Appendix

Reference material for evaluation of alternatives

Research on Advance Bridge Construction in Puerto Rico

Puerto Rico Transportation Technology Transfer Center

University of Puerto Rico, Mayagüez Campus

Puerto Rico Transportation Technology Transfer Center

RECINTO UNIVERSITARIO DE MAYAGÜEZ
CAAM
UNIVERSIDAD DE PUERTO RICO

ABC (Accelerated Bridge Construction)

- ABC consists of construction methods that result in an overall decrease in construction time when compared to the conventional construction methods used to build bridges.

- It uses innovative planning, design, materials, and construction methods in a safe and cost-effective manner to reduce the onsite construction time that occurs when building new bridges or replacing and rehabilitating existing bridges.

Superstructure Elements

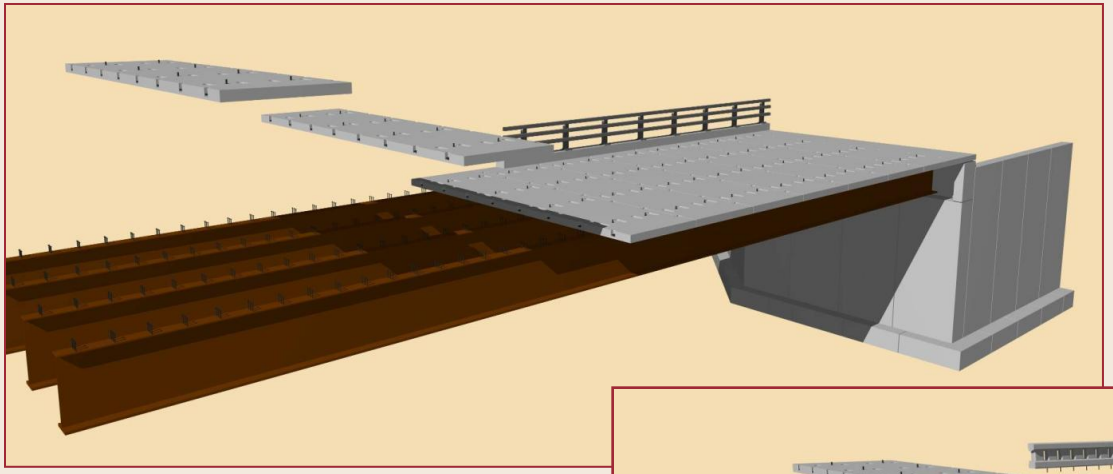
Options that are compatible with ABC to be evaluated:

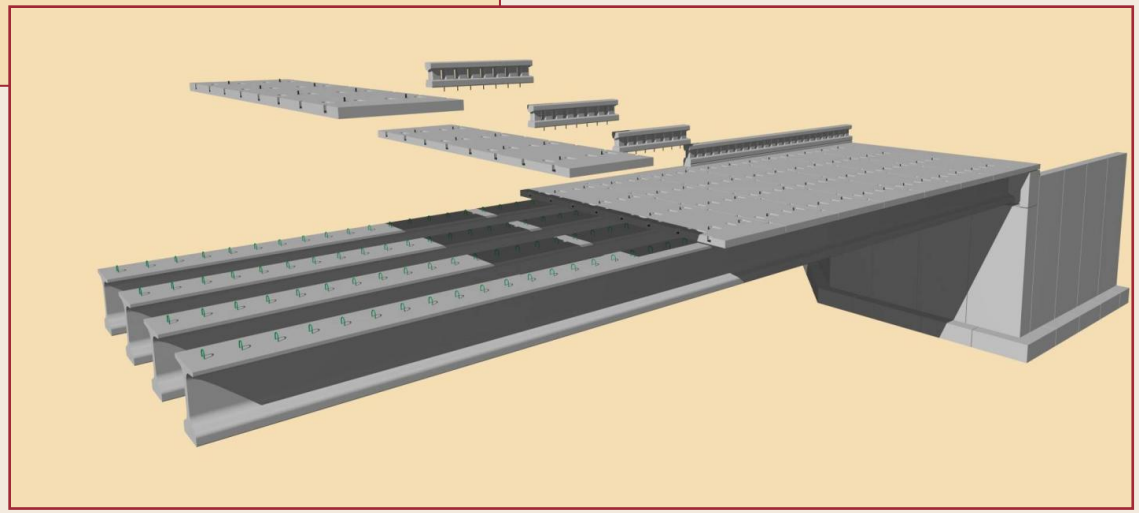
- **Alternative 1**: Full-depth Precast Deck Panels
- **Alternative 2**: Steel girders with integrated concrete deck
- **Alternative 3**: AASHTO beams with integrated concrete deck
- **Alternative 4**: Precast Decked Girders
- **Alternative 5**: Segmental Bridges

Superstructure

Alt. 1: Full-Depth Precast Deck Panels

- Description: The full-depth deck system is precast and subsequently installed.





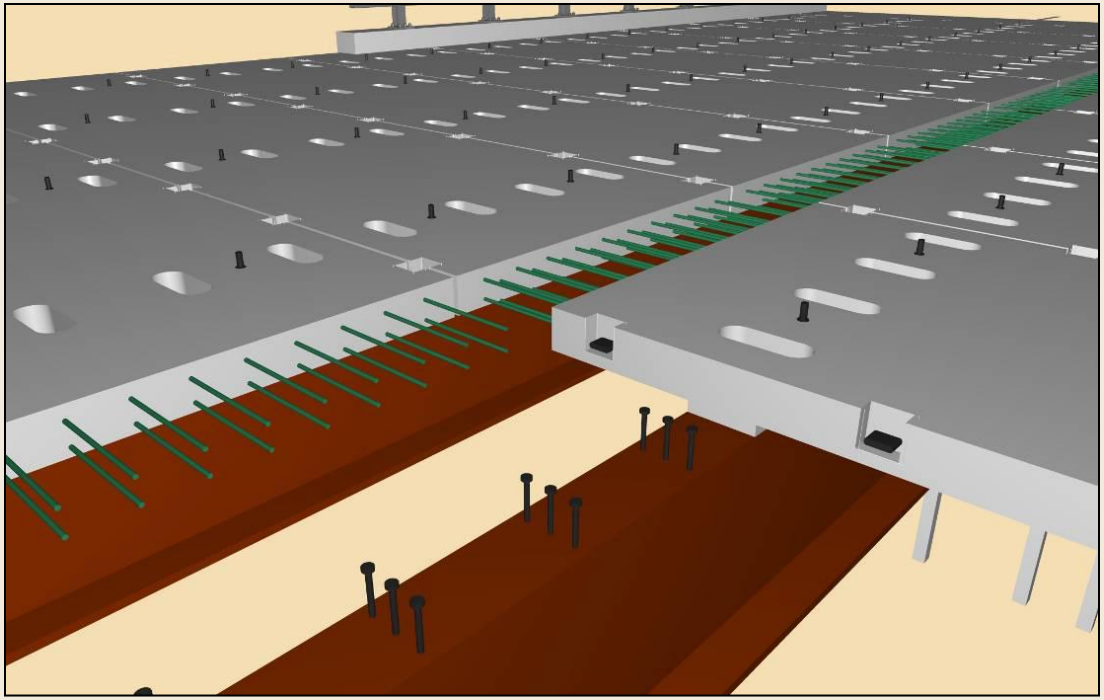
Superstructure

Alt. 1: Full-Depth Precast Deck Panels

Installation of Precast Deck Panels

Superstructure

Alt. 1: Full-Depth Precast Deck Panels



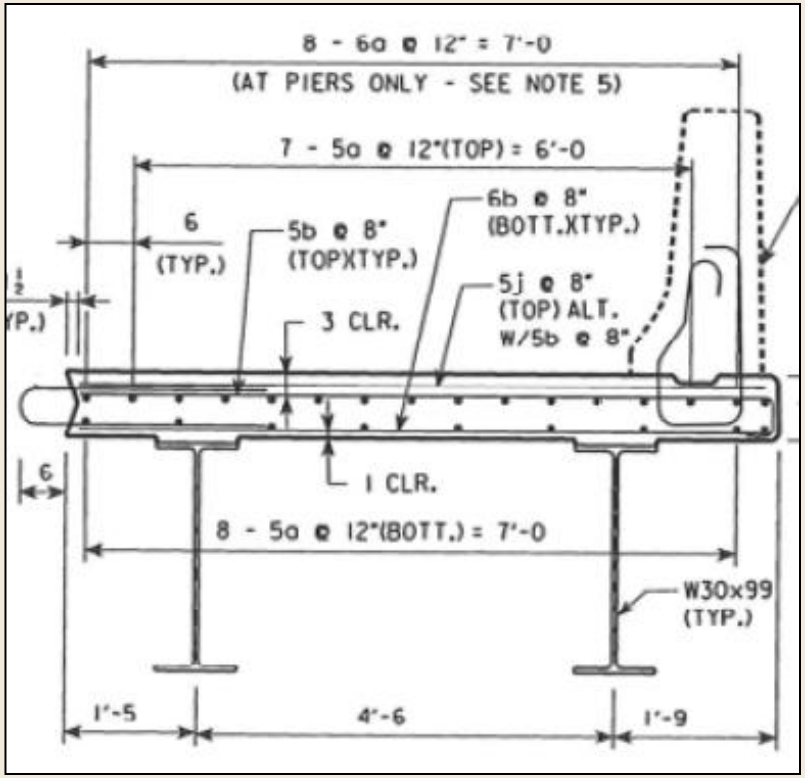
Superstructure

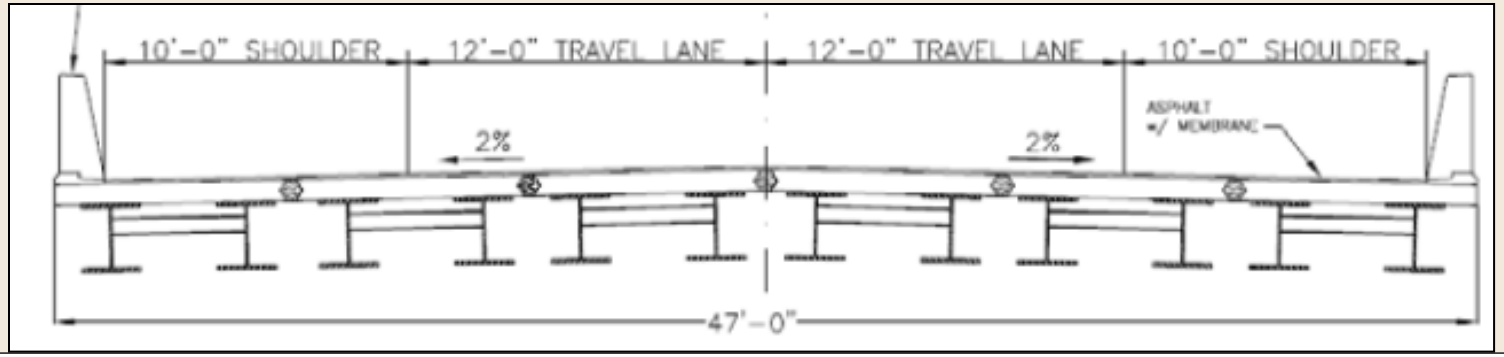
Alt. 2: Steel girder with integrated concrete deck

- Description: A precast deck is cast over steel beams to form a pre-topped module. After the modules have been installed, deck edges are connected with closure pours.

Superstructure

Alt. 2: Steel girder with integrated concrete deck





Superstructure

Alt. 3: AASHTO beams with integrated concrete deck

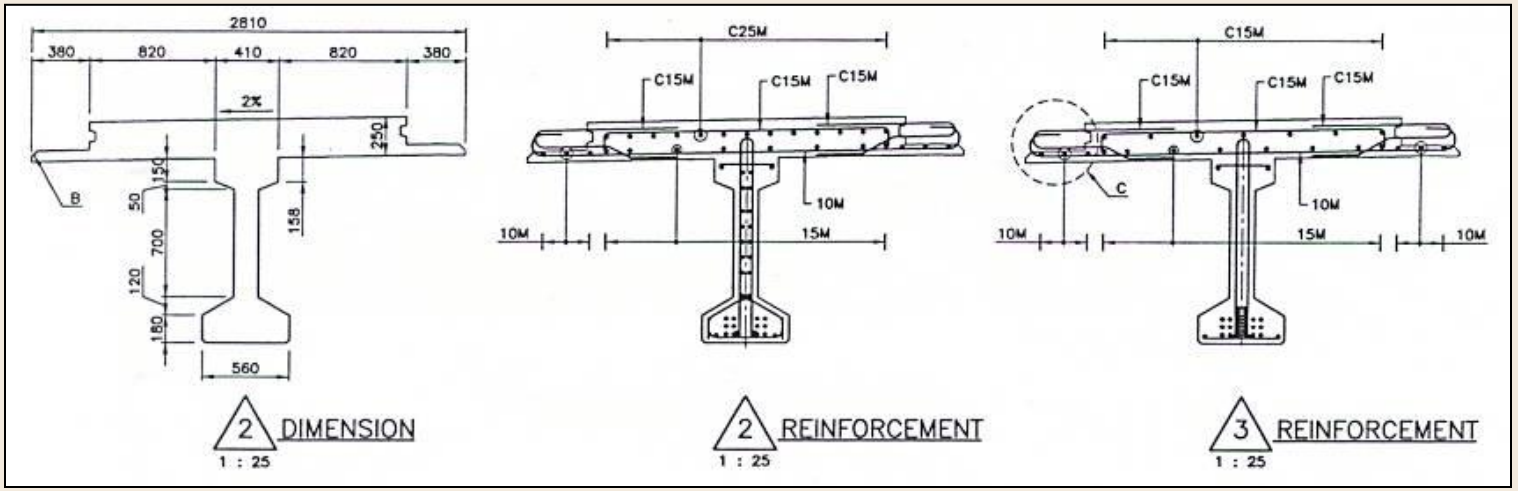
- Description: A precast deck is cast over AASHTO concrete I-girders to form a pre-topped module. After the modules have been installed, deck edges are connected with closure pours.

Superstructure

Alt. 3: AASHTO beams with integrated concrete deck

Superstructure

Alt. 3: AASHTO beams with integrated concrete deck



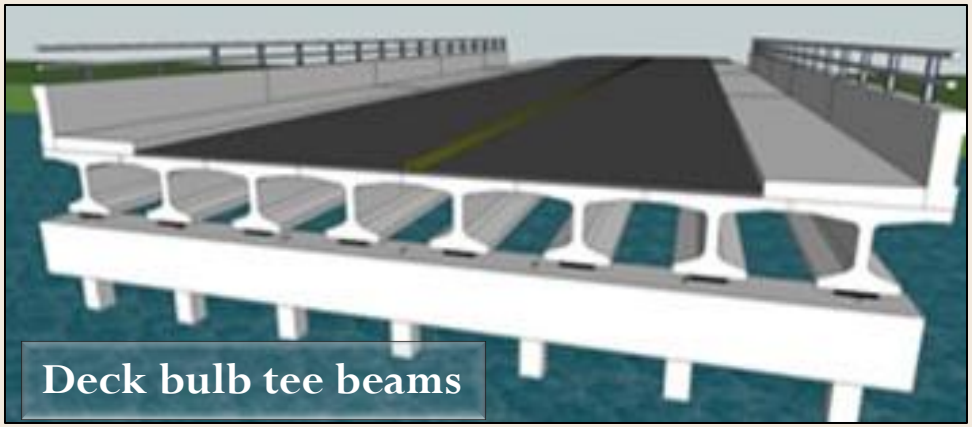
Superstructure

Alt. 4: Precast Decked Girders

Description: Decked precast sections that are placed adjacent to one another to form the riding surface of the bridge.

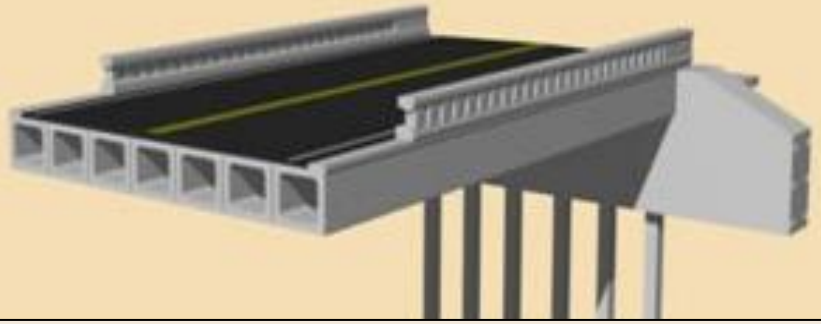
It includes sections such as:

- Adjacent Box Beams
- Deck Bulb Tee Beams
- Double Tee Beams
- Box Girders
- NEXT Beam



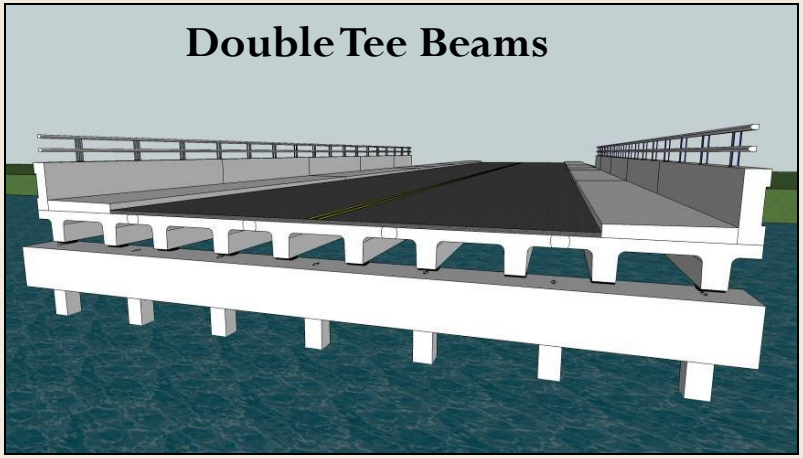
Deck bulb tee beams

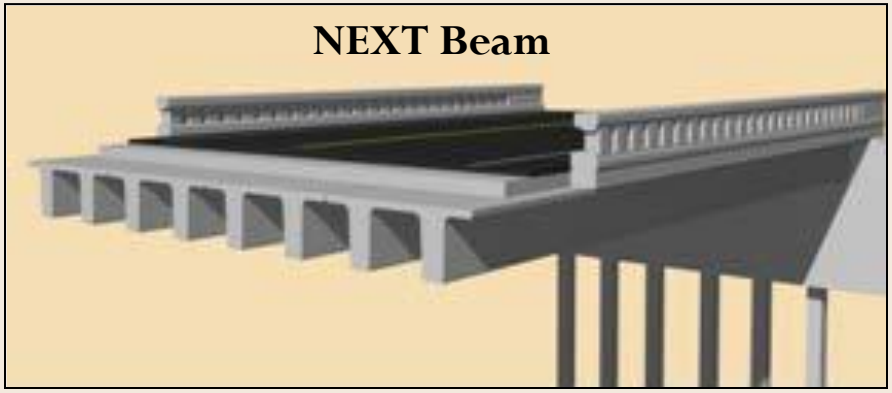
Adjacent Box Beams



Superstructure

Alt. 4: Precast Decked Girders

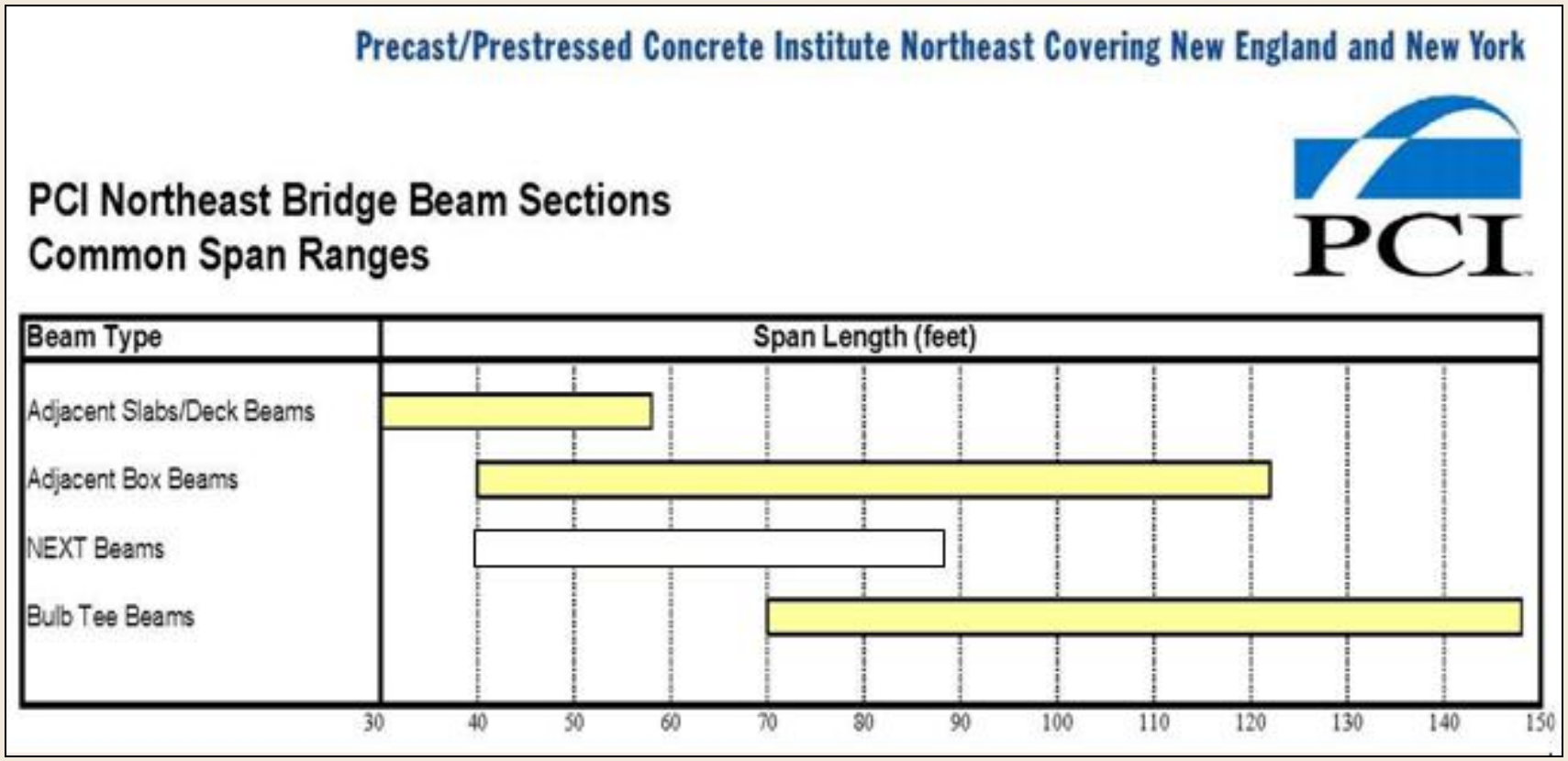




Superstructure

Alt. 4: Precast Decked Girders

Common Span Ranges for typical Precast Decked Girders

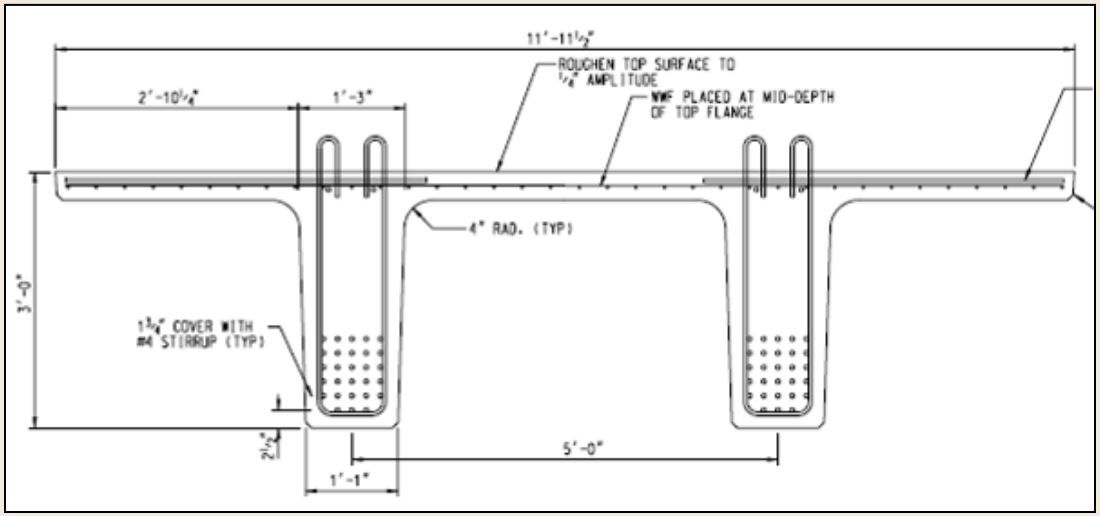


Superstructure

Alt. 4: Precast Decked Girders

The Northeast Extreme Tee Beam (NEXT Beam) is a new section of precast decked girders.

- Depth 24” – 36” in 4” increments
- Typical Span Range 50 – 85’
- Width will vary 8’-0” – 12’-0”



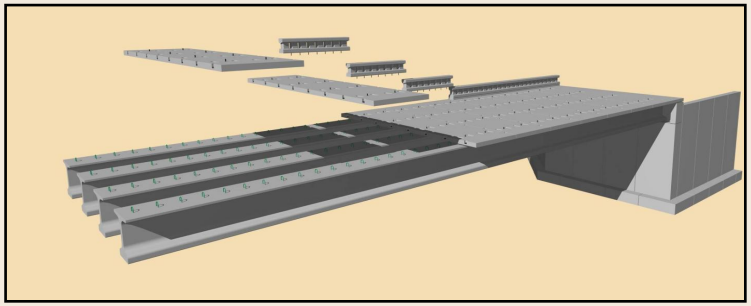
Superstructure

Alt. 5: Segmental Bridges

- Description: Segmental construction involves the connection of numerous full-width concrete elements using post-tensioning. This is considered an ABC method when precast segments that are lifted into place and post-tensioned together are used.

Superstructure Alternatives

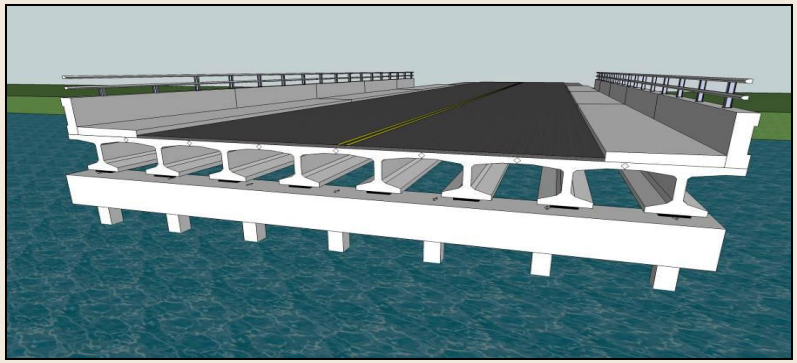
Alt. 1: Full Depth Precast Deck Panels



Alt. 2: Steel girder with integrated concrete dec

Alt. 3: AASHTO beams with integrated concrete deck

Alt. 4: Precast Decked Girders



Alt. 5: Segmental Bridges

Substructure elements:

Supports

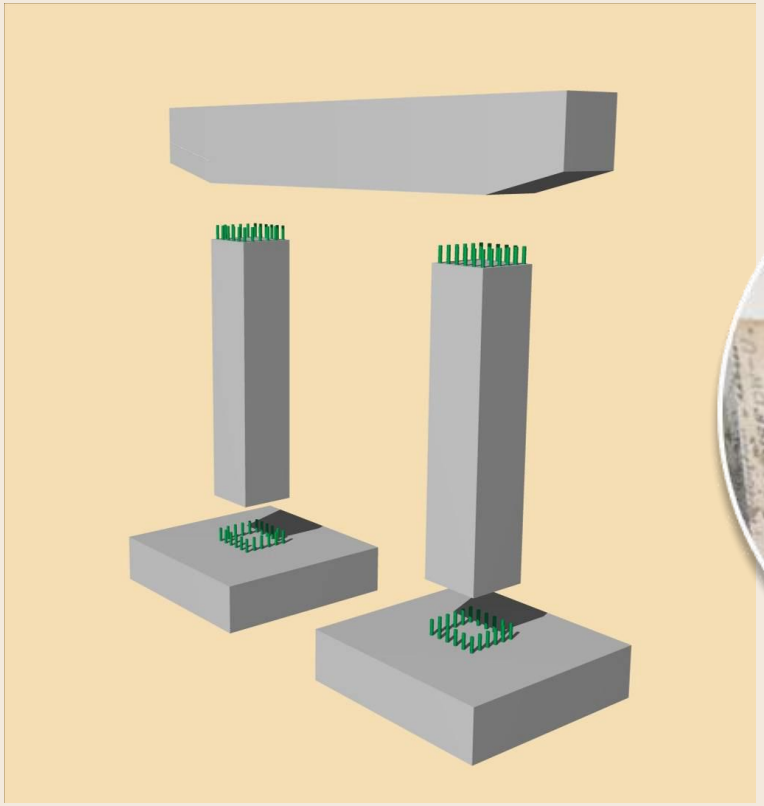
Options compatible with ABC that will be evaluated:

- **Alternative 1**: Full Precast cap beam and columns connected at the top and bottom using grouted splice couplers
- **Alternative 2**: Full Precast cap beam and columns connected using post-tensioned ducts at the top and bottom
- **Alternative 3**: Full Precast cap beam with segmental columns connected using mechanical couplers and corrugated ducts
- **Alternative 4**: Full Precast cap beam and columns connected with corrugated duct at the tops and corrugated end placed into CIP footings

Supports

Alt. 1: Full Precast cap beam and columns connected at the top and bottom using grouted splice couplers

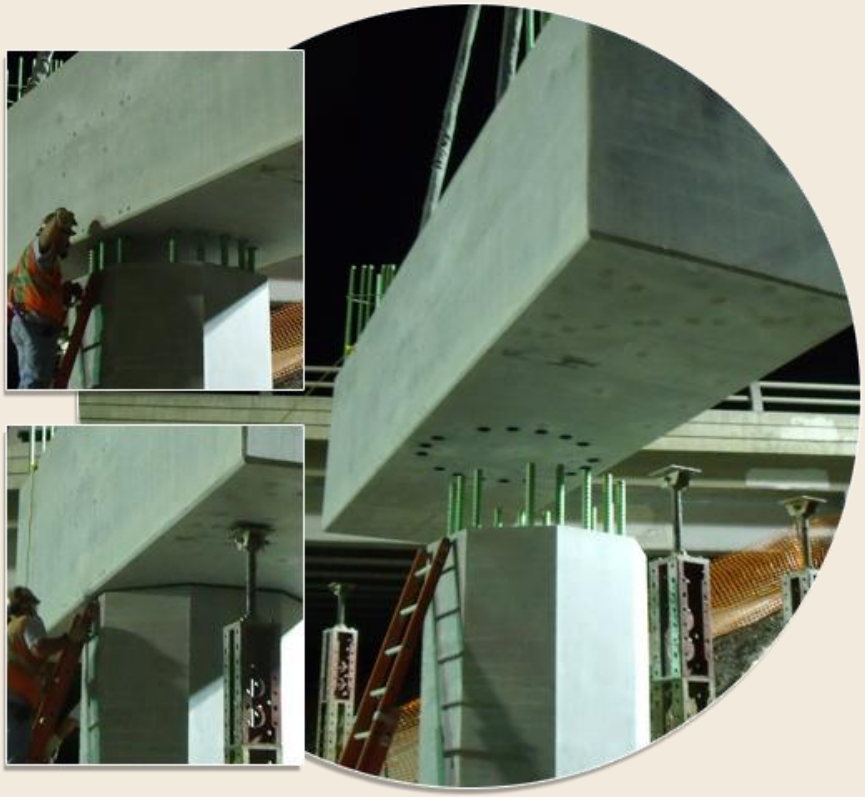
- Columns and pier cap are precast elements.
- Connection between precast elements are made using grouted splice couplers.



Supports

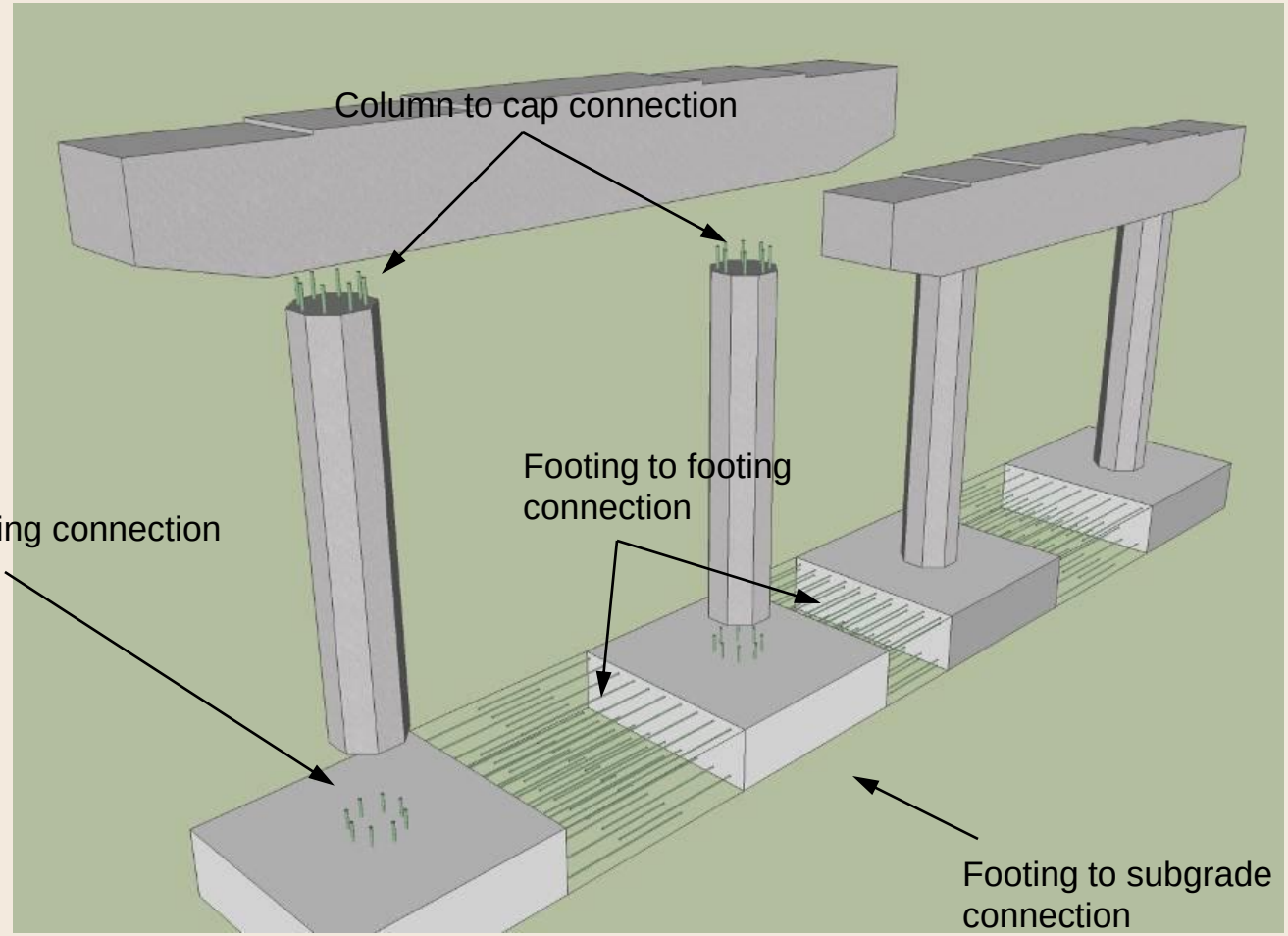
Alt. 1: Full Precast cap beam and columns connected at the top and bottom using grouted splice couplers

- Grouted Splice Couplers
  - Couplers are embedded in one element and they receive bar extensions from the adjacent element.
  - The coupler is grouted with high strength grout.
  - Emulates a reinforcing steel lap splice.



Supports

Alt. 1: Full Precast cap beam and columns connected at the top and bottom using grouted splice couplers

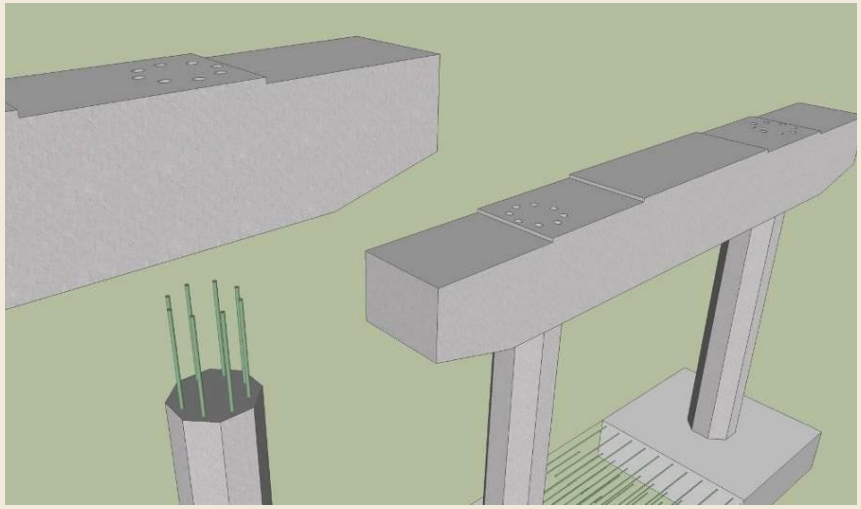


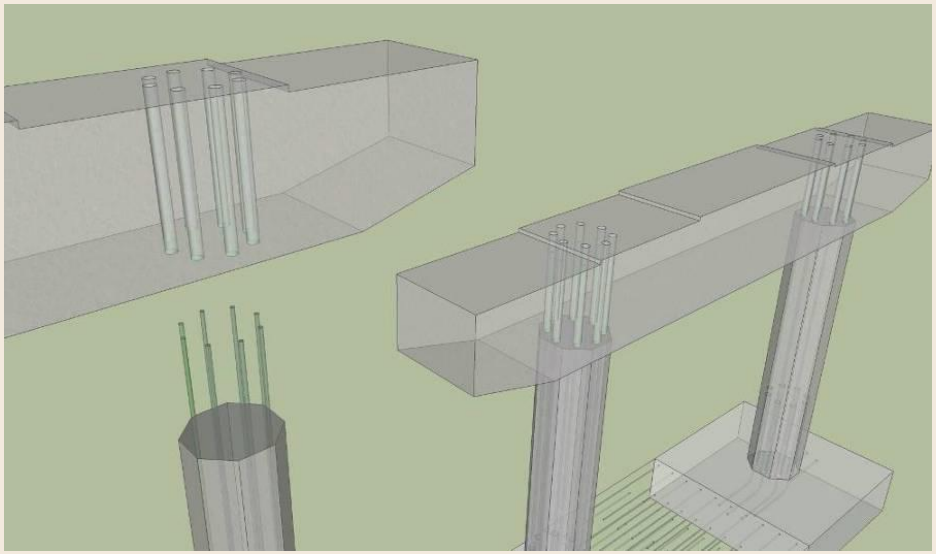
Completed Pier

Supports

Alt. 2: Full Precast cap beam and columns connected using post-tensioned ducts at the top and bottom

- Similar to grouted couplers, except the coupler is replaced with a post-tensioning duct that is cast into one of the elements.
- These connections require longer dowel bar lengths than grouted couplers; however they can be less expensive and allow larger casting tolerances on the dowel bars.

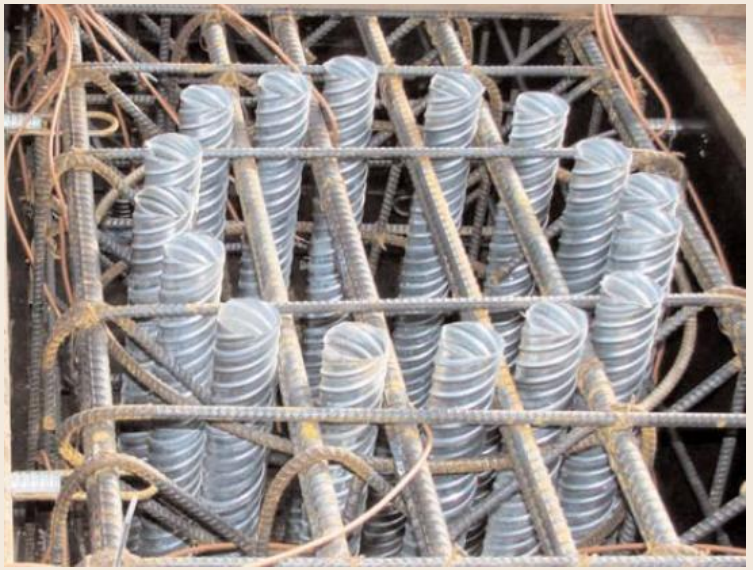


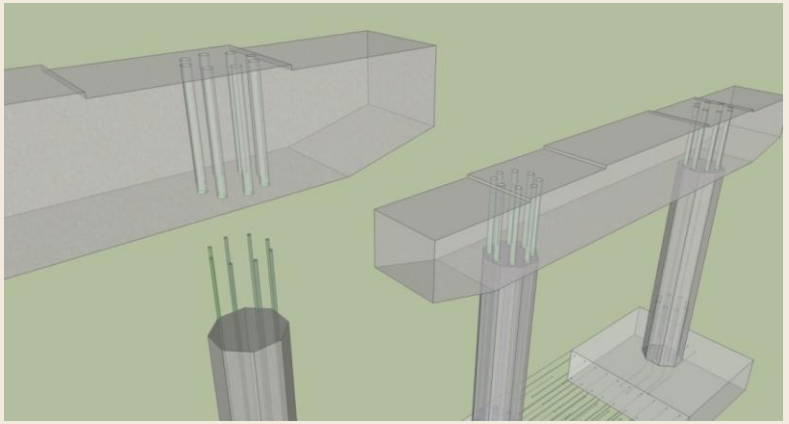


Supports

Alt. 2: Full Precast cap beam and columns connected using post-tensioned ducts at the top and bottom

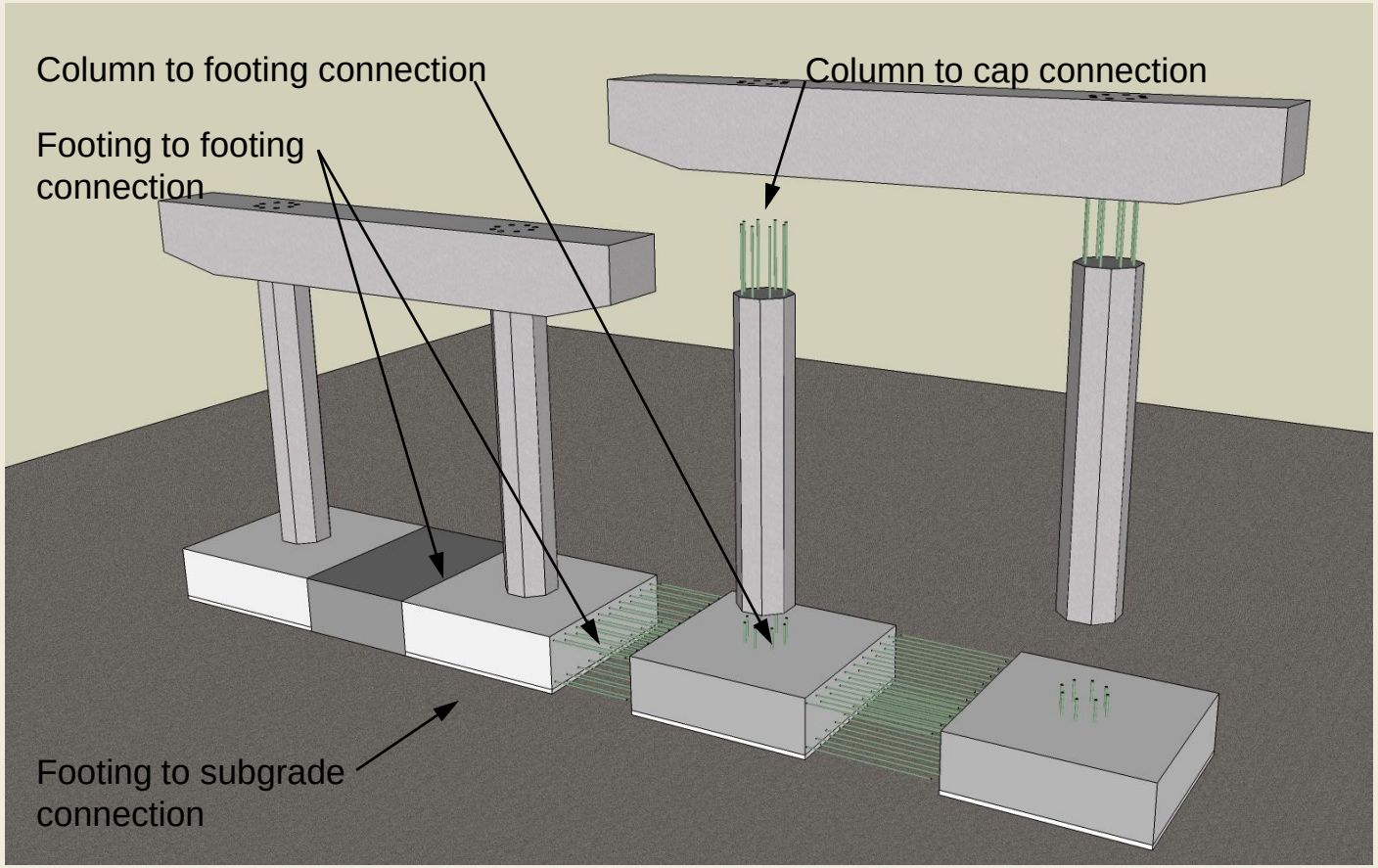
For column to cap connection, use details from NCHRP Report 681





Supports

Alt. 2: Full Precast cap beam and columns connected using post-tensioned ducts at the top and bottom



Completed Pier

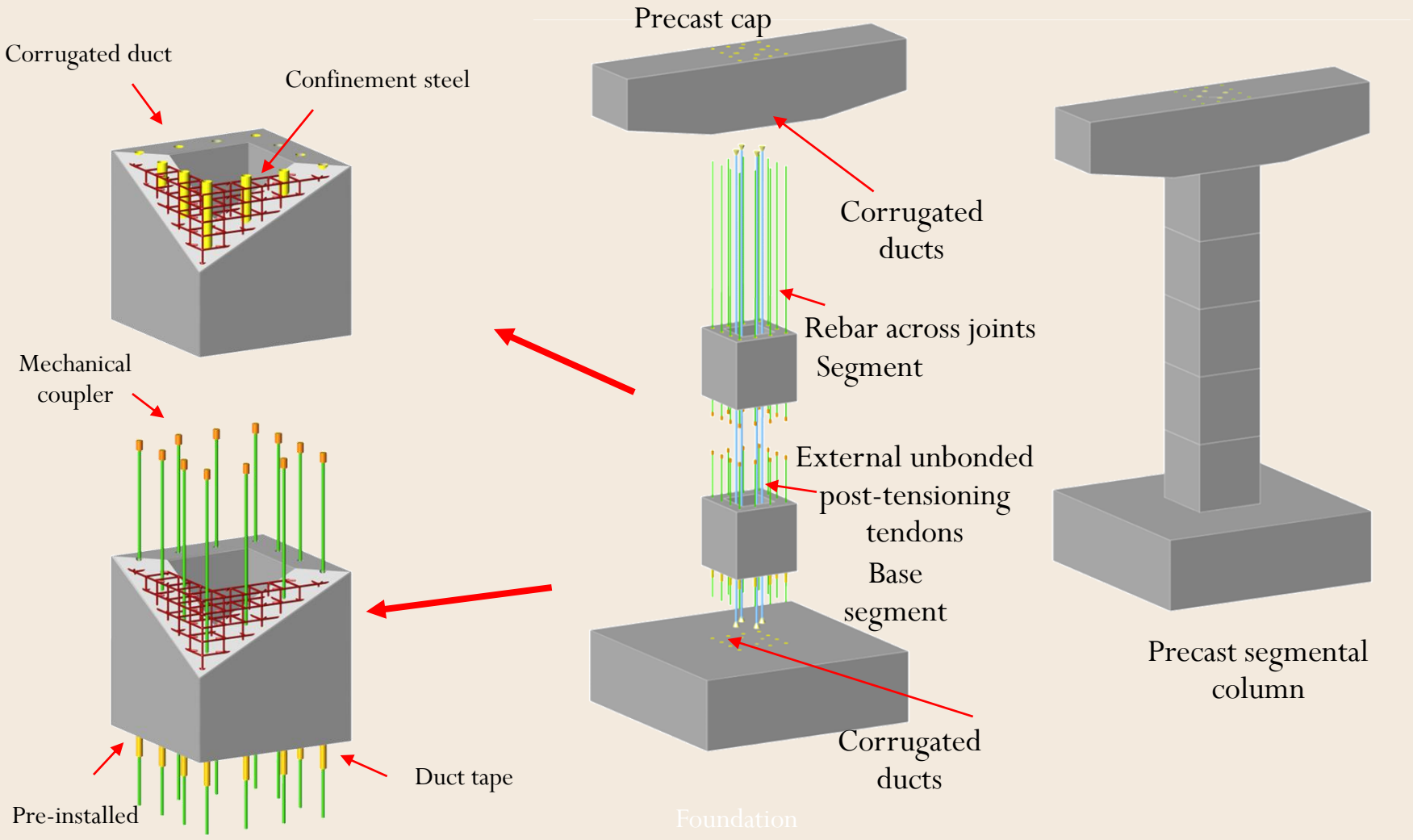
Supports

Alt. 3: Full Precast cap beam with segmental columns connected using mechanical couplers and corrugated ducts

- The columns are fabricated in segments and connected on-site.
- Ideal for projects were columns are large enough that cannot be transported or lifted as a single piece.

Supports

Alt. 3: Full Precast cap beam with segmental columns connected using mechanical couplers and corrugated ducts



Supports

Alt. 3: Full Precast cap beam with segmental columns connected using mechanical couplers and corrugated ducts

Supports

Alt. 4: Full Precast cap beam and columns connected with corrugated duct at the top and corrugated end placed into CIP footings

- It consists of a precast concrete column placed into cast-in-place concrete spread footings.
- It is made by placing the precast concrete column in the excavation, placing the footing steel, then casting the footing concrete.

Supports

Alt. 4: Full Precast cap beam and columns connected with corrugated duct at the top and corrugated end placed into CIP footings

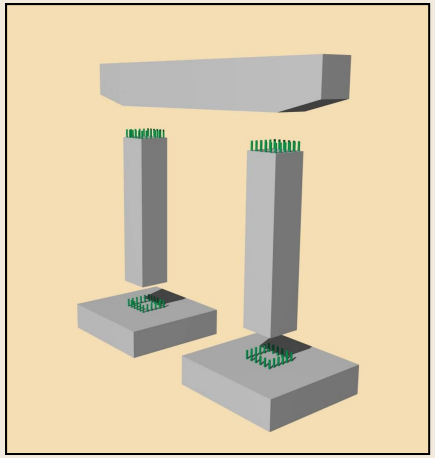
Supports

Alt. 4: Full Precast cap beam and columns connected with corrugated duct at the top and corrugated end placed into CIP footings

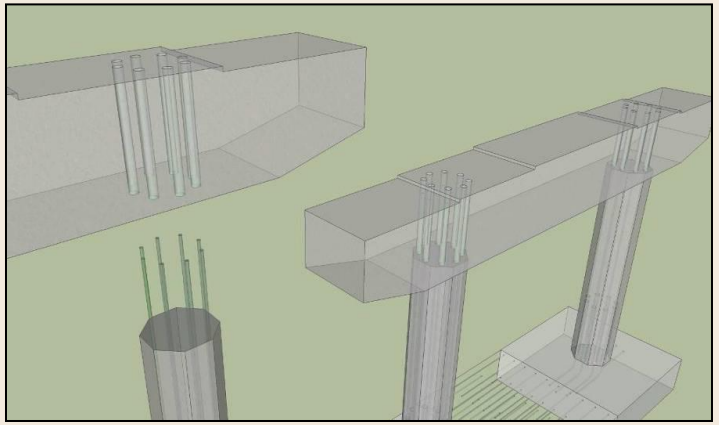
Footing Connection: Construction

Substructure: Supports Alternatives

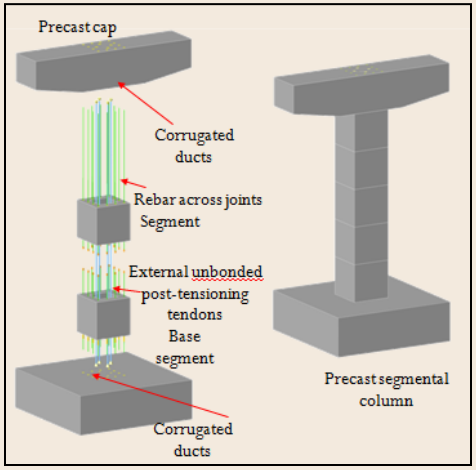
Alt. 1: Full Precast cap beam and columns connected at the top and bottom using grouted splice couplers



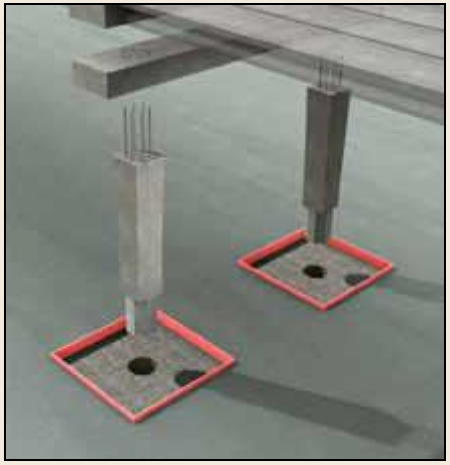
Alt. 2: Full Precast cap beam and columns connected using post-tensioned ducts at the top and bottom



Alt. 3: Full Precast cap beam with segmental columns connected using mechanical couplers and corrugated ducts



Alt. 4: Full Precast cap beam and columns connected with corrugated duct at the tops and corrugated end placed into CIP footings



Substructure elements:

Abutments

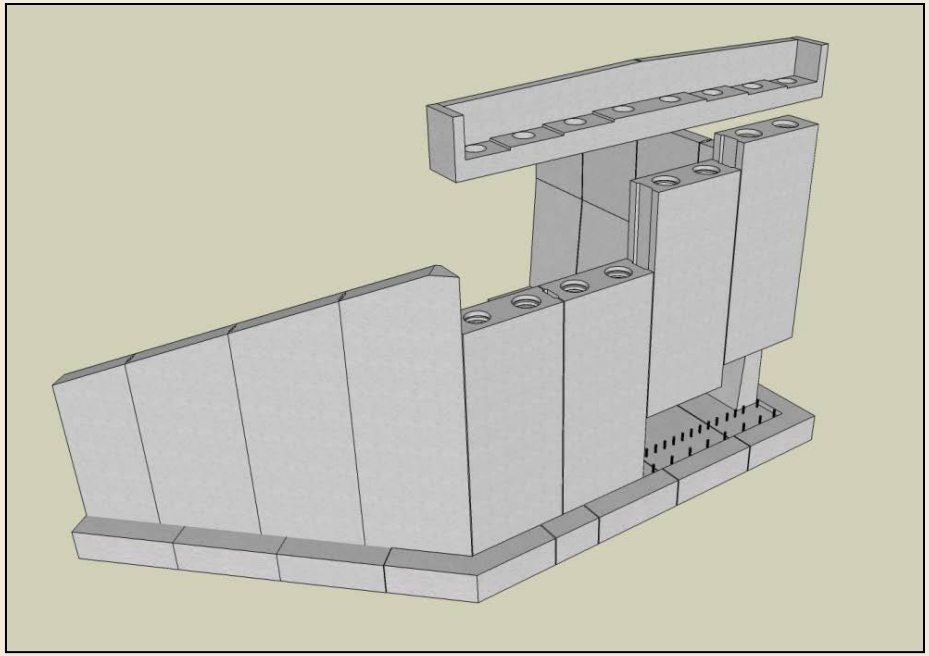
Options compatible with ABC that will be evaluated:

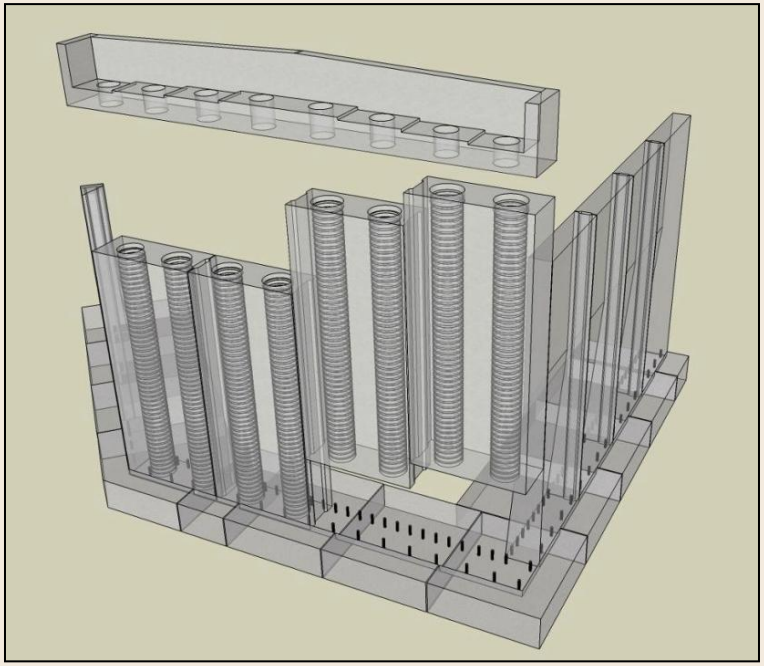
- **Alternative 1**: Precast Cantilever Abutments
- **Alternative 2**: Precast Integral or Semi-Integral Abutments
- **Alternative 3**: Geosynthetic Reinforced Soil (GRS) System

Abutments

Alt. 1: Precast Cantilever Abutment

- Cantilever- Girder and Abutment Wall not connected
  - Footing to wall stems connected using grouted splice couplers
  - Corrugated steel pipes in the abutment walls to reduce weight
  - Abutment cap is connected to the wall stems using a reinforced bar cage cast into the corrugated voids





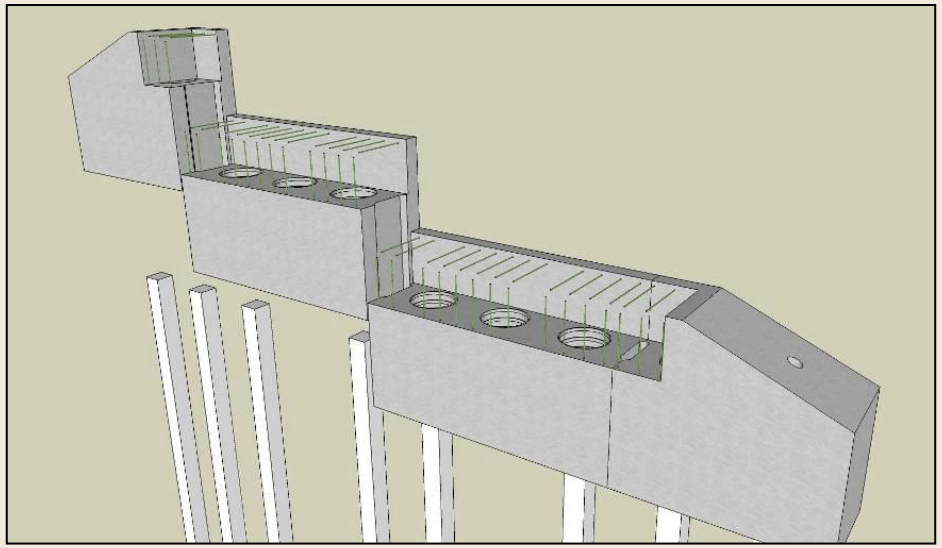
Abutments

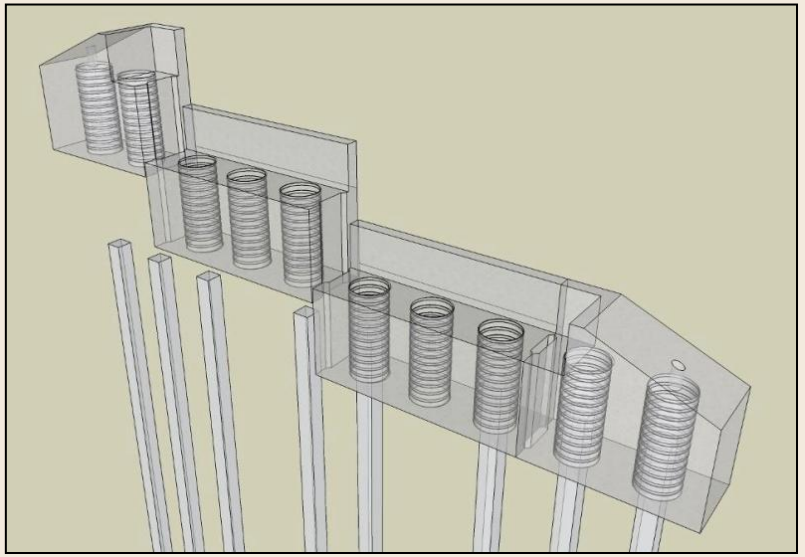
Alt. 1: Precast Cantilever Abutment

Abutments

Alt. 2: Precast Integral or Semi Integral Abutment

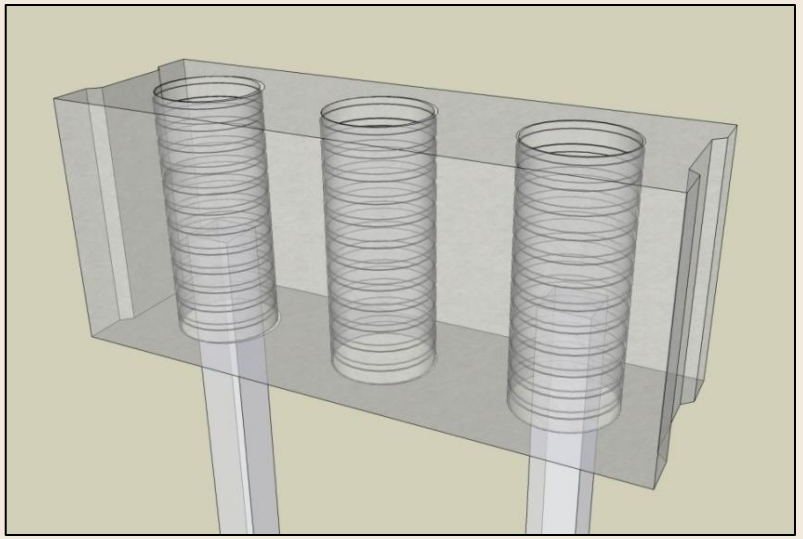
- Girder and Abutment Wall made continuous
  - Corrugated steel pipes to form voids in the stem and complete the connection between the piles and the stem.
  - The connection of the superstructure to the integral abutment is normally accommodated with a cast-in-place concrete closure pour.





Abutments
Alt. 2: Precast Integral or Semi Integral Abutment

- Abutment Details
  - Corrugated metal pipe voids- Placed over pile and filled with concrete
  - Detail developed by Iowa DOT
  - Reduces element weight
  - Has large capacity to transfer pile loads
  - Shear transfer via shear friction

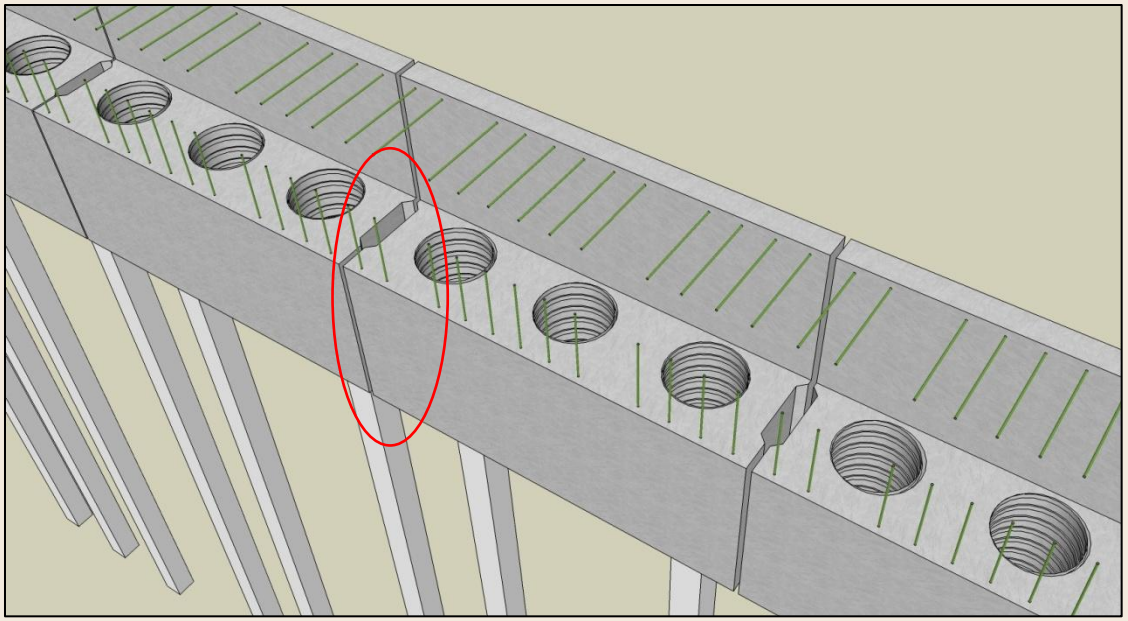


Abutments

Alt. 2: Precast Integral or Semi Integral Abutment

Abutment Cap to Cap Connection

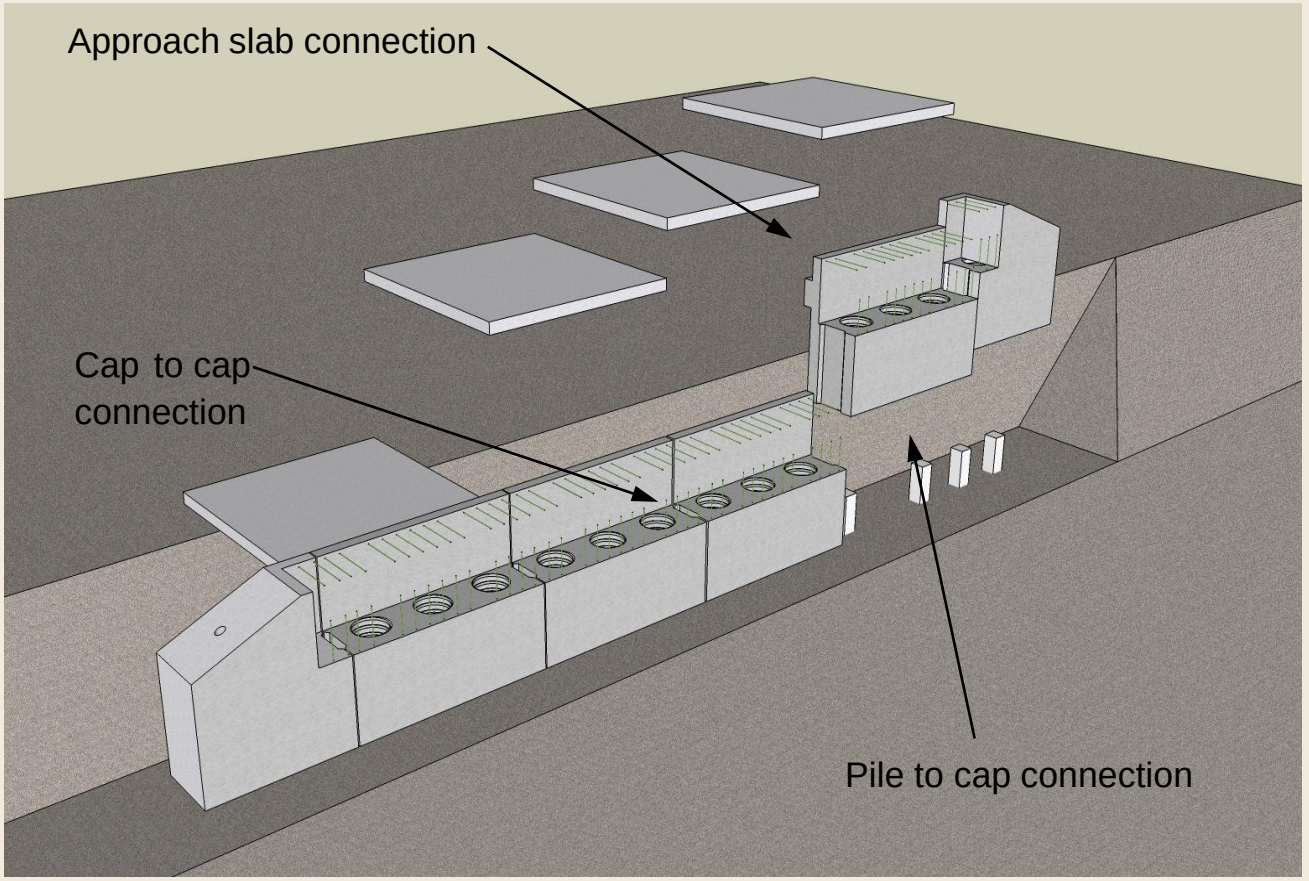
- Use Utah DOT Details
  - Concreted key
  - Use integral diaphragm to link caps together



Abutments

Alt. 2: Precast Integral or Semi Integral Abutment

Completed Abutment

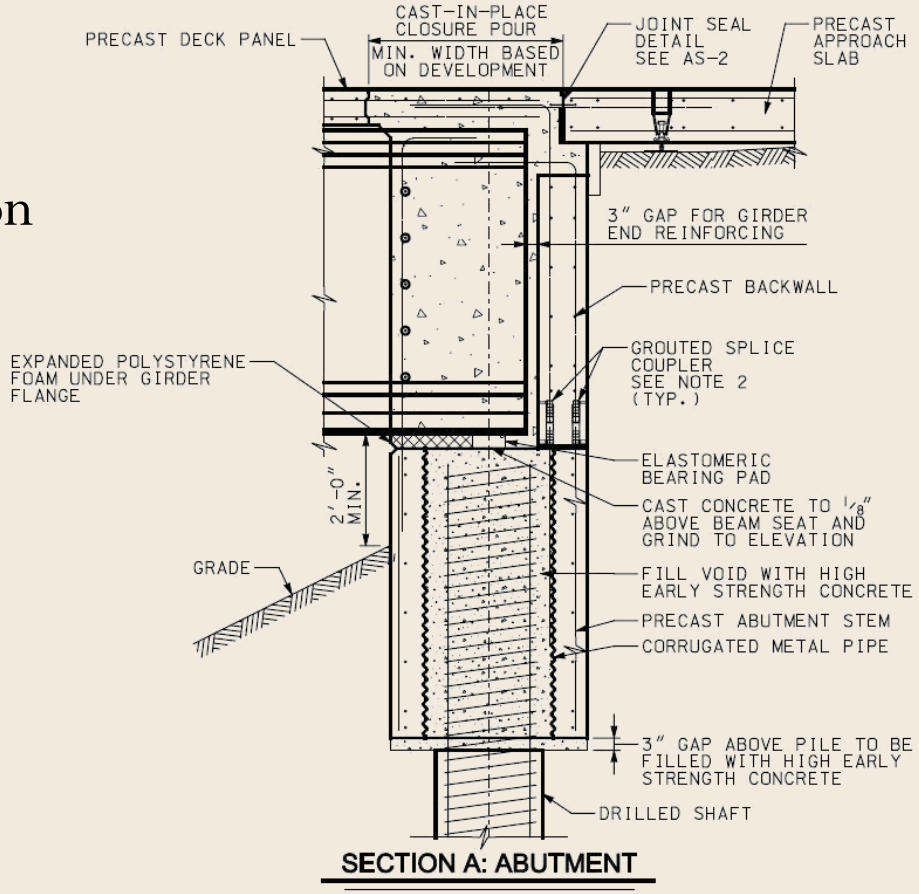


Abutments

Alt. 2: Precast Integral or Semi Integral Abutment

Superstructure to Abutment Connection

- Use CIP Closure Pour
- Utah DOT Detail
- Allows for significant adjustability
- Provides connection between abutment stem elements



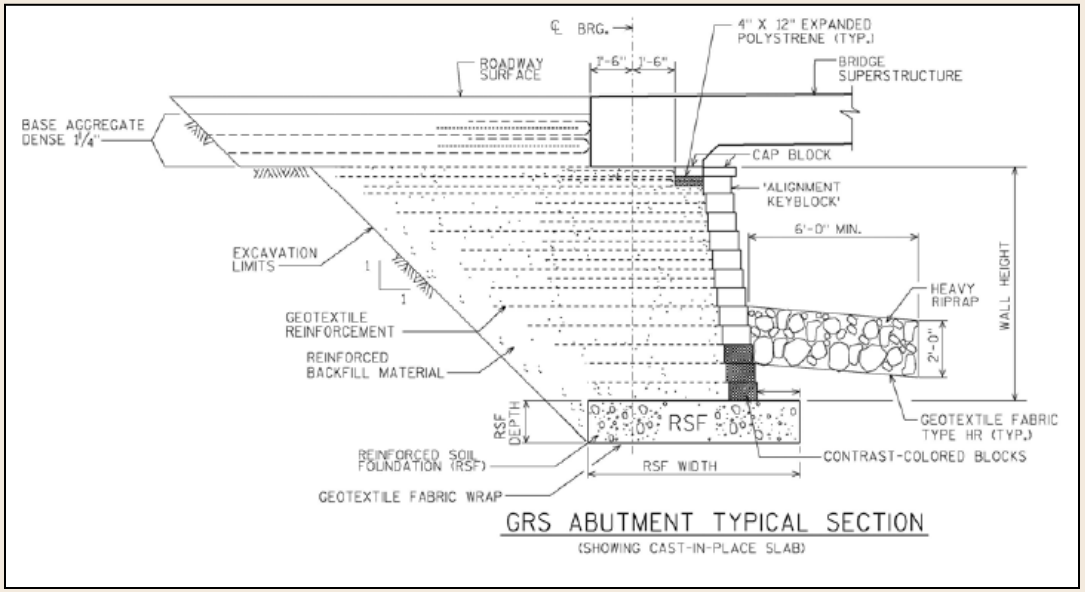
Abutments

Alt. 2: Precast Integral or Semi Integral Abutment

Abutments

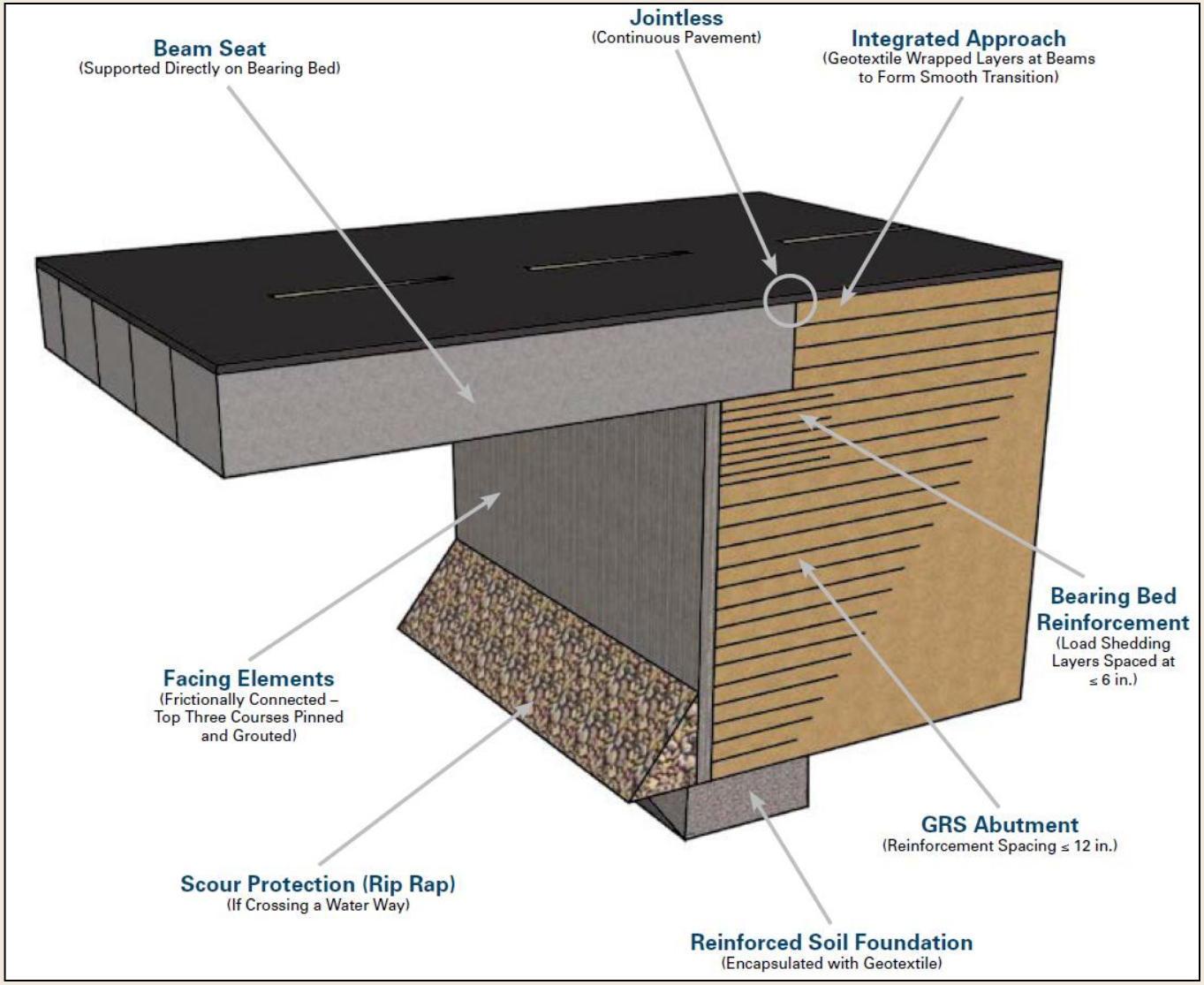
Alt. 3: Geosynthetic Reinforced Soil (GRS) System

- This method involves combining the foundation, abutment and approach embankment into one composite material.



Abutments

Alt. 3: Geosynthetic Reinforced Soil (GRS) System

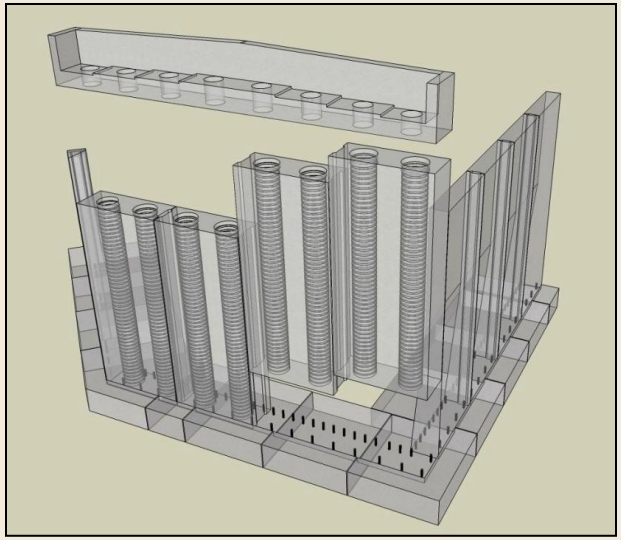


Abutments

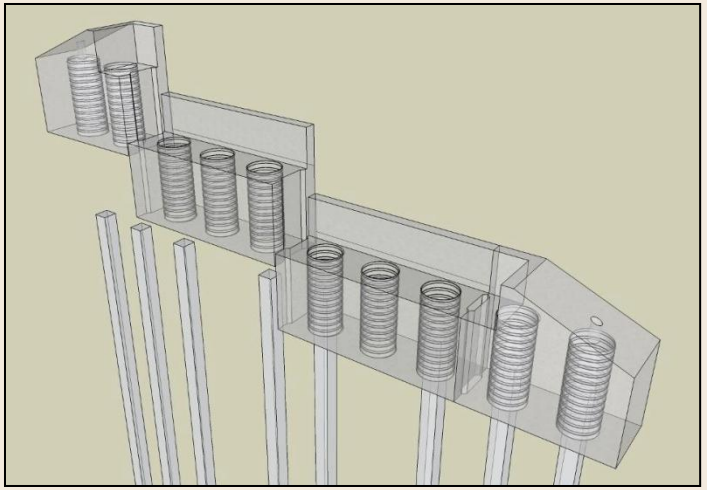
Alt. 3: Geosynthetic Reinforced Soil (GRS) System

Substructure: Abutments Alternatives

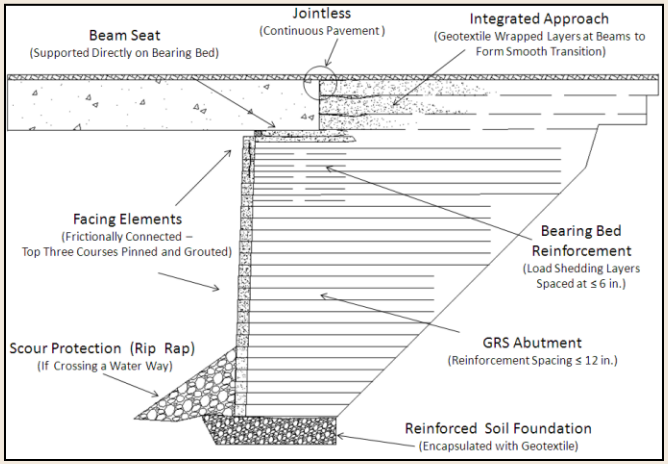
Alt. 1: Precast Cantilever Abutment



Alt. 2: Precast Integral or Semi-Integral Abutment



Alt. 3: Geosynthetic Reinforced Soil (GRS) System



Substructure elements:

Foundations

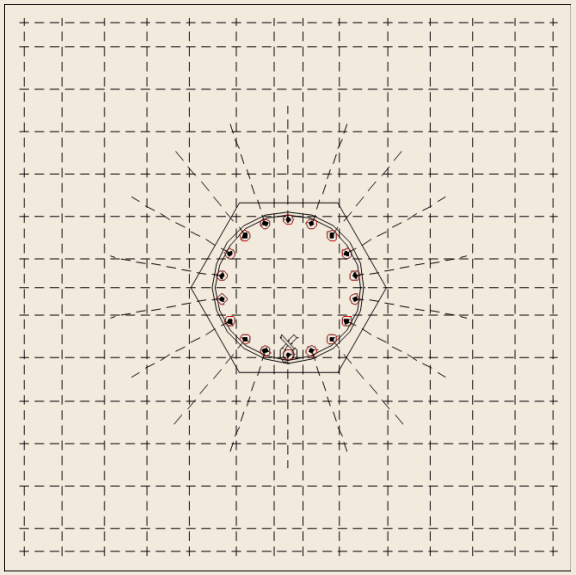
Options compatible with ABC that will be evaluated:

- **Alternative 1**: Full Precast Footing
- **Alternative** 2: Partial precast Footing
- **Alternative** 3: Precast Pile Cap Footings

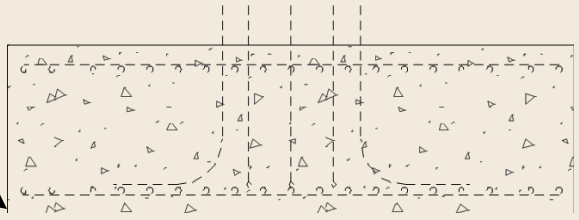
Foundations

Alt. 1: Full Precast Footing

- Ideal for footings small enough that can be transported and lifted as a single piece.



Shim and grout under footing through ports in footing



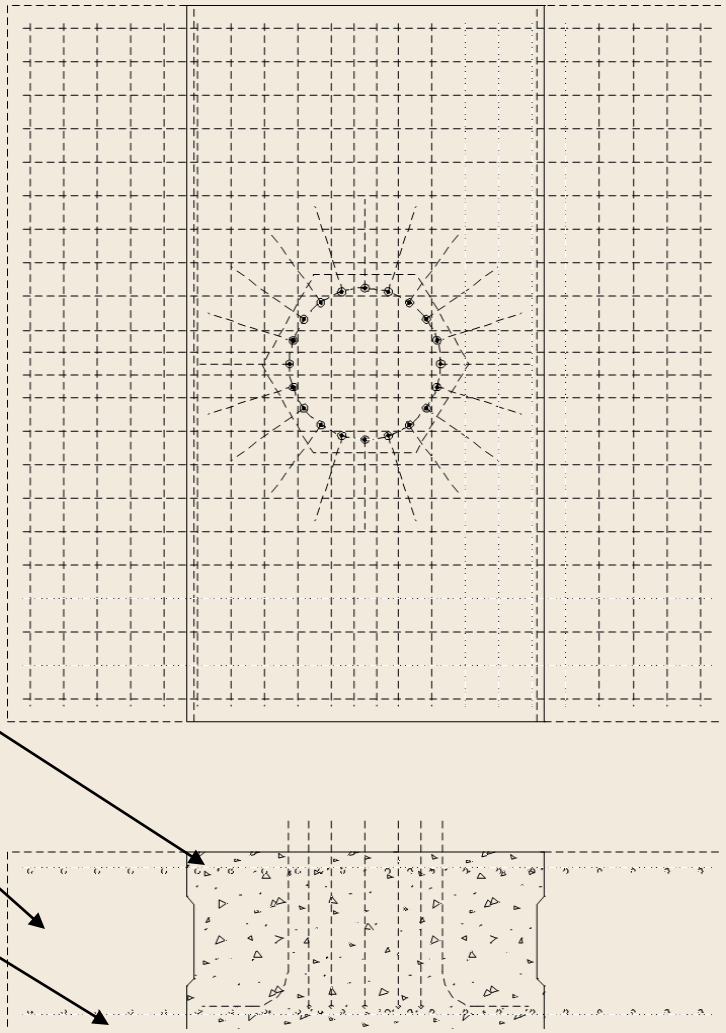
Foundations

Alt. 1: Full Precast Footing

Foundations

Alt. 2: Partial Precast Footing

- Ideal for larger footings
- Precast portion designed to support dead load of bridge
- Cast in place extension designed for other loads

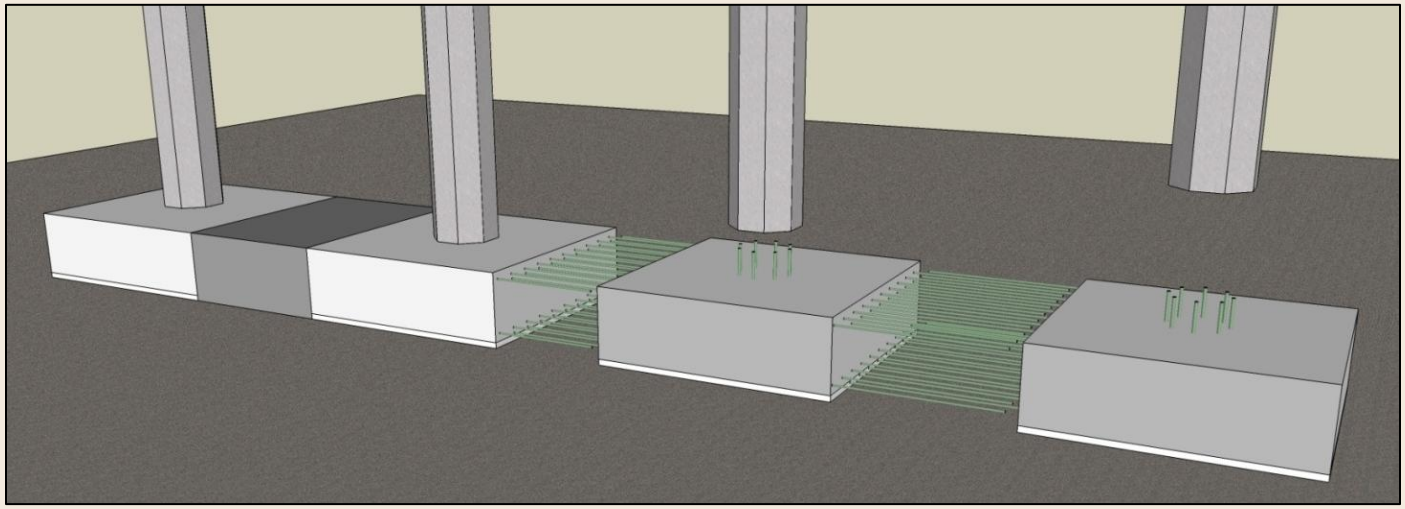


Foundations

Alt. 2: Partial Precast Footing

Footing to footing connection

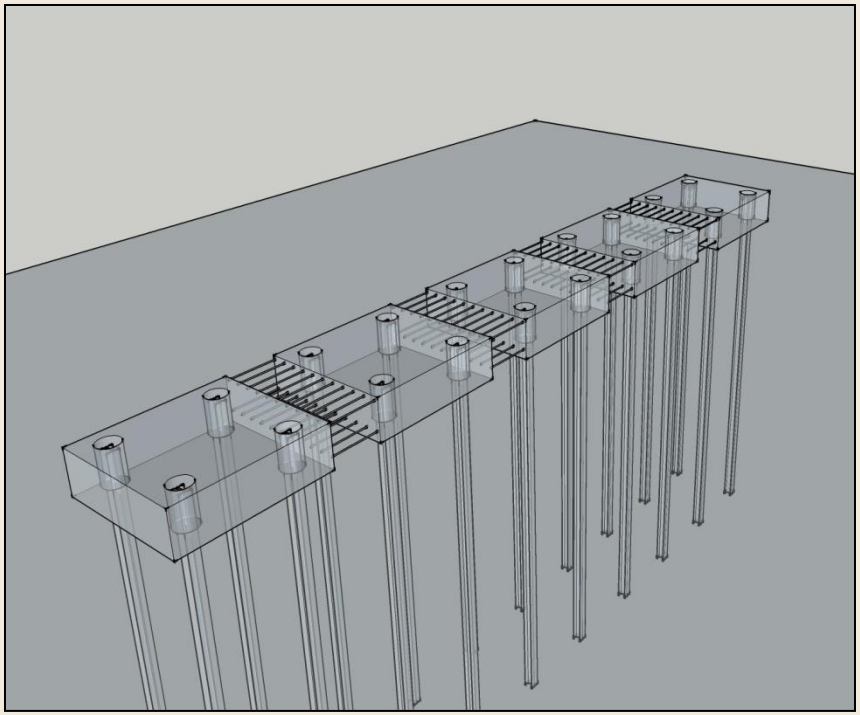
- Use cast in place closure pour
- Cast closure pour during structure erection
- Design precast for structure Dead Load
- Design continuous footing for total loads



Foundations

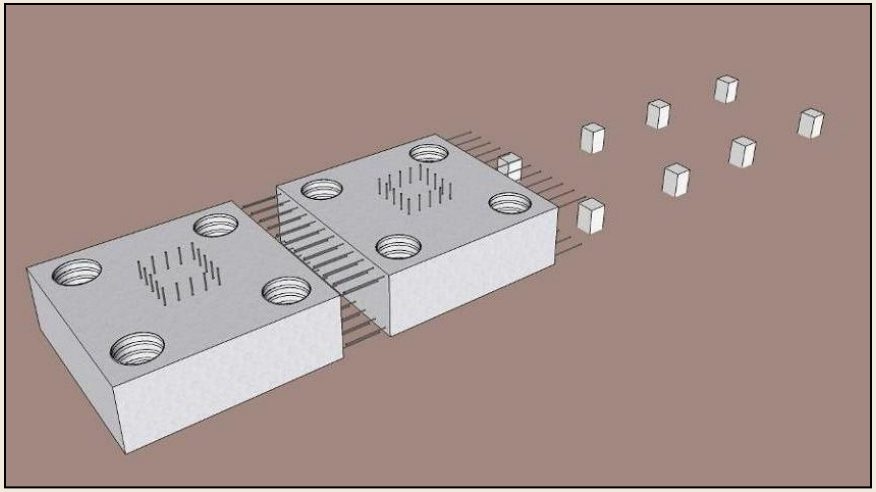
Alt. 3: Precast Pile Cap Footings

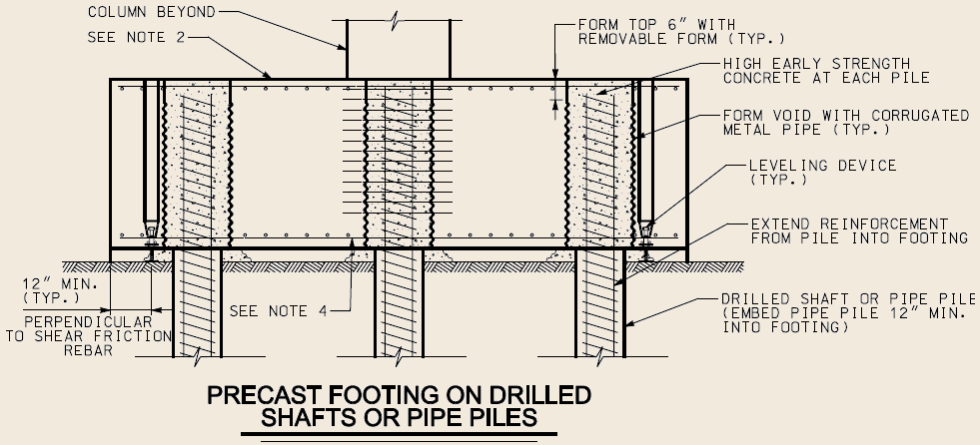
- Pile Caps are made of precast concrete.
- Grouted pockets or corrugated steel pipe voids can be used to connect the piles to the cap.



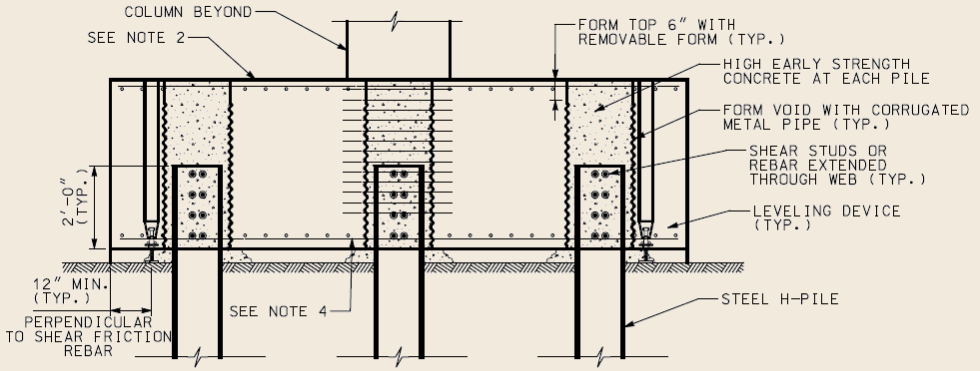
Foundations

Alt. 3: Precast Pile Cap Footings





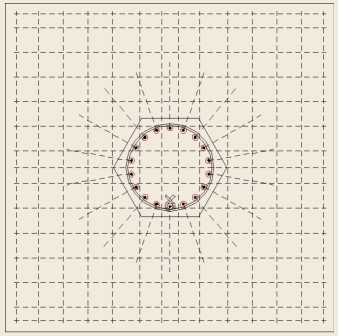
PRECAST FOOTING ON DRILLED SHAFTS OR PIPE PILES



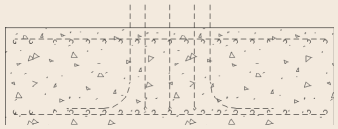
PRECAST FOOTING ON STEEL H-PILE

Substructure: Foundations Alternatives

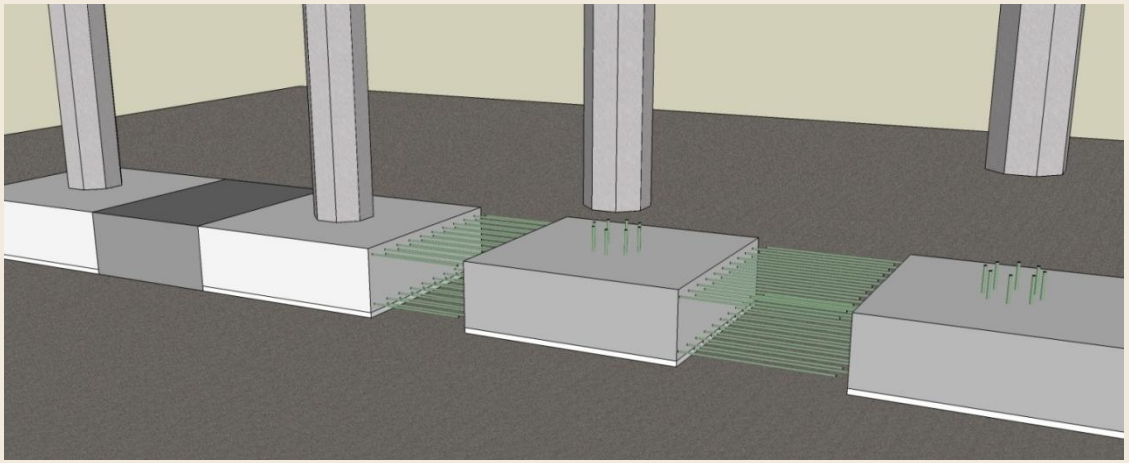
Alt. 1: Full Precast Footing



Shim and grout



Alt. 2: Partial Precast Footing



Alt. 3: Precast Pile Cap Footings