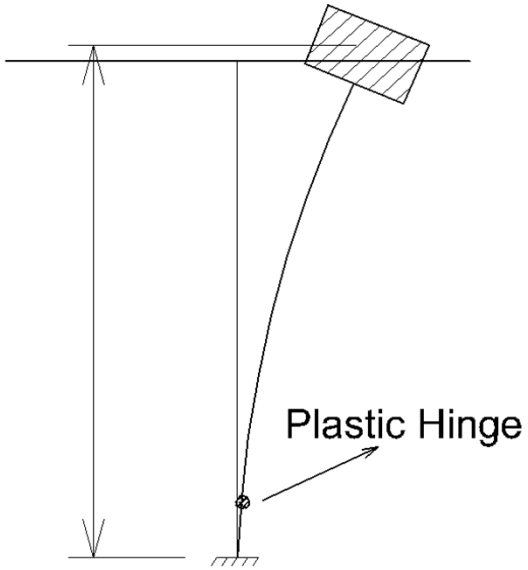
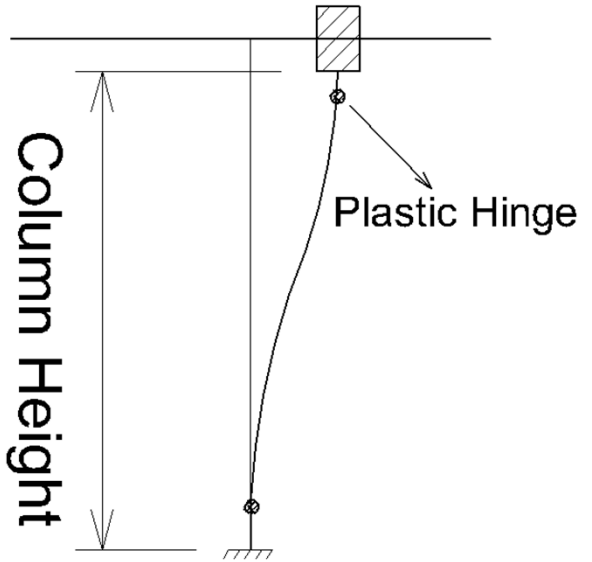
Future Applications of SDCL- Seismic Application



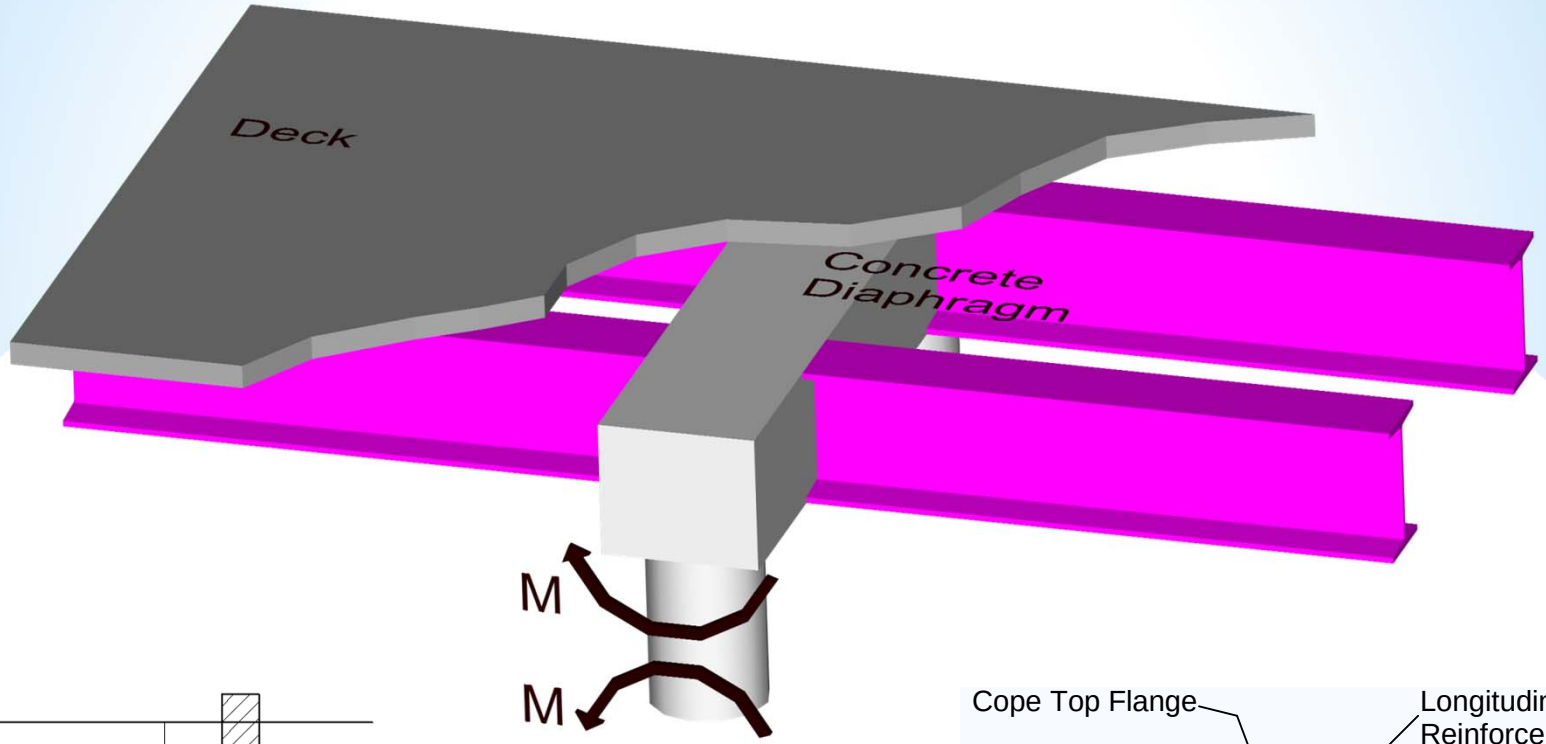


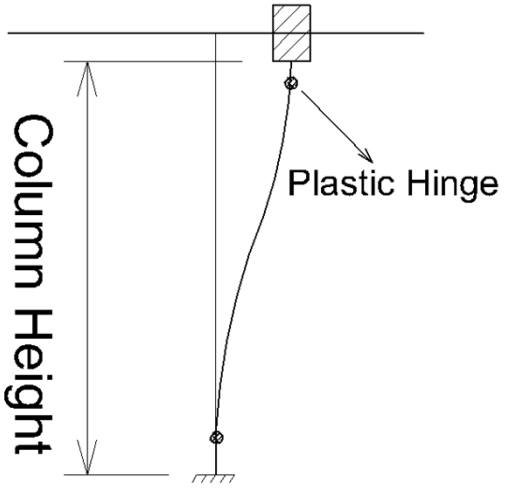
(b) Transverse Deformation



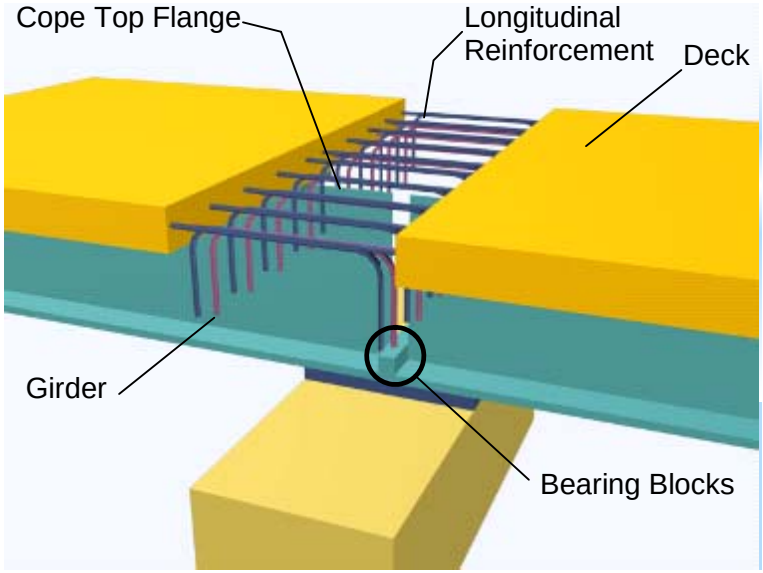
(a) Longitudinal Deformation

Future Applications of SDCL- Seismic Application

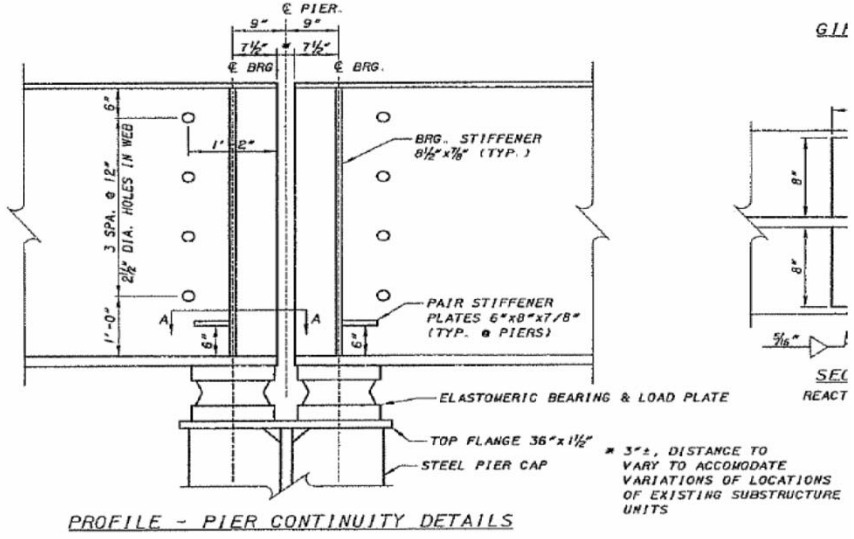


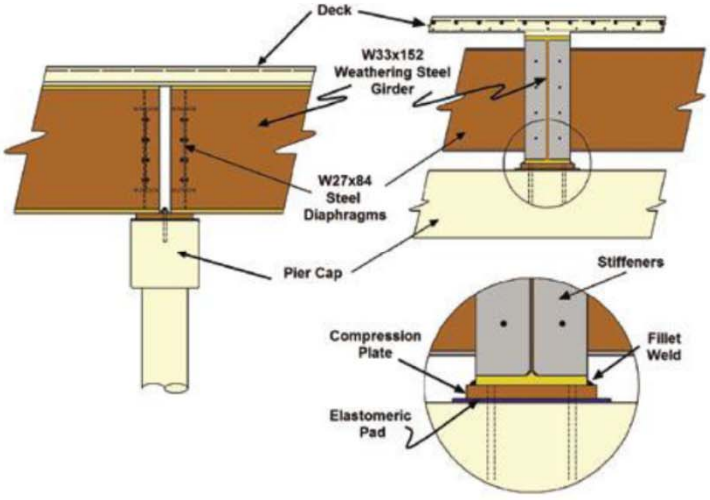


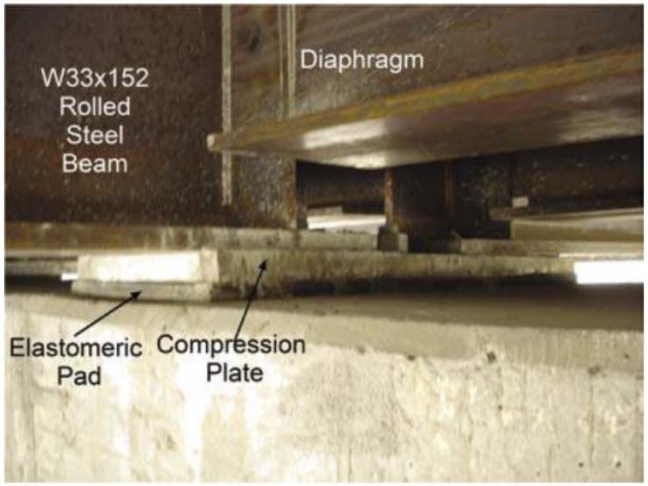
(a) Longitudinal Deformation

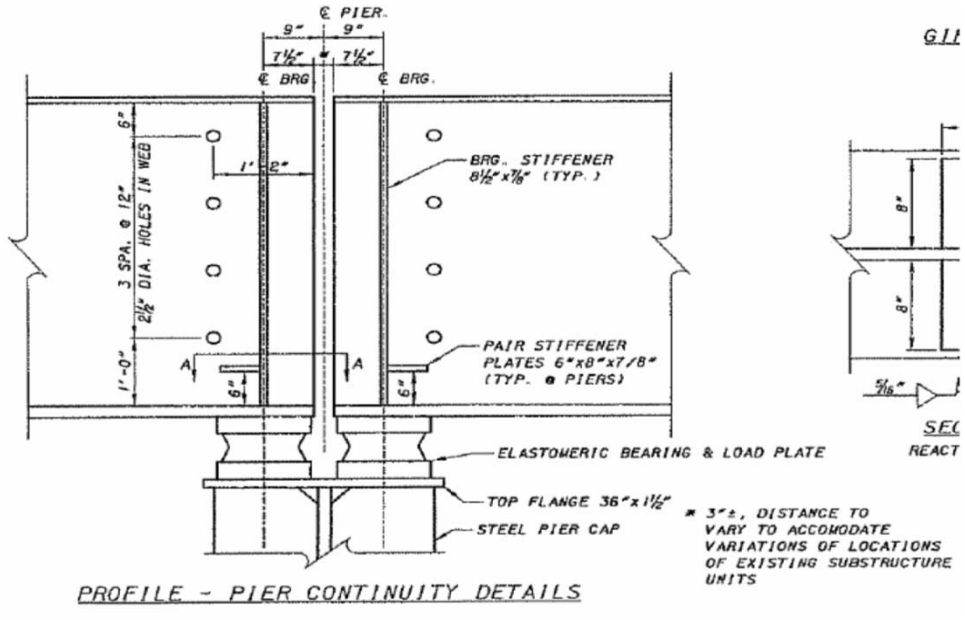


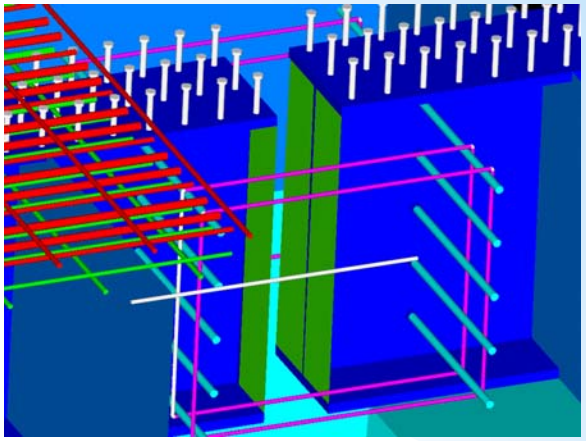
Brief Discussion of other SDCL Details used in Practice

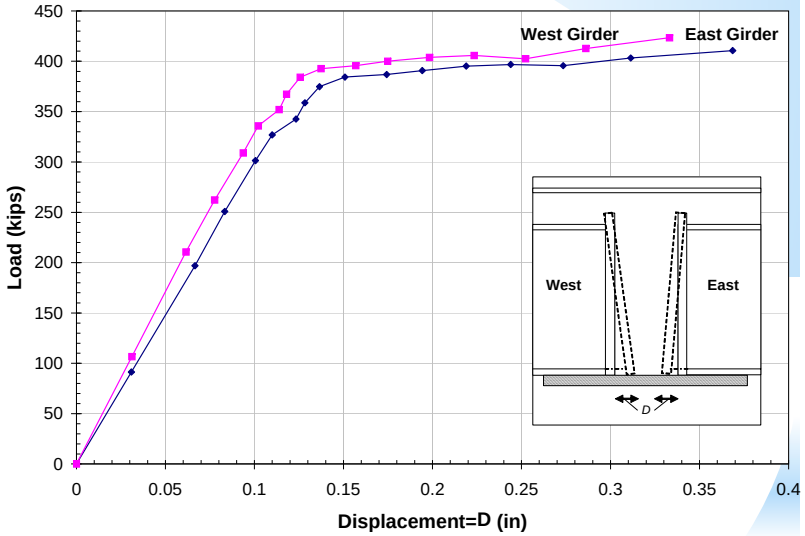












Test results shows that concrete in vicinity of Bottom flanges can crush

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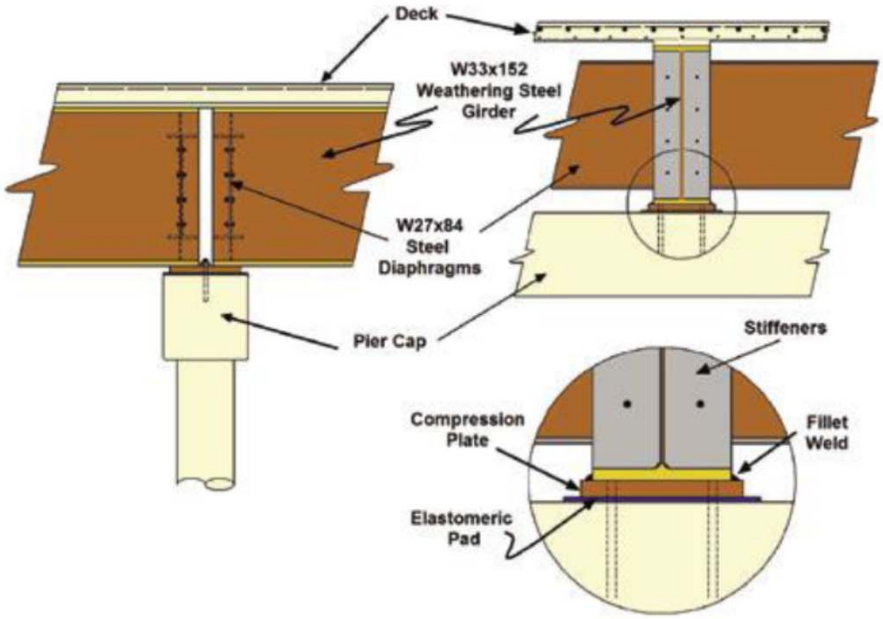
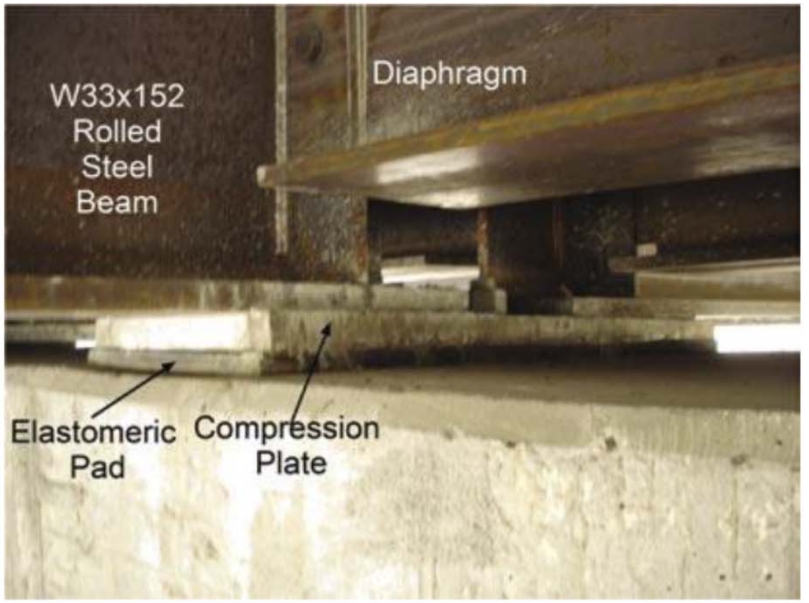
Research results shows that there is no need for top plate

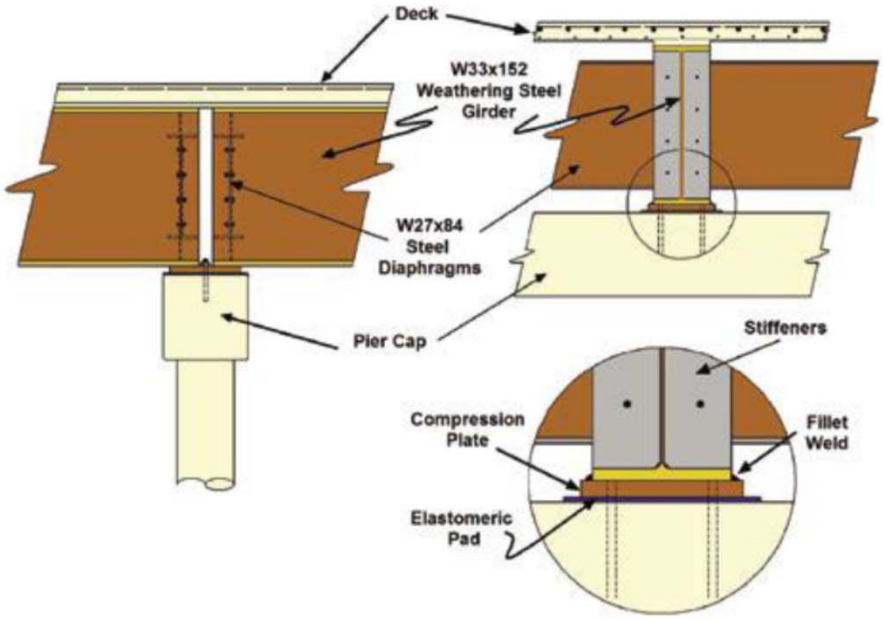
This detail is not recommended

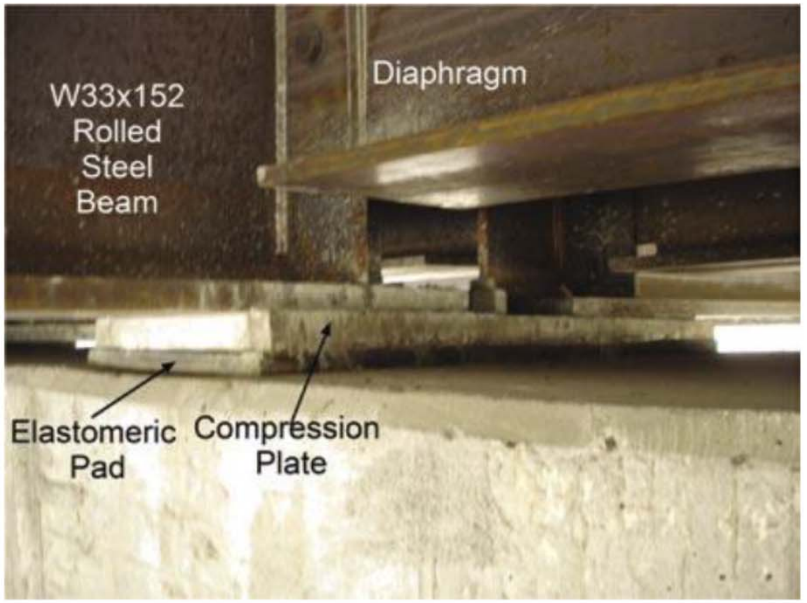




Challenges with this detail (Cast in Place Deck)

- Ends of girders are not protected
- Steel diaphragm is needed at end of each girder.





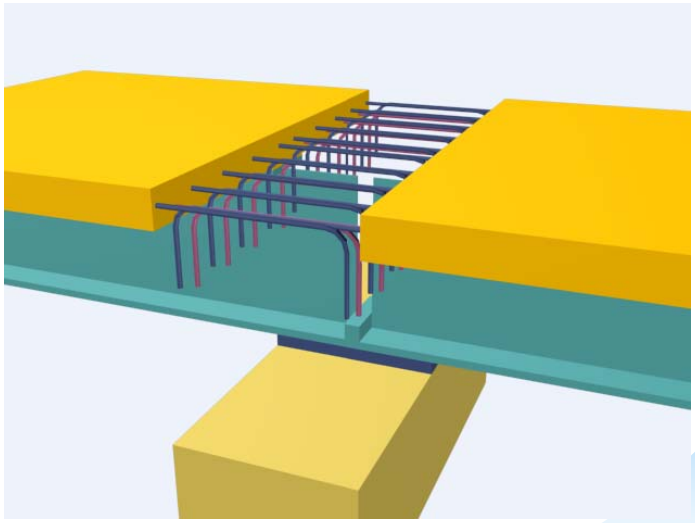
Challenges with this detail (Cast in Place Deck)

- Deck can crack
- Moisture can penetrate from bottom side
- Low fatigue category

Advantages of SDCL Steel Bridge System

Cast in place deck and ABC

- SDCL steel bridge system facilitates use of ABC



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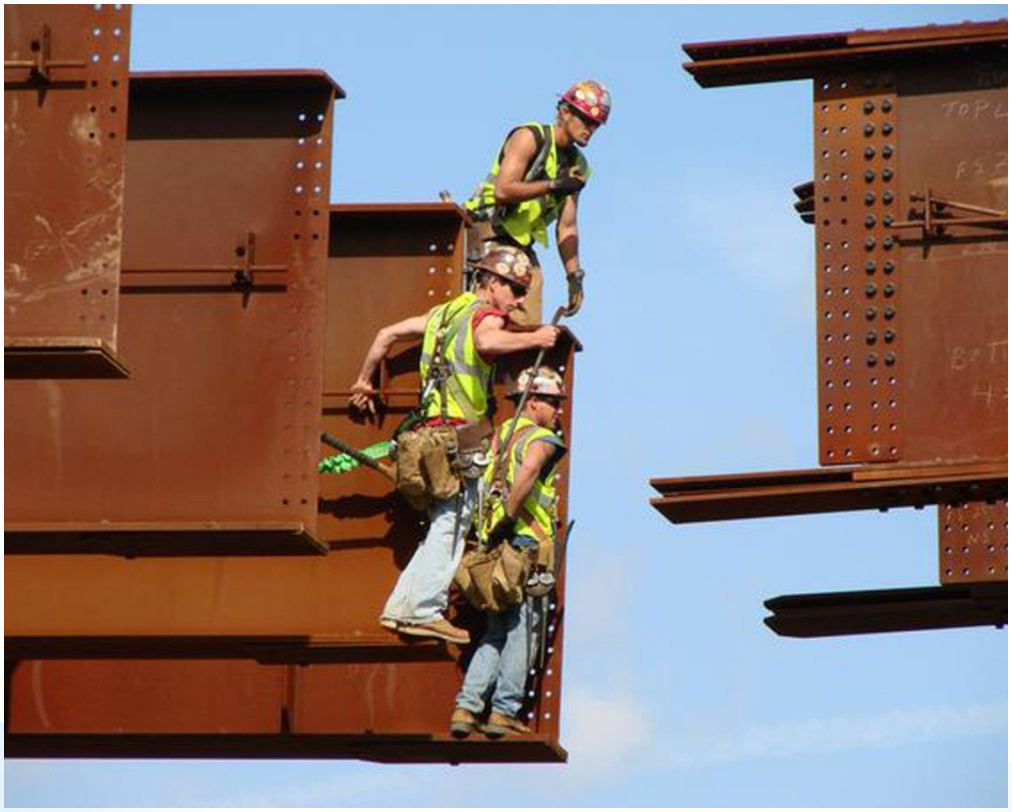
Advantages of SDCL Steel Bridge System

Cast in place deck and ABC

- Eliminating the need for bolted splices



Advantages of SDCL Steel Bridge System

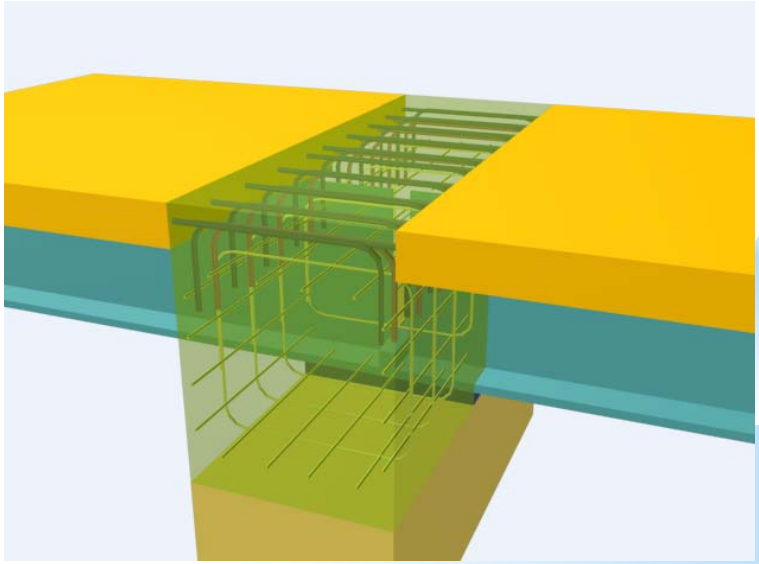
Cast in place deck and ABC

- Allowing use of the same cross section throughout the girder length

Advantages of SDCL Steel Bridge System

Cast in place deck and ABC

- SDCL steel bridge system with recommended detail over pier, protect the girder ends against any possible corrosion and enhances the service life of bridges. Eliminating the bolted splices, also help to enhance the service



AISC *Engineering Journal* special edition- SDCL

- Soliciting papers to collect existing SDCL expertise in one place for easy reference to facilitate standardization of design and construction practices
- Topics include design, construction, or monitoring in-service performance of SDCL steel bridges
- Submittals due January 11, 2013

www.aisc.org/ej

Thanks You

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