

NEW TOP DOWN CONSTRUCTION METHOD FOR THE WASHINGTON BYPASS PROJECT NORTH CAROLINA

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ABSTRACT

Initiated by the North Carolina Department of Transportation to ease traffic congestion, the Washington Bypass Project is the largest design-build project in North Carolina. Flatiron and United Contractors were the selected team to construct this 11 km (6.8 mi) realignment of highway U.S. 17 which includes a 4.5 km (3 mile) precast concrete bridge over protected wetlands and over the Tar River with a 45 ft navigational channel clearance. Flatiron developed a new patented variation of the top-down span-by-span construction technique to ensure minimal disturbance to the environment by eliminating the need of access trestles and associated equipment. This new method allowed the team to break the record for top-down construction for this type of precast girder bridge by constructing 37 m (121 ft) long spans without relying on ground based support equipment. The 181 m (594 ft) long Launching Gantries are conceived as a bridge building assembly line equipped with a rotating pile driving lead and hammer at the front end. This equipment is being used to drive 750 mm (30 in) square piles, erect 37 m (121 ft) long precast girders, install precast pier caps and support the cast-in-place deck pouring operations. These operations are coordinated to allow a smooth progression of the bridge construction. The entire project is scheduled to be completed in early 2010.

Keywords: Top-Down Construction, Overhead Gantry, Pile Driving, Tilting Pile Driving Lead, Rotating Pile Driving Lead, Wetlands,

INTRODUCTION

The Washington Bypass is a North Carolina Department of Transportation design-build project consisting of an 11 km (6.8 mi) bypass route around the city of Washington, N.C. on US17. The project, located on the North Carolina's coastal plain in Beaufort County, features a 4.5 KM (3 miles) structure over the Tar River and the adjoining environmentally sensitive wetlands.

NCDOT hired the Flatiron-United JV design-build team (Flatiron-United) to develop the design and construction of this challenging project. Earth Tech/AECOM is the team engineer of record. McNary Bergeron provided the construction engineering services for the project.

This design-build project, the Department's largest design-build contract to date, was awarded to Flatiron-United in February 2006 for \$192 million.

To minimize the construction footprint in these environmentally sensitive areas, the Flatiron team developed a new and innovative top-down construction approach using a unique overhead gantry prototype specially designed and built for this project. This approach resulted in a minimal impact to the wetlands and an accelerated construction schedule when compared to conventional construction techniques.

More than 80% of the bridge is on tangent horizontal alignment with a 21m (70 ft) wide deck carrying four lanes of traffic. The repetitive nature of this geometry provided ideal conditions to optimize the repetitive construction operations. (Fig. 1)



Fig. 1 Launching Gantry 1 on the south side of the project.

The remainder of the north end of the structure is complicated by a fork in the geometry separating the north and southbound spans in a horizontal curve. In order to deal with the variable geometry, the north gantry was equipped with a wider transverse support beam straddling both northbound and southbound spans, and is thus capable of performing simultaneously all of the construction operations of both superelevated deck sections of the split structure. (Fig. 2)



Fig. 2 Launching Gantry 2 on the North Side of the Project.

The structure design is largely controlled by the equipment loading during the construction stages of the project rather than by normal service load conditions. Since the project site is often in the path of hurricanes, the bridge and gantry were designed to withstand 100 mph wind loads during the construction period. Normal construction activities could proceed until wind speeds reached 45 mph, at which time the gantry was secured in place in a short term out of service condition. Once wind speeds exceeded 64 mph, the gantry was launched back to a position over a completed span and securely anchored in place. This section of the Tar River is also subject to tidal action and the potential scour from storm surge intensified the loading to the substructure elements. Earth Tech performed a sophisticated 2D Flow Model scour evaluation to predict this scour potential.



Fig. 3 Launching Gantry 2 over the Tar River



Fig. 4 Launching Gantry 1 Driving Piles in the Wetlands

CONSTRUCTION METHODS

The patented process consists of two self-contained gantries capable of performing all the tasks associated with the bridge construction, including driving 37.8 M (124-ft) long precast prestressed piles, erecting 45 Tons (50 tons) precast post tensioned bent caps, erecting 37M (121 foot) long precast prestressed girders, and supporting cast in place deck pouring operations. The two self launching 181 M (594 ft) long gantries weighing about 680 Tons (750 tons) each started the bridge building operations, one at each end of the bridge, and worked towards the middle of the structure. The superstructure construction was completed in September 2009 with project completion scheduled for early 2010.

The erection gantry, supplied by Deal from Italy, is fitted with a tilting pile driving lead, supplied by Berminghammer from Canada.



Fig. 5 Tilting Lead Rotating a Pile (US Patent 7,520,0141)

The world's first application of the pile driving operation from an erection gantry is the most unique feature of the system and is the essential element that truly eliminates the need for equipment and temporary access trestles and ground work in the fragile wetlands.

Construction activities are on-going simultaneously across three spans (typically 37M (121 ft) in length) in an assembly line progression. As a span is completed and the deck is cured, the gantry is launched ahead to begin the pile driving on the next span. The dramatic reduction in wetland disturbance offered by this "true top down" construction operation was well received by the US Army Corps of Engineers, North Carolina Division of Water Quality, North Carolina Department of Natural Resources, US Coast Guard, and other environmental agencies during the permitting process.

The pile driving process can be described as follow:

1. The precast piles are delivered to the tail of the gantry.
2. Two overhead trolleys pick up the pile.
3. The trolleys travel with the pile toward the front of the gantry
4. The gantry moves sideways on top of the pile driving location
5. The pile is lowered and secured to the pile driving lead.
6. The lead and pile are rotated vertically
7. The lead/ pile position is adjusted.
8. The pile is driven.
9. The lead is disconnected from the pile.
10. The lead is rotate back into the horizontal position.

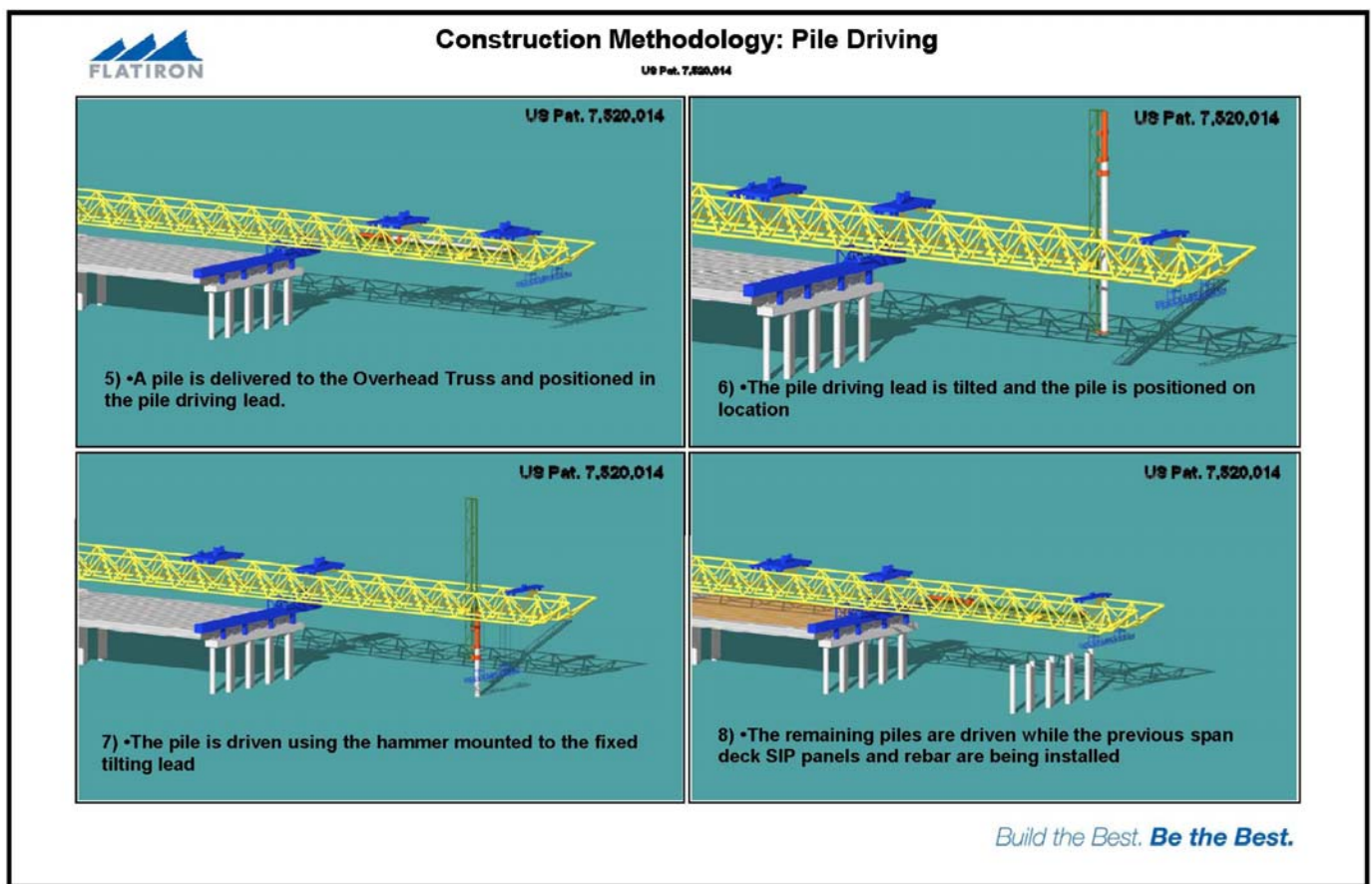


Fig. 6 Construction Methodology for Pile Driving



Fig. 7 Pile Being Positioned in the Tilting Lead



Fig. 8: Launching Gantry 2 over Kennedy Creek, with Minimal Impact of the Pile Driving to Wetlands Below

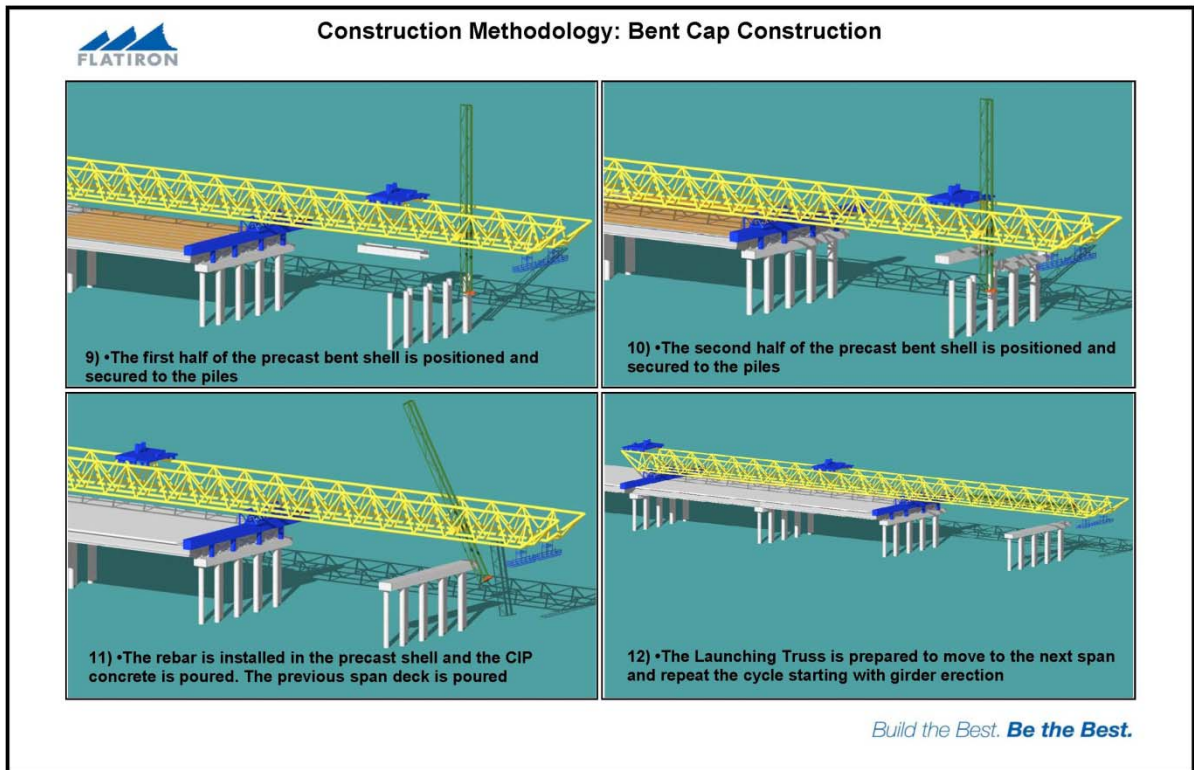


Fig. 9 Construction Methodology for Bent Cap Construction



Fig. 10 Launching Gantry 1 Erecting a Precast Bent Cap

The girder erection process can be described as follow:

1. The precast girder is delivered to the tail of the gantry.
2. Two overhead trolleys pick up the girder
3. The trolleys travel with the girder to the leading span.
4. The gantry moves sideways on top of the girder final position.
5. The trolleys lower the girder on its bearings.
6. The girder is secured in place.
7. The trolleys are disconnected.

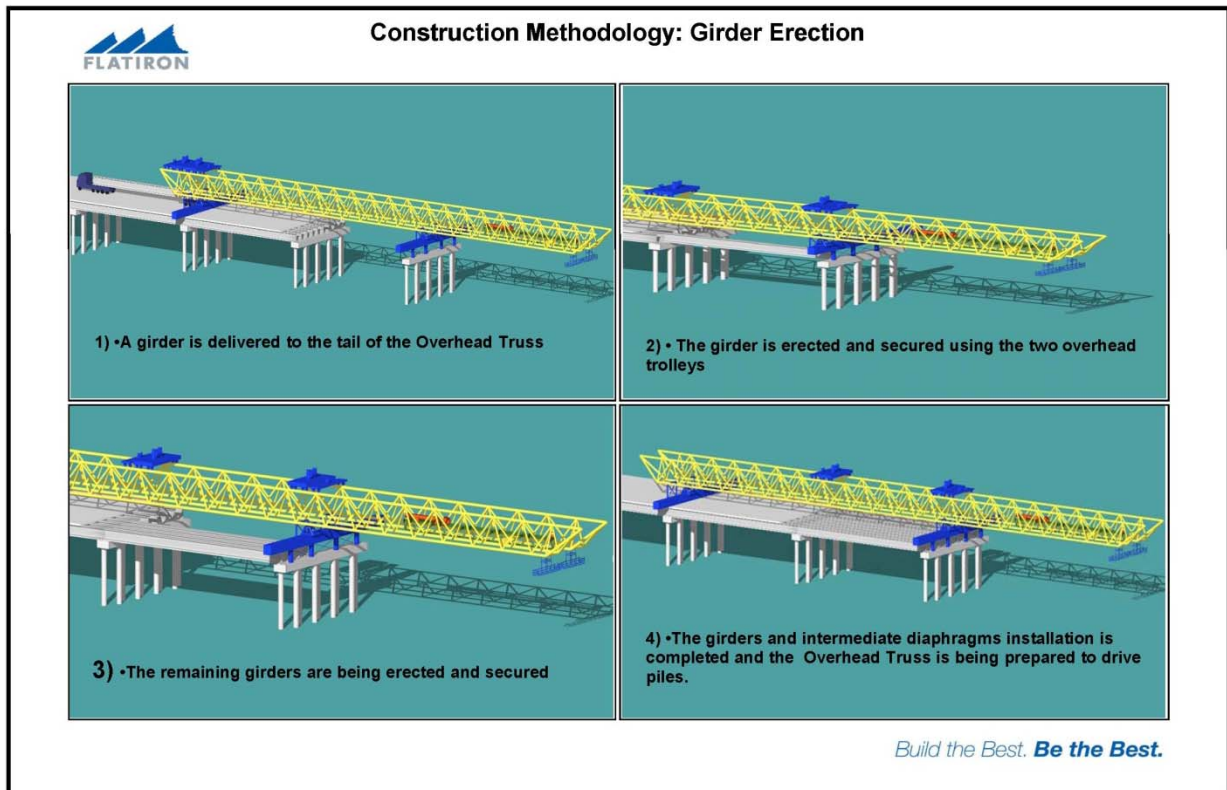


Fig. 11 Construction Methodology for Girder Erection



Fig.12 Launching Gantry 1 Erecting a Precast Girder

Flatiron's innovative construction method represents a great example of environmental stewardship where the design-build team went beyond the traditional bridge construction methods and took the substantial financial risk of developing and implementing a new environmentally conscious construction method.

This method is economically competitive for long bridge with difficult access where the high initial cost of the equipment can be justified by depreciating it over the many repetitive spans.

ENVIRONMENTAL BENEFITS OF NEW METHOD

Some of the environmental benefits offered by this state-of-the-art method compared to traditional bridge construction methods are:

- True Top Down construction
 - Poses significantly less temporary and permanent impact to the fragile wetlands
 - Eliminates need to construct temporary trestles to build the structures
 - Eliminates need to remove and demolish temporary installations used in the construction of the structure
 - Reduces the need for wetland vegetation clearing
 - Drastically reduces the need for grubbing
 - Eliminates the need to use driving templates thus reducing wetlands disturbance

- Eliminates the need to access the work area from the ground level by providing material deliveries and personnel access from the constructed (permanent) structure through the equipment
 - Eliminates need to use barges and tug boats
 - Poses minimal impact to river traffic
 - Poses minimal impact to recreational use
- Eliminates the need to use cranes on a regular basis in the wetlands
 - Eliminates the risk of spillage caused by equipment maintenance operations on the trestles
 - Eliminates the use of older leaking equipment
- New equipment
 - State of the art technology
 - Environmentally friendly hydraulic oils
 - High efficiency fuel injected pile driving hammer
 - Any potential spillage caused by the fuelling or maintenance operations is likely to occur on top of the completed deck where it is easily contained.
 - Cleaner emission pile driving hammer
- Maximizes the use of precast elements
 - Results in longer spans thus reducing the number of foundations and the resulting impact to the wetlands
 - Eliminates the need to build temporary cofferdams to construct the substructure
 - Minimizes the risk of concrete spillage
 - Eliminates the use, overspray and spillage of form oil
 - Use of Stay-in-Place forms for deck and diaphragm
 - Eliminates the concrete dust and stripping debris
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 - Eliminates the concrete dust and stripping debris



Fig. 13 Launching Gantry 1 over Wetlands

CONCLUSIONS

This innovation does to bridge building what Henry Ford did to the automobile industry; it transforms bridge building into an assembly line process. As the overhead gantry moves forward, the landscape is changed from an open field to a completed bridge in a very environmentally friendly process. Basically it is a “green bridge extruding” machine.