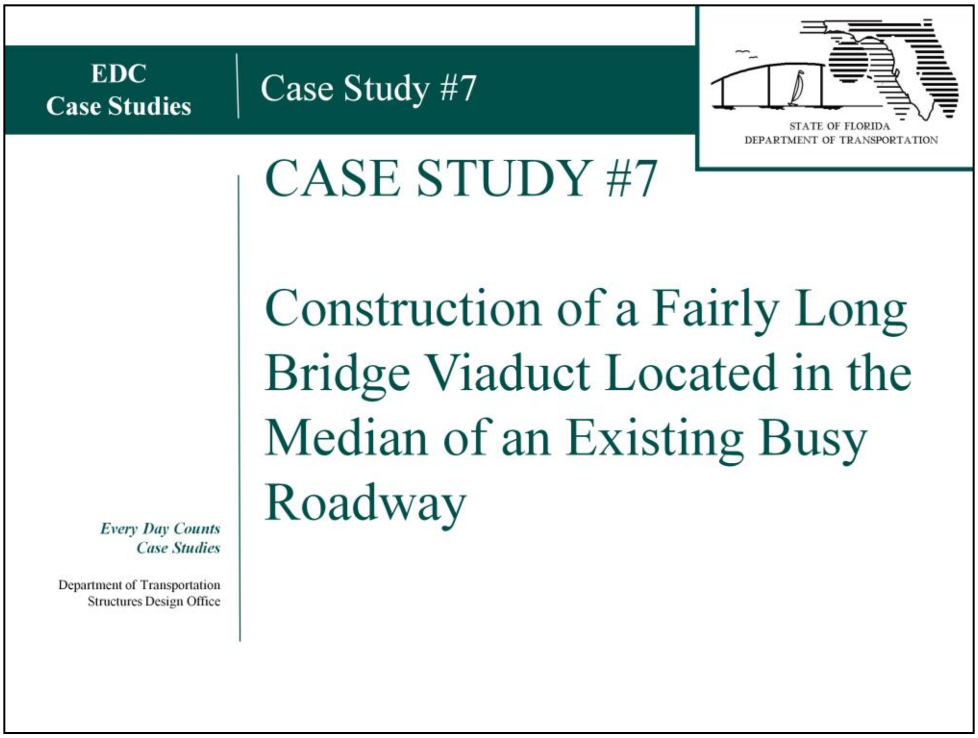


- The purpose of this presentation is to demonstrate factors influencing the decision to employ Prefabricated Bridge Elements and Systems for rapid project delivery. For each case study, particular constraints will be assumed and then possible prefabricated ABC approaches will be explored.
- This case study features the construction of a fairly long bridge viaduct located in the median of an existing busy roadway.
- Of particular interest in this case study is the importance of minimizing traffic disruptions during daytime hours.

EDC
Case Studies

Case Study #7

STATE OF FLORIDA
DEPARTMENT OF TRANSPORTATION

- Project constraints:
  - ¾ Mile Long Uniform Viaduct
  - New Viaduct Overhangs Existing Active Traffic
- Project Challenge – How to Construct Viaduct While Minimizing Traffic Disruptions?

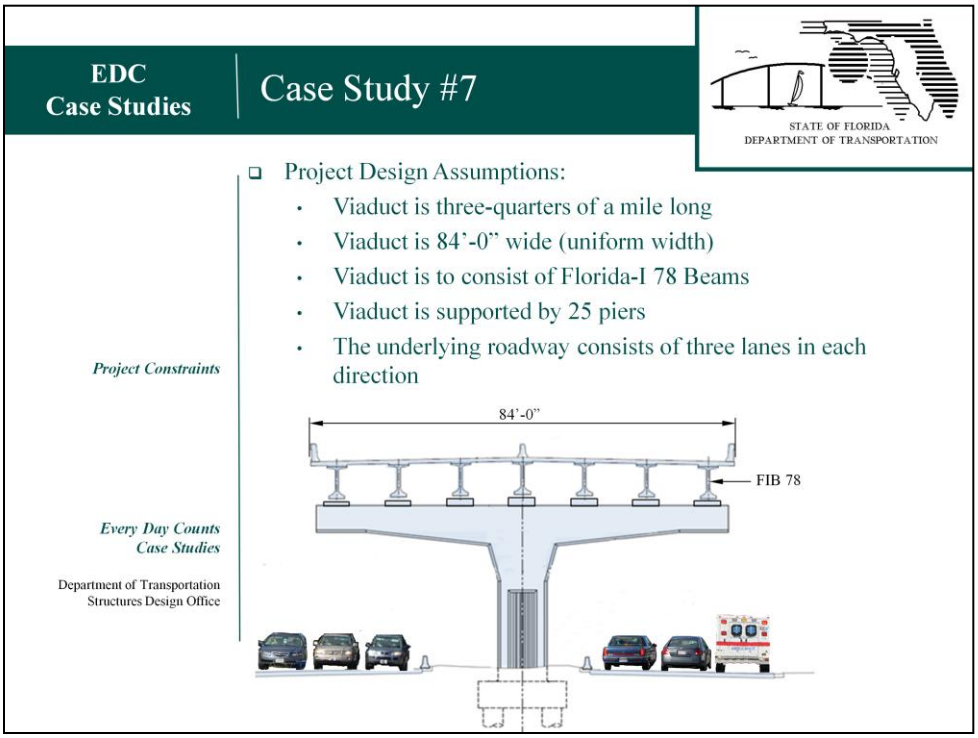
Project Constraints

Every Day Counts
Case Studies

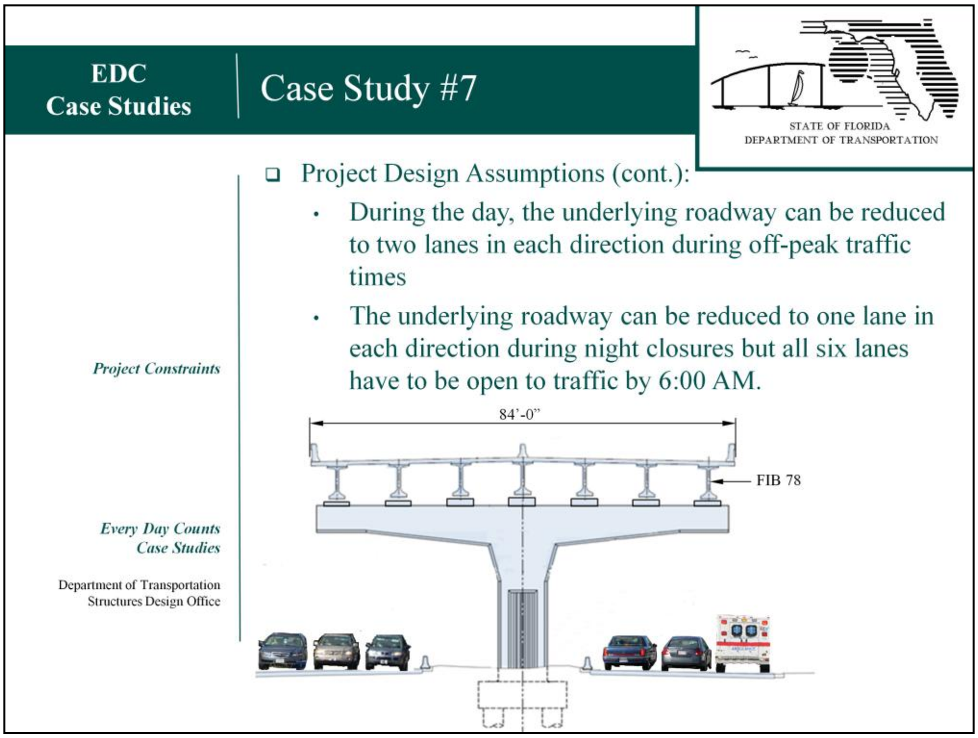
Department of Transportation
Structures Design Office

➢ This photo rendering depicts an existing multi-lane at-grade busy roadway with a proposed new long viaduct to be constructed in the center median.

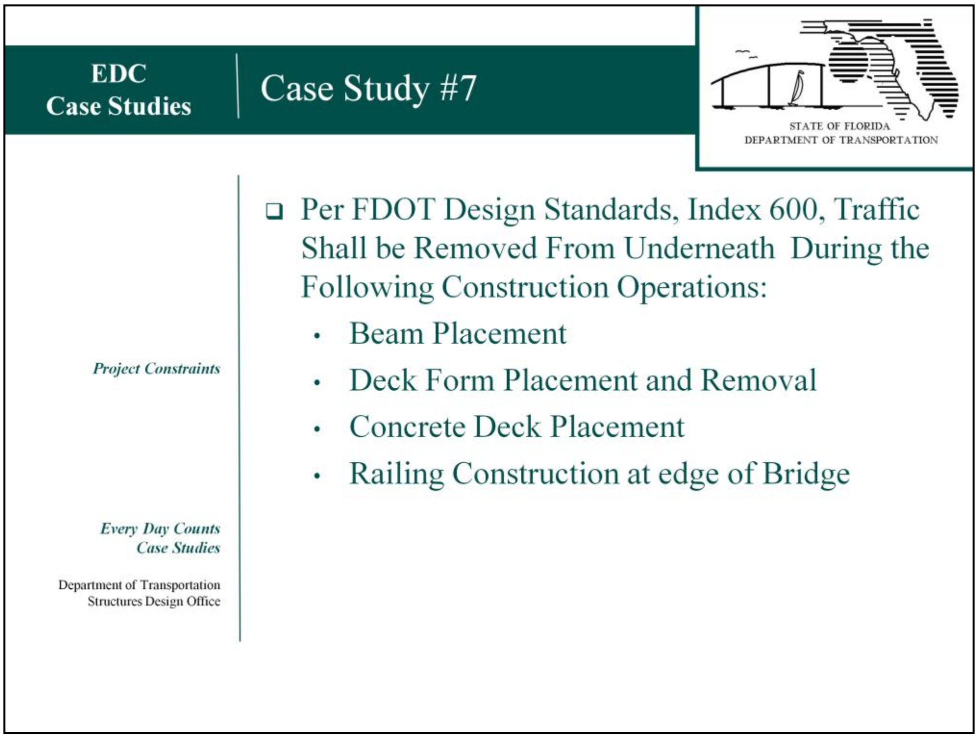
➢ The challenge of this project is to determine a structural solution to construct the long viaduct while minimizing the traffic impacts to the underlying very busy roadway.



- This sketch shows the bridge cross section for the full length.
- This project design assumes:
  - The viaduct is three-quarters of a mile long
  - The viaduct is 84'-0" wide throughout
  - The viaduct superstructure is to consist of Florida-I 78 Beams
  - Viaduct is supported on 25 piers
  - The existing underlying roadway consists of three lanes in each direction



- The Design also Assumes that:
  - The underlying roadway can be reduced to two lanes in each direction during off-peak traffic times during daytime hours
  - The underlying roadway can be reduced to one lane in each direction during night closures but all six lanes have to be open to traffic by 6:00 AM.



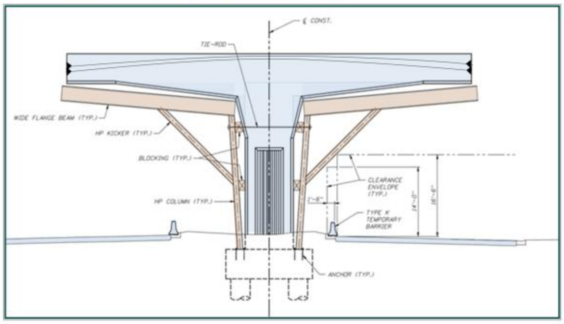
- Standard Index 600 requires that traffic be removed from underneath during the following construction operations:
  - Beam placement
  - Deck form placement and removal
  - Concrete deck placement
  - Railing construction at the edge of bridge

EDC Case Studies | **Case Study #7**

STATE OF FLORIDA
DEPARTMENT OF TRANSPORTATION

- For This Project, Traffic Shall Also be Removed From Underneath During the Following Construction Operations:
  - Pier Cap Form Placement and Removal
  - Pier Cap Concrete Placement
  - Pier Cap Post-tensioning

Project Constraints



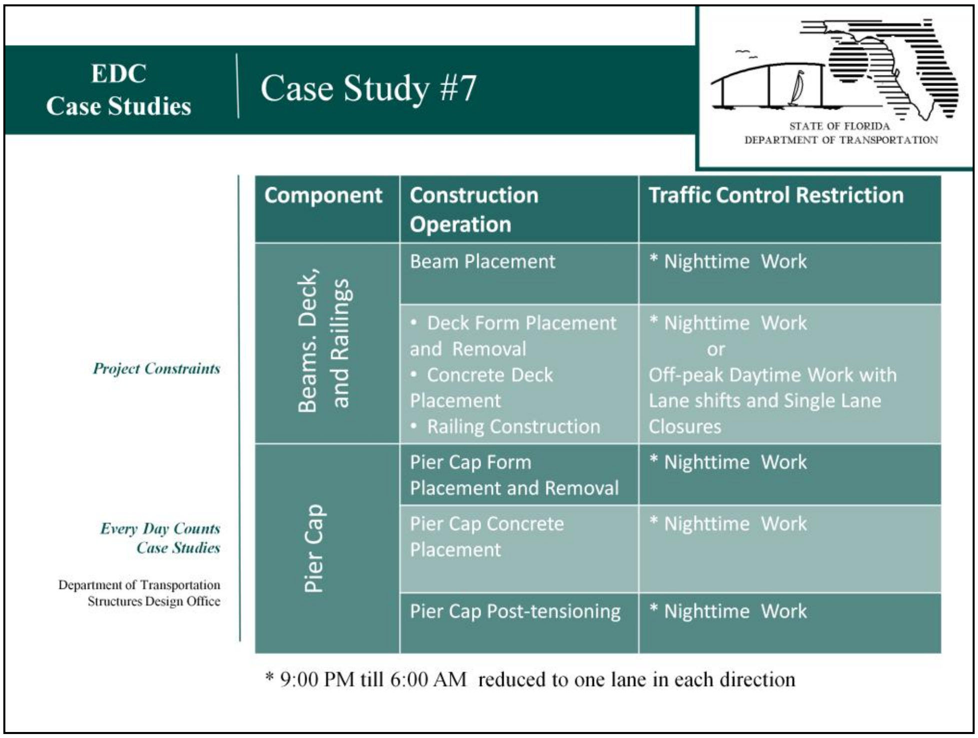
Initial Proposed Forming Concept

Every Day Counts Case Studies

Department of Transportation
Structures Design Office

➢ For this project, traffic also has to be removed from underneath during the following construction operations:

- Pier cap form placement and removal
- Pier cap concrete placement
- Pier cap post-tensioning and grouting



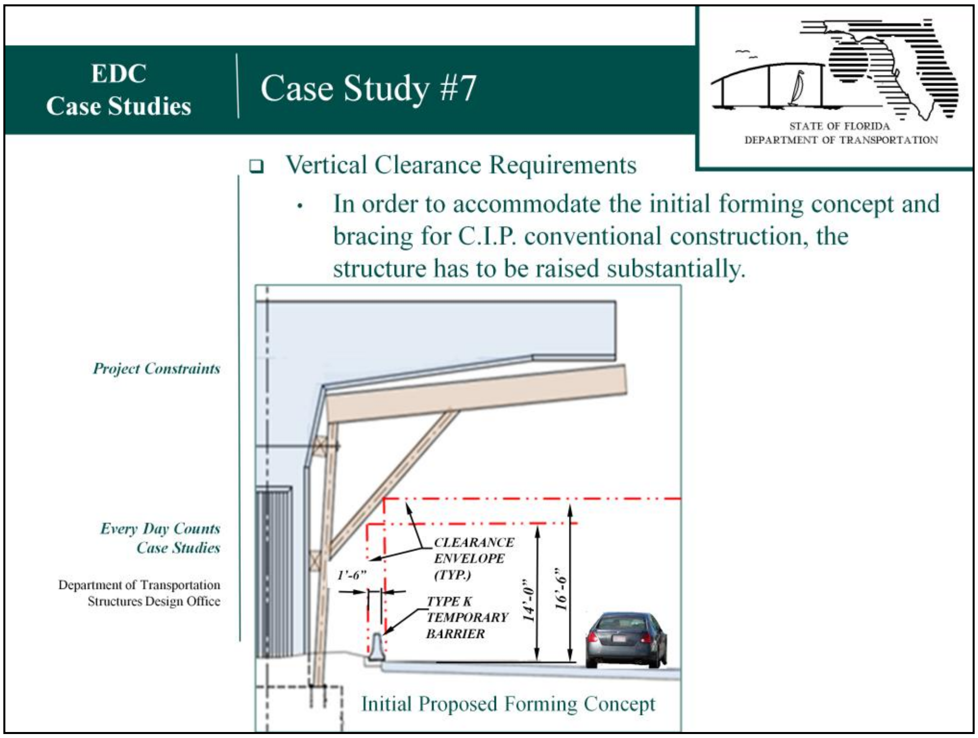
Component	Construction Operation	Traffic Control Restriction
Beams. Deck, and Railings	Beam Placement	* Nighttime Work
	• Deck Form Placement and Removal • Concrete Deck Placement • Railing Construction	* Nighttime Work or Off-peak Daytime Work with Lane shifts and Single Lane Closures
Pier Cap	Pier Cap Form Placement and Removal	* Nighttime Work
	Pier Cap Concrete Placement	* Nighttime Work
	Pier Cap Post-tensioning	* Nighttime Work

* 9:00 PM till 6:00 AM reduced to one lane in each direction

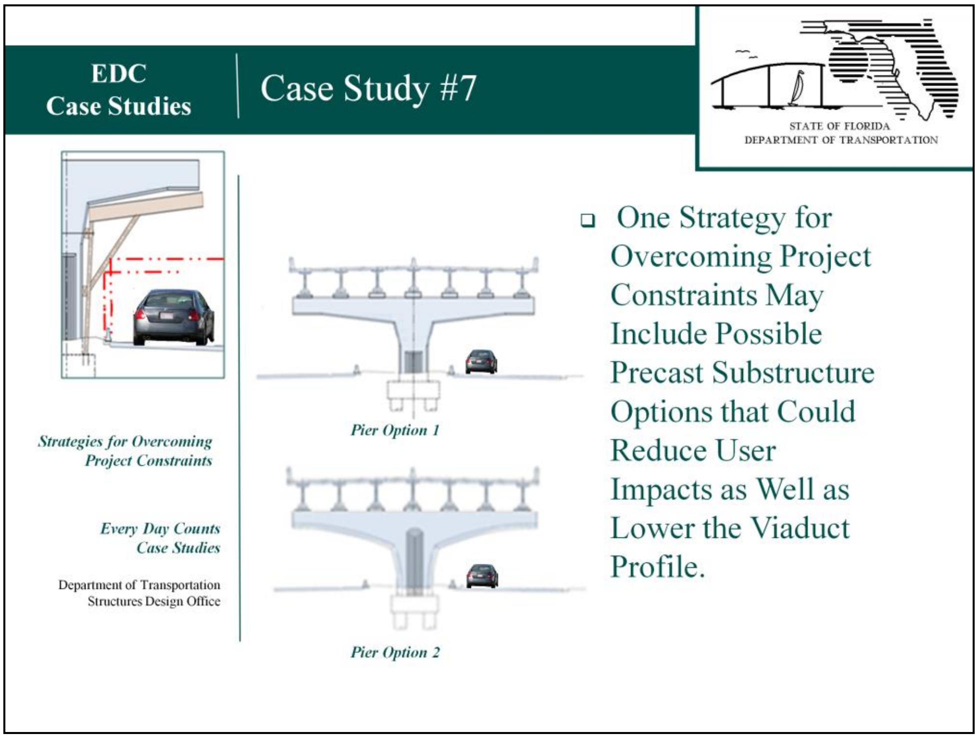
➢ The table on this slide, depicts the traffic control restriction likely to be used by the Contractor for each construction operation based on project constraints.

➢ Note that all forming, pouring, and post-tensioning of all of the 25 pier caps on the project is restricted to nighttime work as are all beam placement operations.

➢ Restricting such a large portion of the work to nighttime operations increases costs and construction time. Daytime work is very limited once the footings are in place. Also, nighttime labor rates are typically higher than daytime rates.



- In order to accommodate the forming and formwork bracing for the initial cast-in-place pier concept, the structure has to be raised substantially in order to meet temporary vertical clearance envelope requirements.
- This cast-in-place construction approach necessitates that the formwork be considered as temporary works affecting public safety per Section 5 of the Specifications, because the project Traffic Control constraints and production rates at night requires traffic to be placed under the poured concrete pier cap at 6:00 AM prior to reaching design strength.



- One strategy for overcoming project constraints may be to design precast pier options. The two precast pier options shown would facilitate a much lower bridge profile if forming and formwork bracing were not required, as in the case of a precast pier cap option.
- The next few slides will investigate possible precast substructure options that would reduce user impacts as well as lower the viaduct profile.

EDC Case Studies

Case Study #7

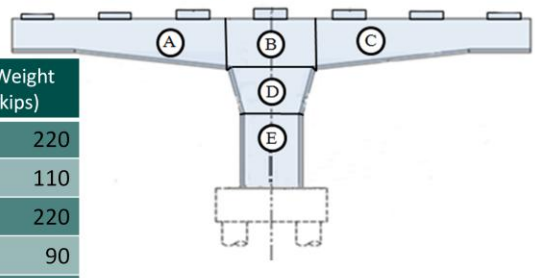
STATE OF FLORIDA
DEPARTMENT OF TRANSPORTATION

Strategies for Overcoming Project Constraints

Every Day Counts Case Studies

Department of Transportation
Structures Design Office

- Precast Pier Investigation - Component Lifting Weights
  - After sizing the pier, the next step in developing a precast pier concept is to determine the lifting weights involved.
  - The weights given are based on the dimensions required for a post-tensioned cap. A non-post tensioned cap would require a deeper and heavier section.



Item	Weight (kips)
A	220
B	110
C	220
D	90
E	140

➢ After sizing the pier cap and column, the next step is to get a feel for the approximate lifting weights of the various components of the hammerhead pier to see if precasting of the substructure is even feasible.

➢ This table lists each component weight in kips.

➢ One of the challenges is to keep weights below normal crawler crane sizes in order to reduce equipment overhead costs, but also to reduce crane set-up times. Very large cranes require longer times to setup and take-down than smaller cranes. This is especially critical on projects where all of the lifting operations have to occur during night closures from 9:00 PM to 6:00 AM, which is the case here.

EDC Case Studies

Case Study #7

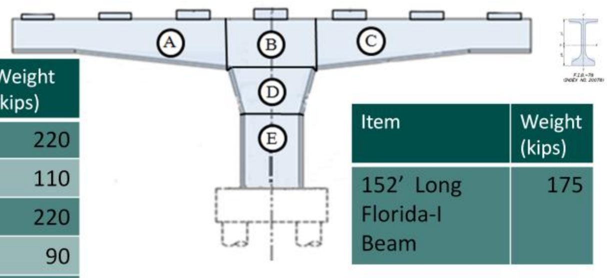
STATE OF FLORIDA
DEPARTMENT OF TRANSPORTATION

Strategies for Overcoming Project Constraints

Every Day Counts Case Studies

Department of Transportation
Structures Design Office

- Precast Pier Investigation - Component Lifting Weights
  - After sizing the pier, the next step in developing a precast pier concept is to determine the lifting weights involved.
  - The weights given are based on the dimensions required for a post-tensioned cap. A non-post tensioned cap would require a deeper and heavier section.



Item	Weight (kips)
A	220
B	110
C	220
D	90
E	140

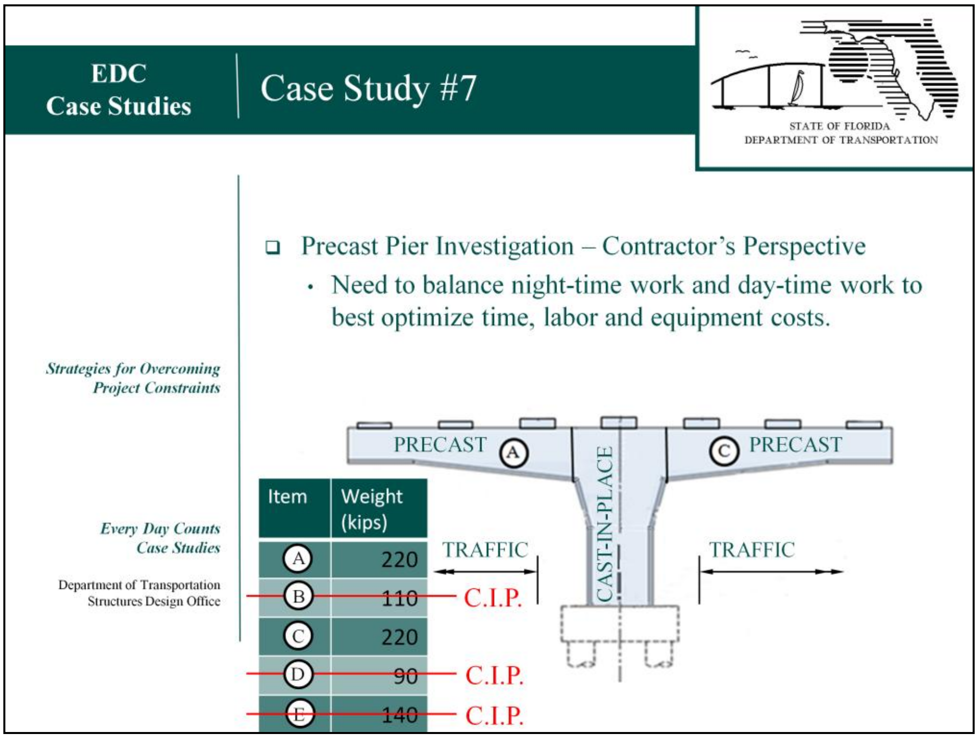
Item	Weight (kips)
152' Long Florida-I Beam	175

➢ One approach is to see what crane sizes would be needed to place the Florida-I 78 Beams in order to compare existing crane requirements assuming no precast substructure option. A 152 foot long Florida-I 78 Beam weighs about 175 kips and is typically lifted with two cranes. We are assuming here that two cranes could also be used to place these precast substructure components and that comparable crane reaches would be used for both.

➢ Based on this quick assessment, one can quickly conclude that a single full-width precast pier cap weighing 550 kips would not be feasible.

➢ Note that that if this cap element were to be broken into smaller more manageable components, then the challenge would be to develop a connection that could be placed within a single night closure window and that would be structurally adequate prior to releasing traffic at 6:00 AM.

➢ Lastly, note that the controlling elements potentially adversely affecting traffic impacts are the elements overhanging the underlying roadway, items A and C. The next few slides discuss precast solutions that concentrate on prefabricating these two pier components.



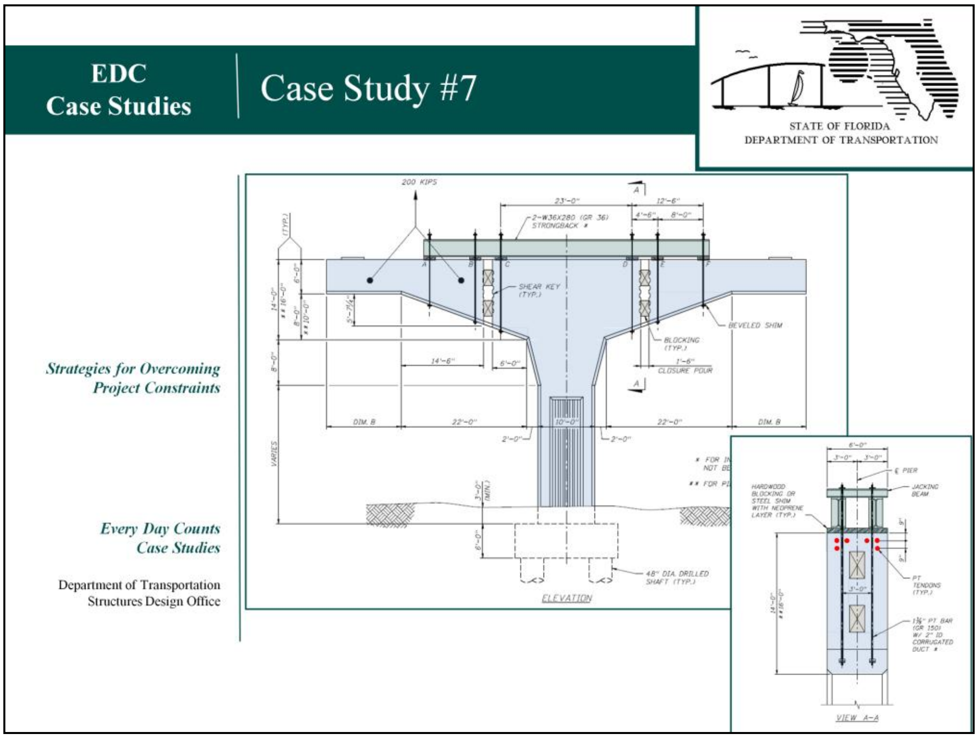
➢ This slide looks at precasting just the elements which overhang the underlying roadway, items A and C.

➢ A few factors influencing the decision include:

- The fact that cast-in-place pier components constructed in-situ on the side of the road using pumped concrete can be constructed either during the daytime or nighttime operations with little impacts to traffic.

- The fact that any precast pier column solution would require additional nighttime closures. Stated another way: precast pier columns could not be placed easily during the day because the cranes necessary to place the elements would require lane closures.

- The fact that nighttime labor rates are more costly than daytime labor rates.



➢ These sketches show a preliminary working drawing which detail a possible partial precast pier option. This hybrid hammerhead consists of a cast-in-place central cap and column portion and a precast cap overhang wing section.

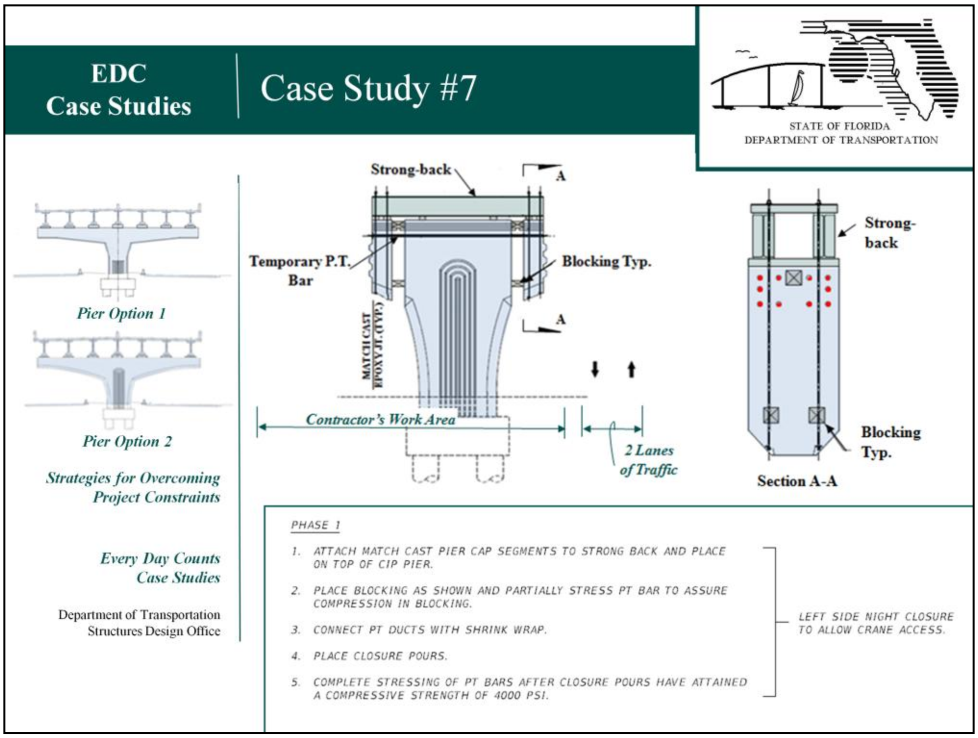
➢ This concept includes a 1'-6" closure pour and strong-back. It utilizes concepts taken from segmental bridge technologies and includes a combination of partial stressing of PT bars against blocking and a strong-back which is used to secure the precast element in the temporary condition.

➢ Note that the closure pour location was chosen to allow all CIP concrete to be placed outside of the limits of traffic lanes but as far away from the column element as possible in order to reduce the lifting weight of the precast element. In this case the weight of Item A depicted in the previous slide was reduced from 220 kips to 200 kips which is still greater than the 175 kips of a 152' long, 78 inch high prestressed beam, but is considered feasible.

➢ The proposed construction sequence would be as follows:

- ➢ First, secure the strong-back onto the top of the cast-in-place column/cap.
- ➢ Next, lift one precast cap element on one side of the cast-in-place column/cap and connect to the strong back, temporarily stress against blocking, splice PT ducts, pour closure pours, then when strength is reached, fully stress PT bar.
- ➢ Repeat the process for the other side. After both sides are complete, install post-tensioning tendons for the full width of the cap and stress during a night closure.

➢ Note however the inherent fit-up difficulty in lifting each precast component under the cantilevering strong-back and securing. The fit-up and stability of the precast element over traffic prior to making the closure pour and stressing may be problematic. The next few slides concentrate on improving the constructability aspects of these preliminary details to better address fit-up and safety.

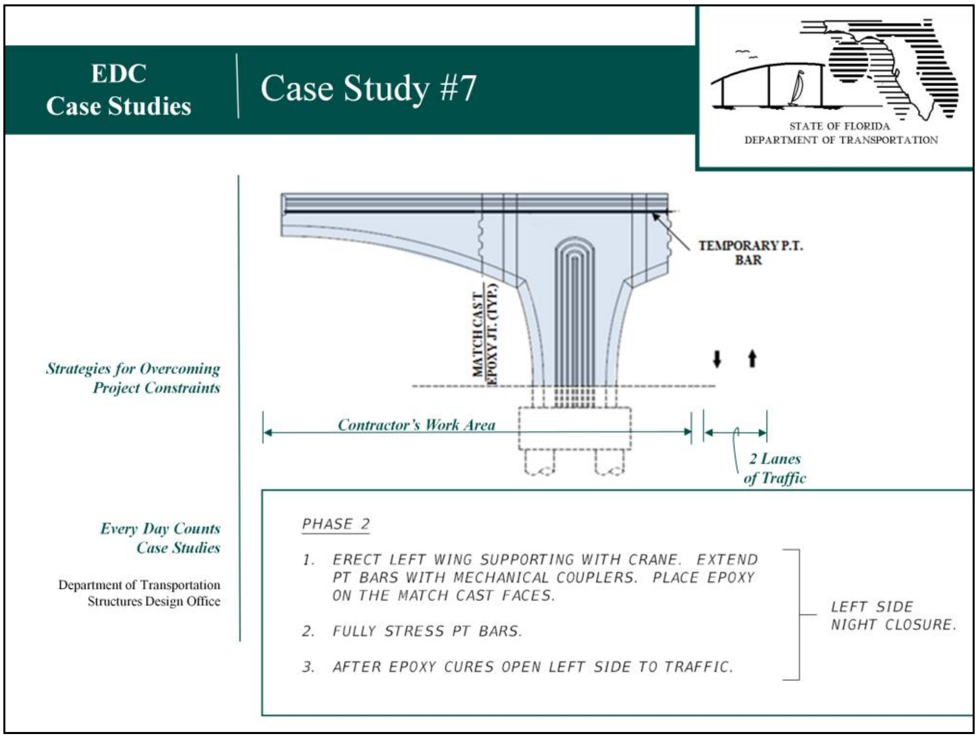


➢These sketches show a modification to the previous concept in order to improve the fit-up and safety aspects of the connection. It still uses a hybrid cast-in-place/precast approach, but here two additional match cast epoxied joints are introduced in order to simplify the connection for the pieces extending over traffic as well as to simplify the closure pour construction.

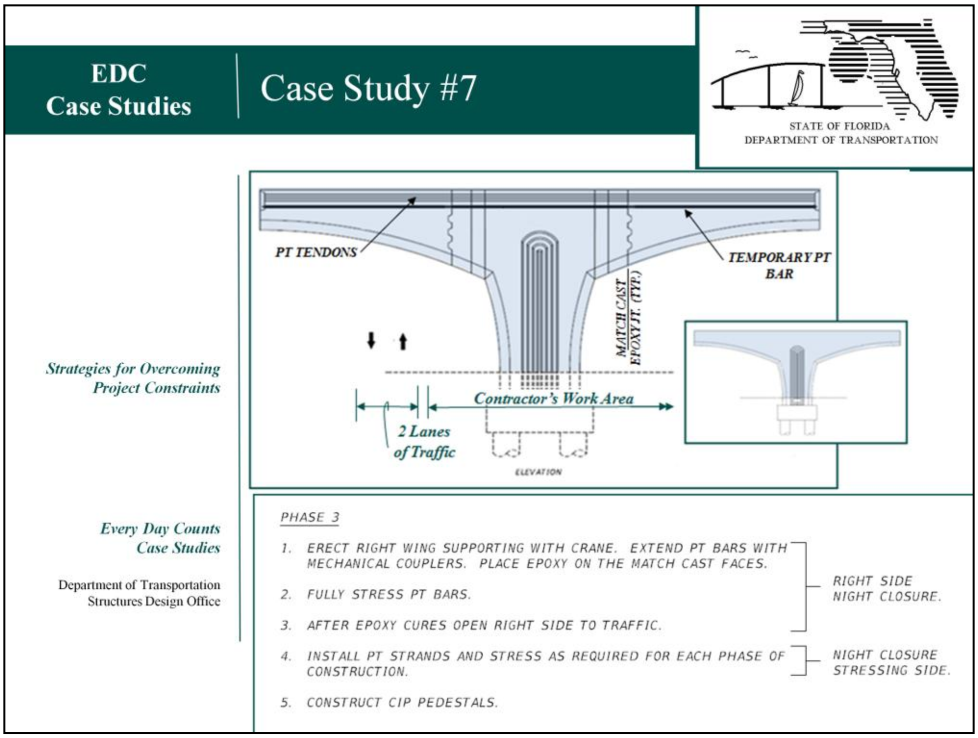
➢ In this case, Pier Option 2 is being developed as the final pier shape for the project.

➢ The construction sequence for this improved connection is as follows:

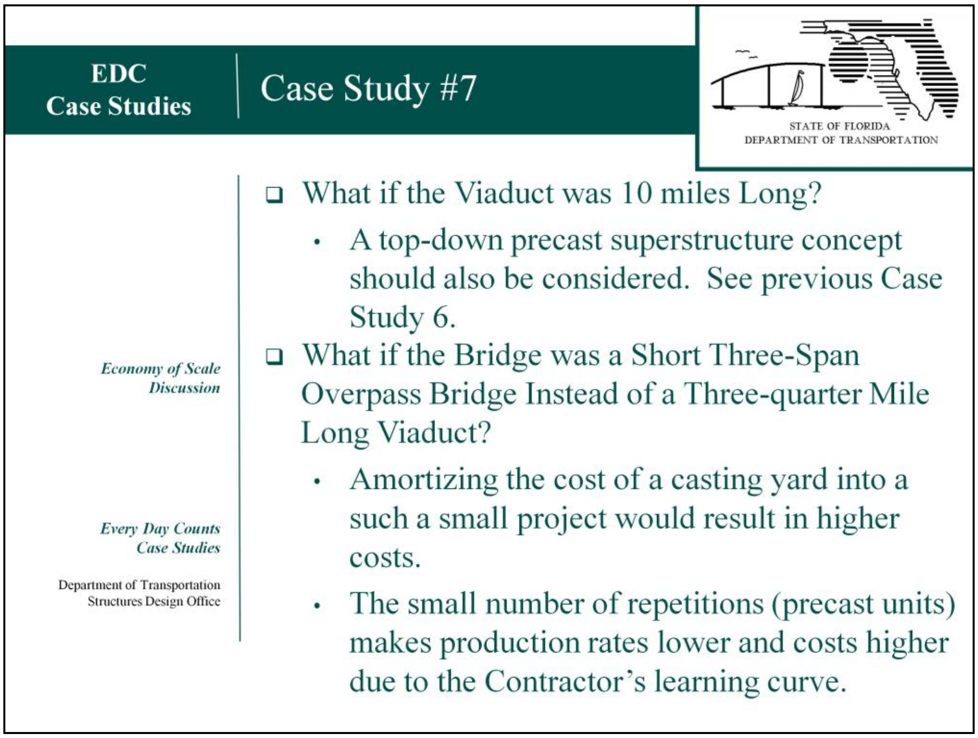
- First, secure the match-cast pier cap segments to the strong-back and place the entire assembly on top of the cast-in-place column/cap in a single crane pick.
- Place the blocking in between the segments and the cast-in-place pier top and temporarily stress the PT bars.
- Connect ducts and construct the closure pour.
- Once the closure pour has obtained the necessary compressive strength, fully stress the PT bars.



- During a nighttime construction operation, place epoxy on both faces of the match-cast surfaces, and erect the left pier wing segment by connecting to existing PT bars with bar couplers similar to balanced cantilever segmental construction.
- Fully stress the PT bars.
- In this way, several left pier wings can be constructed during a given night closure and the underlying roadway can be safely opened to traffic by 6:00 AM each morning.



- Repeat the process for the right pier cap wing.
- Once both left and right wings are installed, and PT bars stressed, install PT tendons and stress either in phases or all at once depending the design requirements. There may be cases where the beams will need to be placed prior to stressing some of the tendons to avoid overstressing the cap in the temporary condition.
- The beam pedestals could be allowed to be precast or cast-in-place at the Contractor's option.
- This revised connection detail, has been successfully constructed on many FDOT segmental projects and meets all of the objectives of the project – which are intended to reduce user impacts of the underlying roadway.
- It is recommended that specifications similar to the ones used for segmental projects be utilized for this conventional bridge application.
- Notice that this Case Study outlines a targeted precast/cast-in-place approach where the design focuses only on the components that affect the traveling public. In that way, the benefit to the traveling public is maximized while minimizing costs, lifting weights and equipment costs are appropriately considered, and all construction operations are performed within a series of nighttime windows assuring traffic can be released every morning safely by 6:00 AM.



- This slide is intended to discuss the impacts of this case study based on the economy of scale for a given project.

- What if the viaduct was not three-quarters of a mile long, but was 10 miles long?
  - This hybrid precast/CIP substructure solution would still be very viable under this scenario. Considerations for a total precast substructure option could become more cost effective; however, pier size, lifting weights, median width and equipment sizing would likely still limit the solution to a hybrid pier. As discussed earlier, a cast-in-place pier column constructed in-situ on the side of the road using pumped concrete can be constructed either during the daytime or nighttime operations with little impacts to traffic. Any total precast column solution would require additional nighttime closures.
  - Also given the magnitude of a possible ten mile long project, a top-down total precast superstructure concept should also be considered. See previous Case Study #6 for viable technologies.
- What if the bridge was a short three-span overpass bridge instead of a three-quarter mile long viaduct?
  - Amortizing the cost of a casting yard into a such a small project would result in higher costs.
  - The small number of repetitions involved in constructing the few precast pier wings for just two piers makes production rates lower and costs higher due to the Contractor's learning curve. It takes time and repetition for the Contractor's crews to learn how the pieces fit together.
  - In general, the economy of scale of such a small project would preclude precasting as a viable choice unless standardized statewide component shapes were to be adopted to allow formwork reuse from project to project.