



Prefabricated Bridge Elements & Systems (PBES)



PBES Cost Study: Accelerated Bridge Construction Success Stories

**Federal Highway Administration
2006**



Prefabricated Bridge Elements and Systems Cost Study: Accelerated Bridge Construction Success Stories

Introduction

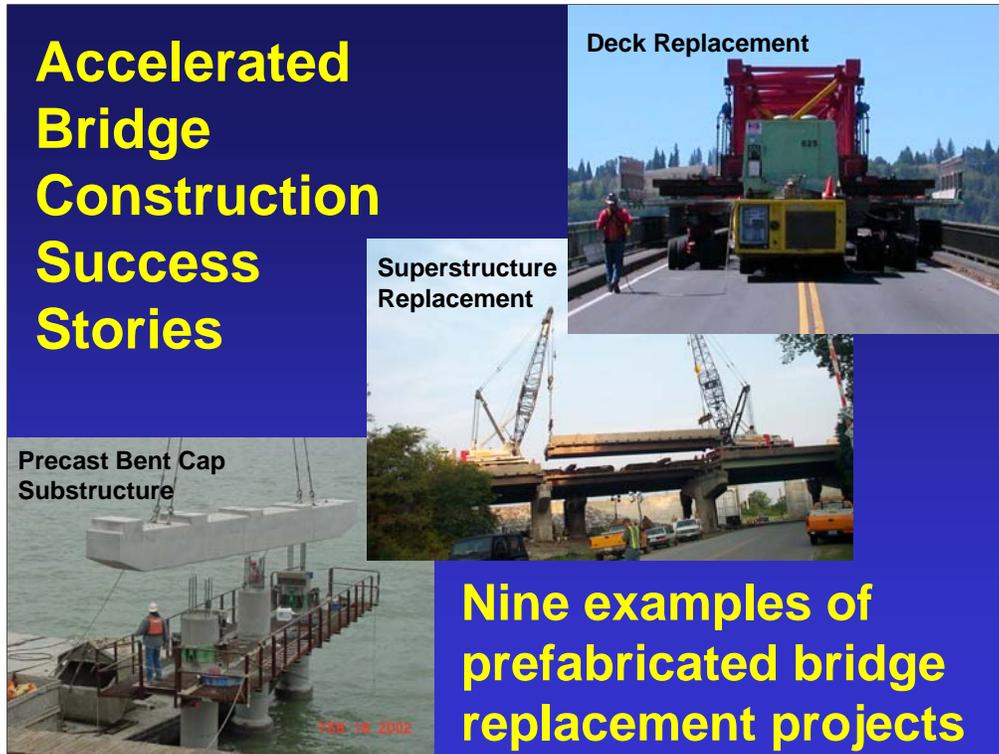
The prefabricated bridge elements and systems (PBES) cost study documents the details related to savings in time and money on nine PBES projects in states across the country. All nine projects are replacement projects, and as such reducing the impact of onsite construction to motorists was a priority. Each project is an example of how various combinations of prefabrication and effective contracting strategies were used to achieve the accelerated onsite construction timeline.

In all cases the onsite construction time was significantly reduced relative to conventional construction, and five of the replacement projects were completed with no impact to rush-hour traffic. The combined construction cost savings on these nine projects is \$30M, where savings are defined as the difference between engineer's estimate and awarded bid.

Projects

The owner, the project name, and the year of completion are shown below for each of the nine projects included in this cost study.

- 1) Colorado Department of Transportation's State Highway 86 Bridge over Mitchell Gulch - 2002
- 2) Maryland State Highway Administration's MD Route 24 Bridge over Deer Creek – 2001
- 3) New Hampshire Department of Transportation's Mill Street Bridge over Lamprey River – 2004
- 4) New Jersey Department of Transportation's Route 1 Bridges over Olden Avenue & Mulberry Street - 2005
- 5) New York City Department of Transportation's Belt Parkway Bridge over Ocean Parkway – 2004
- 6) Ohio Department of Transportation's U.S. Route 22 Bridge over Scioto River in Pickaway County – 2003
- 7) Texas Department of Transportation's State Highway 66 Bridge over Lake Ray Hubbard - 2003
- 8) Virginia Department of Transportation's Interstate 95 Bridge over James River – 2002
- 9) Washington State Department of Transportation's SR 433 Lewis & Clark Bridge over Columbia River - 2004



A number of prefabricated bridge projects have been constructed to date across the country. The following nine projects are examples of how prefabrication was used to accelerate onsite construction time. The awarded bids for these projects were also typically lower than the engineer's estimate.

For each project, first an overview is given that includes the name, location, date of construction, owner, brief description of project, benefits including reduced impact to traffic, and duration compared to conventional construction. The construction process is then briefly described, followed by contract requirements that include incentives and disincentives. Construction costs are then discussed, including engineer's estimate, number of bidders, low bid and second lowest bid, savings both in time and money, and incentives paid.

All nine projects are replacement projects, and as such reducing the impact of onsite construction to motorists was a priority. Each project is an example of how various combinations of prefabrication and effective contracting strategies were used to achieve the accelerated onsite construction timeline. In all cases the onsite construction time was significantly reduced, and five of the replacement projects were completed with no impact to rush-hour traffic.

The combined construction cost savings on these nine projects is \$30M, where savings are defined as the difference between engineer's estimate and awarded bid.

State Highway 86 Bridge over Mitchell Gulch, Colorado – 2002



46-hour
weekend
construction
of 40-ft long,
43-ft wide
single-span
bridge

No impact to rush-hour traffic



The State Highway 86 Bridge over Mitchell Gulch between Castle Rock and Franktown in Douglas County southeast of Denver was a timber bridge built in 1953 and rated in 2002 as one of Colorado's worst 10 bridges. That year the Colorado Department of Transportation accepted a value engineering proposal from the contractor and his design team to build a totally prefabricated bridge over a weekend in August 2002. During construction the bridge was closed and the 12,000 vehicles per day were diverted to a short detour around the bridge site.

The existing 40-ft long 2-span bridge was 26-ft wide with two 11-ft lanes and two 1.5-ft shoulders. The new 40-ft long bridge with 35-ft-clear single span was 43-ft wide to accommodate two 12-ft lanes and two 8-ft shoulders.

The new prefabricated bridge was opened just 46 hours after closure. Construction occurred over a weekend, with no impact to rush-hour traffic. Construction would have taken 2 to 3 months using conventional methods.

State Highway 86 Bridge over Mitchell Gulch, Colorado – 2002



Prior to the bridge closure, the contractor constructed a short detour to divert traffic for the weekend, and also drove 40-ft deep steel H piles at the abutments in the stream banks just outside the existing roadway width. The precast concrete abutments, wingwalls, and superstructure units were fabricated at Plum Creek Products Company in Littleton and shipped to the site just before being installed.

At 7 p.m. on a Friday in August 2002, the bridge was closed and traffic diverted to the detour. The existing timber bridge was demolished. Early Saturday morning, 44-ft wide precast abutments and 23-ft long precast wingwalls with embedded steel plates were erected with a crane and welded to the steel H piles and to each other prior to placing flowable fill behind the abutments. On Saturday afternoon, the eight 38'-4" long, 5'-4" wide, and 1'-6" deep precast superstructure units were erected, including the edge units complete with precast railing. The units were then transversely post-tensioned and grouted. Work stopped at 11 p.m. on Saturday and resumed Sunday morning at 7 a.m. to complete the earthwork and asphalt overlay.

The bridge was reopened to traffic at 5 p.m. on Sunday, 46 hours after closure of the existing bridge. Only 38 hours of construction work were required for the replacement.

The bridge is expected to see a 75-year service life due to the quality of its prefabricated components and the attention given to connection details.

State Highway 86 Bridge over Mitchell Gulch Contract Requirements

- ☑ Contract specified 3-cell cast-in-place concrete box culvert to replace 2-span timber bridge
- ☑ Value engineering change proposal by contractor/design team
 - ☑ Prefabricated single-span bridge
 - ☑ Completion in one weekend

The Colorado DOT awarded the construction contract to replace the deteriorated bridge with a conventional 3-cell cast-in-place concrete box culvert. However, the contractor, Lawrence Construction Company, was concerned about the safety of his construction crews on this project because of the steep downward grade of the highway approach from the west in combination with the nearby curve of the detour around the bridge site. The contractor teamed with Wilson & Company, a local design firm, to submit a value engineering change proposal to build the single-span totally prefabricated bridge over a weekend to limit the onsite exposure time of his crew.

State Highway 86 Bridge over Mitchell Gulch Contract Requirements, cont'd.

- ☑ CDOT response:
 - ☑ Accepted VE change proposal
 - ☑ Implemented lane rental fee
- ☑ Lane Rental Specification
 - ☑ \$500/hr starting 6 a.m. Monday
 - ☑ Fee based on user costs to occupy SH 86

The Colorado DOT accepted the value engineering change proposal, with no change to the project funding. However, as part of the acceptance of the proposal, CDOT implemented a lane rental specification that imposed significant costs should the contractor exceed the allowed weekend closure. If the bridge wasn't opened by 6 a.m. on Monday, the contractor was required to pay a lane rental fee of \$500 per hour or portion of an hour of lane closures on SH 86. The lane rental was based on road user costs to occupy SH 86.

No incentives were included in the contract.

State Highway 86 Bridge over Mitchell Gulch – 2002 Construction Costs

☑ Engineer's Estimate	\$ 394.2 K
☑ Number of bidders	12
☑ 2 nd Lowest Bid	\$ 365.8 K
☑ Low Bid	\$ 365.2 K
☑ Savings – 7 %	= <u>\$ 29.0 K</u>

Closure: Only 46 hours

The engineer's estimate for this project was \$ 394.2K. The low bid bid of \$365.2K from Lawrence Construction Company was 7% or \$29,000 less than the engineer's estimate. There was steep competition among contractors on this project. Twelve contractors bid on the project, and the 2nd lowest bid of \$365.8K was just \$644 higher than the awarded low bid.

The 5 p.m. Sunday opening of the new bridge was 13 hours earlier than the required 6 a.m. Monday opening. No rush hours were impacted and, therefore, no lane rental fees were charged. Motorists who traveled home from work on Friday over the existing bridge and then to work Monday morning over the new bridge never experienced a construction delay or detour.

The existing bridge was replaced with a totally prefabricated bridge in just 46 hours, and the contractor anticipates cutting the time in half on similar subsequent projects. In addition to huge savings in user costs and significantly improved safety, this bridge was also completed under budget.

MD Route 24 Bridge over Deer Creek, Maryland – 2001

122.5-ft long & 33-ft
wide historic through-
truss bridge ...



Rehabilitated Bridge



Deck replacement

... FRP deck panels
installed in just 3 days

The MD Route 24 Bridge over Deer Creek near Rock State Park in Harford County in northeastern Maryland is a 122.5-ft long, 33-ft wide single-span 2-lane historic through-truss bridge built in 1934 and eligible for inclusion in the National Register of Historic Places. In 2001 the deck was deteriorated and required a replacement that maintained the historic characteristics of the bridge. The rehabilitation project was also a challenge because the bridge was on a school bus route and could only be closed for rehabilitation a maximum of 10 weeks in the summer. Replacing the deck with one that would last longer than the typical maximum 40 years due to the harsh climate was another challenge. In addition, replacing the deck with one that did not further reduce the live-load capacity of this weight-restricted bridge was a challenge. Other challenges were the low 24.5-ft vertical clearance that restricted crane use and the 56-degree skew.

In 2001 the Maryland State Highway Administration (SHA) decided to address these challenges with fiber-reinforced polymer (FRP) deck panels. Following removal of the existing deck, steel angles were welded to the girders and the panels were installed in just 3 days. The rapid installation possible with these panels allowed the bridge to be rehabilitated during the summer and opened prior to the start of school. The corrosion resistance of the panels is anticipated to almost double the deck's service life, to at least 70 years. In addition, the significantly lighter weight of the FRP panels allowed easier placement and increased the live-load capacity of the bridge.

The project was completed in 10 weeks. Deck replacement with FRP panels was done in 1/3 the time required for a conventional concrete deck.

MD Route 24 Bridge over Deer Creek, Maryland – 2001

FRP panels:

- Easily installed with forklift
- Corrosion resistant



- Lightweight, resulting in increased load capacity, e.g., for weight-restricted bridges

The bridge consists of two warren trusses each with five 24.5-ft long panels connected to overhead members. The trusses are supported by eight steel girders at 4-ft spacing. The FRP panels, which were manufactured by the protrusion method, are E-glass fiberglass strands and fabric coated with an isophthalic polyester resin.

Because of limited vertical clearance, the most efficient deck installation method is with a forklift to place the panels, and the use of a forklift was possible because of FRP's light weight. The FRP deck system that was selected allowed immediate construction loads without the full grouting required for some FRP deck systems. This enabled the forklift to immediately move onto the newly-placed panel to position the next panel as it progressed from one end of the bridge. The panels were installed perpendicular to the girders and act as a continuous beam across the girder supports.

The method used to attach the panels to the girders was similar to the method used in the region to construct reinforced concrete decks on steel girders. Steel angles were welded to the sides of the girders to form a haunch, the panels were placed on the angles, shear studs were installed in prefabricated pockets in the panels, and the shear stud pockets were filled with non-shrink grout. An asphalt overlay was then placed to provide the required skid resistance, to form the roadway crown, and to protect the FRP from ultraviolet radiation. While a polymer overlay is typically used in Maryland, the asphalt overlay was allowed because the FRP panels will not corrode.

Once the existing deck was removed and the existing girders cleaned, it took only 15 working days for the bridge to be opened to traffic.

MD Route 24 Bridge over Deer Creek Contract Requirements

- ☑ Maximum 10 weeks of closure
- ☑ Disincentive of \$4,700 per day past 10 weeks

The low traffic volume of 3,700 ADT (in 2000) allowed the bridge to be closed during a 10-week period in the summer when school was out. Traffic was diverted to a 21-mile detour during this time.

A penalty for time violations was included in the contract. For every day beyond the 10-week closure period that the detour was in place, the contractor would be fined \$4,700. No incentives or other accelerated construction strategies were included in the contract.

In addition to replacing the deck, the contract included cleaning and painting the truss members. During construction several steel members were found to be deteriorated and required repair. These repairs increased the time it took the contractor to complete the work, but it was still within 10 weeks. No penalties were assessed.

MD Route 24 Bridge over Deer Creek - 2001 Construction Costs

☑ Engineer's Estimate	\$ 924.4 K
☑ Number of bidders	5
☑ 2 nd Lowest Bid	\$ 929.6 K
☑ Low Bid	\$ 911.1 K
☑ Below Estimate	<u>\$ 13.3 K</u>

Deck panels installed in just 3 days

The engineer's estimate for this project was \$ 924.4K. The low bid of \$911.1K was slightly below the engineer's estimate. Five contractors bid on the project, and the 2nd lowest bid was only slightly higher than the low bid.

The deteriorated deck was replaced with a deck that is anticipated to last at least 70 years compared to 40 years for typical concrete decks in the region. The FRP deck, connections and grout weigh just 25 pounds per square foot (lbs/sq ft). Adding the 45 lbs/sq ft for the asphalt overlay results in a total deck weight of just 70 lbs/sq ft compared to 115 lbs/sq ft for a traditional reinforced concrete deck. This 40% reduction in deck weight increased the live load capacity of this historic bridge. In addition, the accelerated construction made possible using FRP panels allowed the bridge to be completely rehabilitated within the available 10-week period.

This project was the Maryland State Highway Administration's first use of FRP bridge decks. The FRP deck cost \$88/sq ft compared to \$35/sq ft average cost for a traditional concrete deck replacement in 2001. Costs for replacements with FRP deck panels are anticipated to go down with subsequent projects.

Use of FRP on this historic bridge helped the State Highway Administration maintain the heritage of the region. They partnered with the University of Maryland and received an FHWA Innovative Bridge Research and Construction Program grant that covered part of the cost to install and monitor the FRP deck. A recent inspection in 2006 found the deck still looking new, with no signs of problems. The Maryland SHA is planning rehabilitation with FRP deck panels for similar historic through-truss bridges in their State, although future availability of multiple suppliers of FRP deck panels is an concern.

Mill Street Bridge over Lamprey River, New Hampshire – 2004



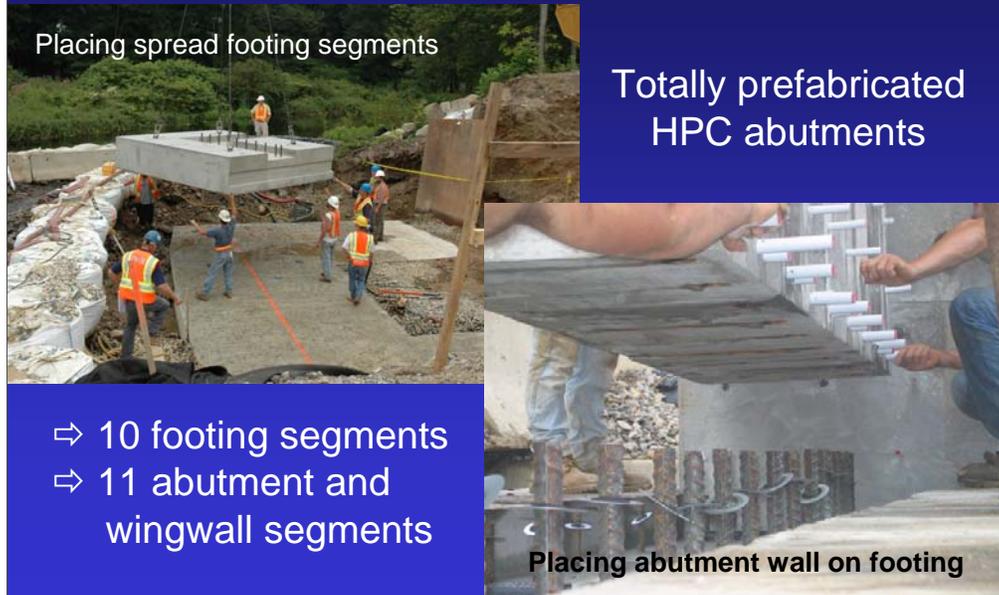
Totally Prefabricated Bridge, erected in just 8 day!

In 2003 the town of Epping's existing 28-ft wide 2-lane Mill Street Bridge over the Lamprey River consisted of two 30-ft long spans separated by a 60-ft long center pier causeway. The spans were deteriorated and required replacement. The low traffic volume crossing the bridge in combination with a short half-mile detour allowed complete closure of this bridge during its replacement. The site was selected for the New Hampshire Department of Transportation's first use of totally prefabricated cantilevered substructure construction. The location minimized the overall risk of using the precast abutment system that was newly developed by a team with members from the NHDOT, FHWA, University of New Hampshire, Precast/Prestressed Concrete Institute's Northeast Region Technical Committee, and local general bridge contractors and precasters.

In August 2004 the existing bridge was replaced with a 115-ft long and 28-ft wide 2-lane single-span pretensioned concrete adjacent box beam superstructure on full-height cantilevered precast concrete abutments founded on precast concrete spread footings. Thirty-two precast concrete segments were used to construct the bridge.

The erection of the bridge, from start of footing placement to opening to traffic, required 8 days. The bridge was closed to traffic for a total of 2 months, compared to 5 months that would have been required for conventional construction.

Mill Street Bridge over Lamprey River, New Hampshire – 2004



The 32.4-ft wide 5,000 psi precast reinforced high performance self-consolidating concrete abutments consist of 10 spread footing segments and 11 abutment wall and wingwall segments. All precast segments were fabricated at the J. P. Carrara & Sons plant in Middlebury, Vermont and shipped 170 miles to the jobsite.

Spread footings provide significant speed and simplicity to bridge construction when soil conditions permit their use as in this project and in many other New Hampshire bridge projects. The spread footings and other substructure components were fabricated in segments as determined by the contractor and precaster to facilitate shipping and handling, and were standardized to reduce fabrication costs. The precaster used a template in the plant fabrication to ensure adequate tolerances between the abutments, wingwalls, and footing segments. The contractor developed the assembly plan.

Following placement of the footings, a minimum 3-inch thick flowable grout bed was injected through grout tubes in the footings to provide a sound bearing surface for the roughened bottom surfaces of the footings. Proper grading was assured by using leveling screws cast in the corners of each footing segment. The abutment walls and wingwalls had splice sleeve connections to accommodate the reinforcing bars protruding from the tops of the footings. The walls were lowered into place, and the splice sleeves were then grouted to complete the bar splices. All horizontal joints are full-moment connections with grouted reinforcing bars, and vertical joints have grouted shear keys.

The erection of the abutments took 2 days, plus a 3rd day to cure the grout and prepare for the backfill. Similar conventional cast-in-place abutments would have required 6 separate concrete placements and two months to construct.



The 115-ft long and 28-ft wide superstructure consists of seven 4-ft wide adjacent box beams. The beams are made of 8,000 psi high performance pretensioned concrete. The use of HPC in combination with 0.6-inch diameter pretensioning strands stretched the 3-ft deep box beams to 115 ft, allowing the use of a single span. Following erection of the beams, a precast concrete pilaster was set along the top of the stem wall on each side of the outside box beams to provide lateral load transfer between the superstructure and substructure and to also provide a more finished look. Full-depth shear keys were then cast between each box beam, and the span was transversely post-tensioned in 6 locations to complete the connection between beams. A 3-bar aluminum railing was then installed. A waterproofing membrane was applied to the top surfaces of the box beams, followed by an asphalt overlay.

In spring 2006, the Lamprey River crested 1 to 2 ft above the bridge deck after heavy rains. Although the area has a significant flooding history, this level was the highest seen by Epping residents. The inundation battle-tested the bridge in its second year of existence, with no ill effects. The bridge is expected to see a service life of at least 75 years due to the use of HPC, the quality of its prefabricated construction, the attention given to connection details, and an aggressive NHDOT maintenance and preservation program.

Mill Street Bridge over Lamprey River Original Contract Requirements

- ☑ 30-day bridge closure
- ☑ Assembly of bridge in 14 days
- ☑ Incentives/disincentives:
 - ☑ \$1,500 per day less/more than 30-day
 - ☑ \$5,000 per day less/more than 14-day

Because the focus of this project was to develop project details and processes that will reduce the onsite bridge construction timeline and improve safety on future projects, the project was originally bid with a maximum 30-day bridge closure and a maximum 14-day bridge assembly. The 30-day bridge closure compared to a 5-month closure for conventional construction. The 14-day assembly limitation started with lifting the first footing and ended with opening to traffic. The limitation on assembly time allowed the NHDOT to evaluate the effectiveness of this new bridge substructure system by removing the site-specific conditions; the 14-day clock would start after the site was prepared.

Two separate incentive/disincentive clauses were also included in the project that was originally bid. The first was an incentive of \$1,500 per day for completion before the 30-day closure limit and a disincentive of the same amount per day for completion after the 30-day closure limit. The second was an incentive of \$5,000 per day for completion before the 14-day bridge assembly limit and a disincentive of the same amount per day for completion after the 14-day bridge assembly limit.

The low bid for the original project was \$1.4M, which was 40% higher than the \$1.0M budgeted for the project. The bid was not awarded.

Mill Street Bridge over Lamprey River Final Contract Requirements

- ☑ Assembly of bridge in 14 days
- ☑ \$5,000 per day:
 - ☑ Incentive if less than 14 days
 - ☑ Disincentive if more than 14 days

The NHDOT modified the contract to eliminate the 30-day closure window and the incentive/disincentive related to the closure limit. The 14-day assembly limit and its incentive/disincentive clauses remained in the contract. The project was re-advertised 3 months later.

Mill Street Bridge over Lamprey River – 2004 Construction Costs

☑ Engineer's Estimate	\$ 0.95 M
☑ Number of bidders	6
☑ 2 nd Lowest Bid	\$ 1.20 M
☑ Low Bid	\$ 1.05 M

Erection of bridge in 8 days

The engineer's estimate for the re-advertised project was \$ 0.95M. The low bid of \$1.05M from R. M. Piper Construction was 10% or \$97,000 more than the engineer's estimate. Since there were 6 bidders for the project and the second low bid was \$152,000 or 15% above the low bid, the NHDOT awarded the contract. Partial funding was received from the FHWA Innovative Bridge Research and Construction Program.

The bridge assembly was completed in just 8 days. This was 6 days ahead of the 14-day limit in the contract. At \$5,000 per day, the contractor received an incentive of \$30,000.

The NHDOT plans to use the knowledge gained from this demonstration project to design and construct future bridges with their new precast abutment system. They are developing a plan to provide standard detail sheets for prefabricated elements that could be substituted for cast-in-place concrete designs at the contractor's option at bid, as they now do for partial-depth precast deck panels. The standard sheets in the contract plans will include prefabricated full-depth panels, multi-column bents, cantilevered abutments, and stub abutments. The contractor will be required to submit an assembly plan to pull the components together if he chooses the prefabricated standards option.

Route 1 Bridges over Olden Avenue & Mulberry Street, New Jersey – 2005

Olden Avenue

Mulberry Street

Route 1
Freeway
through
City of
Trenton



NJDOT's 1st Hyperbuild Project

Each day the New Jersey Department of Transportation's Route 1 carries more than 50,000 vehicles through the city of Trenton in Mercer County on the western edge of New Jersey. Route 1 is a vital link to adjacent Pennsylvania as well as locations within New Jersey. Three bridge decks on the Route 1 Freeway through the capital city, one at the Olden Avenue Connector and two at Mulberry Street, were deteriorated and in need of constant maintenance. In 2005 the replacement of these three bridges was the NJDOT's first Hyperbuild project.

The term "Hyperbuild" was coined in 2004 by NJDOT Commissioner Jack Lettiere. Hyperbuild projects were initiated to shave years off road construction projects and save millions of dollars in design, construction, and road user costs. To qualify for Hyperbuild status, a project should have a well-defined scope and, if possible, require limited right-of-way acquisition, utility relocations and environmental impacts.

All three bridges in this project were replaced with no impact to rush-hour traffic. The Route 1 bridge over the Olden Avenue Connector was replaced during a weekend closure in August 2005. The Route 1 Southbound bridge over Mulberry Street was replaced during a weekend closure in September 2005, followed by the Route 1 Northbound bridge over Mulberry Street during a weekend closure in October 2005. Design and construction would have taken 22 months using conventional methods.

Route 1 Bridges over Olden Avenue & Mulberry Street, New Jersey – 2005



The 2-lane 86.8-ft long, 35.0-ft wide single-span Route 1 bridge over the Olden Avenue Connector is a highly-skewed steel girder bridge with concrete deck. Its deck was in very poor condition and required constant maintenance.

The 4-lane 60.0-ft long, 82.2-ft wide single-span Route 1 bridge over Mulberry Street consists of two bridges with a median barrier separating each direction of traffic. The decks of these steel girder bridges were also in very poor condition.



The Route 1 bridge over the Olden Avenue Connector was closed at 7 p.m. on a Friday in August 2005, and traffic was rerouted onto a 5-mile detour. The bridge was demolished in place using conventional methods. The existing abutments were repaired and new bearing seats constructed. The prefabricated superstructure was then erected. The longitudinal joints between superstructure segments were then sealed, and the expansion joints at the ends of the span were completed. The cast-in-place parapets were connected to the outside segments with bars in threaded inserts.

The Route 1 Southbound and Northbound bridges over Mulberry Street were closed at 7 p.m. on a Friday in September and October 2005, respectively, and traffic was rerouted onto a 5-mile detour for Southbound Mulberry, while off- and on-ramps were used for Northbound Mulberry. The construction methods and time required to replace these bridges were similar to the bridge over the Olden Avenue Connector. Parapets and median barriers were cast-in-place concrete.

Each superstructure span consists of 5 full-length segments of varying width, each with two Grade 50W steel girders and a 9-inch thick composite concrete deck (Inverset) system. The 86.8-ft long bridge span over Olden Avenue required W36x182 girders, and the 60-ft long bridge spans over Mulberry Street required W30x99 girders. The 15 segments were designed and fabricated at The Fort Miller plant in Schuylerville, New York, assembled at the plant to verify field tolerances, and trucked to an airport parking lot near the bridge. The segments were required to be onsite 24 hours prior to the start of demolition of the existing bridge. The contract specified high performance concrete for all concrete on the job.

Each bridge is expected to see a 75-100 year service life due to the quality of its prefabricated superstructure, the use of high performance concrete, and the attention given to connection details. Conventionally constructed bridges have an average minimum 50-year life in New Jersey.

Route 1 Bridges over Olden Avenue & Mulberry Street

Contract Requirements

- ☑ For each bridge, maximum 57 hours from complete closure to 2 lanes open
- ☑ Lane Occupancy Charge up to \$10K/da
- ☑ Substantial Completion by November 16, 2005
- ☑ All work completed by January 13, 2006

Each of the 3 bridges was allowed a 57-hour window from complete closure to re-opening of both lanes. If this window was exceeded, a Lane Occupancy Charge would be assessed, up to \$10,000 per day. In addition, Substantial Completion of all 3 bridges was required by November 16, 2005, and all work was to be completed by January 13, 2006.

Route 1 Bridges over Olden Avenue & Mulberry Street Incentives

- ☑ If less than 57 hours:
 - ☑ Bridge over Olden Avenue
 - ☑ \$1,500 per hour
 - ☑ Cap of \$27,000
 - ☑ Each bridge over Mulberry Street
 - ☑ \$2,000 per hour
 - ☑ Cap of \$36,000

Incentives were also included on this project to encourage the contractor to minimize onsite construction time even further than 57 hours per bridge.

For the bridge over the Olden Avenue Connector, an incentive of \$1,500 per hour was specified if the work was completed in less than 57 hours, not to exceed a maximum of \$27,000.

For each bridge over Mulberry Street, an incentive of \$2,000 per hour was specified if the work was completed early, not to exceed \$36,000.

Route 1 Bridges over Olden Avenue & Mulberry Street

Liquidated Damages

- ☑ If more than 57 hours:
 - ☑ Bridge over Olden Avenue
 - ☑ \$1,500 per hour
 - ☑ Each bridge over Mulberry Street
 - ☑ \$2,000 per hour
- ☑ If after Nov. 16 – \$4,200 per day
- ☑ If all work not completed by Jan. 13 – additional \$900 per day

Liquidated damages were also specified. The contractor would be charged \$1,500 per hour if he took longer than 57 hours to open the bridge over the Olden Avenue Connector to traffic, and \$2,000 per hour if he took longer than 57 hours to open either of the bridges over Mulberry Street.

Also, the contractor would be charged \$4,200 per day if the bridges weren't substantially completed by November 16, 2005, and an additional \$900 per day if all work was not completed by January 13, 2006.

Route 1 Bridges over Olden Avenue & Mulberry Street - 2005 Construction Costs

☑ Engineer's Estimate	\$ 3.8 M
☑ Number of bidders	5
☑ 2 nd Lowest Bid	\$ 3.8 M
☑ Low Bid	\$ 3.5 M
☑ Savings - 8 %	= <u>\$ 0.3 M</u>

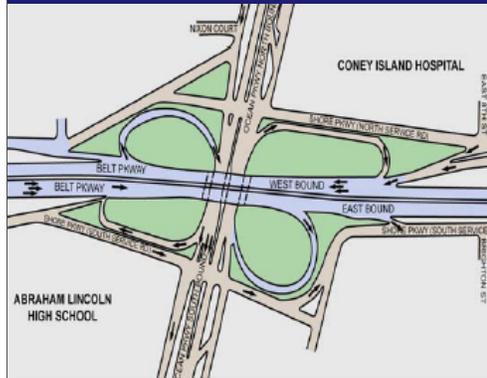
3 bridges replaced in 3 weekends

The engineer's estimate for this project was \$ 3.8M. The low bid of \$3.5M from Neshaminy Constructors, Inc., was 8% or \$297,000 less than the engineer's estimate. There were 5 bidders on this project. The second lowest bid was 10% higher than the low bid.

All three bridges were opened in less than the required 57 hours. The bridge over the Olden Avenue Connector was opened in 56 hours, the bridge over Southbound Mulberry was opened in 51 hours, and the bridge over Northbound Mulberry was opened in 54.5 hours. With all three bridges opened well before Monday morning rush hour, the contractor earned an \$18,500 incentive.

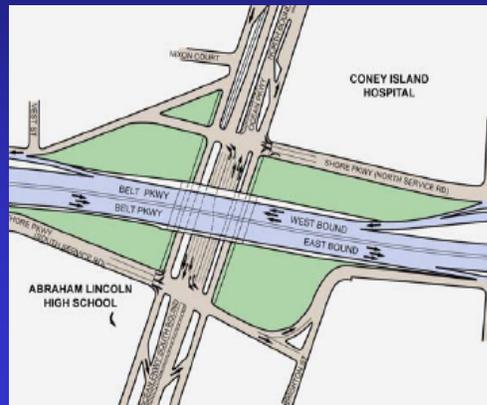
Each of the 3 bridges in the New Jersey DOT's first Hyperbuild project was replaced in a weekend, during a total of 6 days over 3 consecutive months. The replacements were completed in significantly less than the 22 months required for conventional design and construction, and they were completed under budget. The design and construction savings, including delay-related user costs, are in excess of \$2M.

Belt Parkway Bridge over Ocean Parkway, New York City (Brooklyn) – 2004



Existing Interchange

Reconstructed Interchange



The New York City Department of Transportation's Belt Parkway Bridge over Ocean Parkway in south Brooklyn was deteriorated and required complete replacement. The entire design-build project included replacing the existing bridge with a longer and wider bridge, reconfiguring the existing outdated cloverleaf interchange into a modified tight diamond interchange, and other rehabilitation and upgrade work to the Parkways.

The selected design-build team of Granite Halmar/Gannett Fleming specified extensive use of prefabricated bridge components to achieve an accelerated onsite construction timeline. The rapid construction was required to minimize disruption to the 166,000 average daily traffic volume that used the Belt Parkway, a major artery through Brooklyn that also had a large hospital and two schools fronting on the project limits.

Onsite installation of each half of the new bridge took only a few nights in each of two weeks. The entire design-build project was completed in 14 months, including a 3-month winter shutdown. Construction would have taken 3 to 4 years using conventional methods.

Belt Parkway Bridge over Ocean Parkway, New York City (Brooklyn) – 2004

Replaced existing
2-span, 149-ft long,
78-ft wide bridge
with 3-span, 221-ft
long, 134-ft wide
bridge ...



... with no lane closures
during peak traffic hours

The old 2-span 149-ft long, 78-ft wide Belt Parkway Bridge was lengthened and widened to a 3-span 221-ft long, 134-ft wide bridge with span configuration of 49 ft - 107 ft - 65 ft. The width was increased to add shoulders and acceleration/deceleration lanes at the entrance and exit points, in addition to the existing 3 lanes in each direction.

Throughout the project, six lanes of traffic remained open during rush hour, with limited lane closures as needed during off-peak hours. A temporary bridge was erected adjacent to the south side of the existing bridge to maintain the existing number of lanes on Belt Parkway during the bridge reconstruction. Traffic was diverted onto the temporary bridge and the south portion of the existing bridge while the north portion of the existing bridge was demolished and reconstructed. Traffic was then rerouted to the six lanes, three in each direction, on the new north portion of the bridge which was overbuilt to accommodate the six lanes. The south portion of the existing bridge was then demolished and reconstructed.



To minimize traffic disruption, prefabricated components were used extensively. Prefabricated components included concrete-filled steel pipe piles, precast T-walls, precast post-tensioned cap beams, prefabricated superstructure segments, precast bridge parapets, median barriers, and approach slabs. High performance concrete with 4000 psi compressive strength was specified for all precast components. Stainless steel reinforcement was specified for the precast decks, parapets, and median barriers. While the stainless steel reinforcement increased the cost of the bridge by approximately one percent, the bridge is anticipated to last twice as long as the 45-year-old bridge it replaced.

The 51 span-length prefabricated superstructure segments, as well as the other precast concrete components, were fabricated at the Fort Miller plant in upstate New York and shipped 200 miles to the jobsite. Each (Inverset) superstructure segment consisted of two steel girders and a composite deck.

Various processes were adjusted to maximize onsite construction speed. For example, the mini-piles were installed with limited headroom while the existing bridge remained in use. Another example is pre-erection of the superstructure segments in the plant to ensure adequate tolerances for field erection.

The bridge is expected to see a 75-100 year service life due to the quality of its prefabricated components and the attention given to connection details, including the loop-on-loop closure joints connecting the deck segments.

Belt Parkway Bridge over Ocean Parkway Contract Requirements

- ☑ “A” + “B” Bidding Method to achieve reduced onsite construction timeline
 - ☑ “A” = bid items
 - ☑ “B” = “Critical Duration” x \$85,000

The NYCDOT utilized a modified “A” + “B” bidding method, where “A” equals the bid items and “B” equals a “Critical Duration” (number of days specified by the contractor) times \$85,000 to translate the duration into a delay-related user cost. “Critical Duration” was defined as the period of time from when the design-build team permanently impacted the roadways for construction until the time that all new roadways were in their final completed configuration.

Belt Parkway Bridge over Ocean Parkway

Incentives/Disincentives

- ☑ Incentive for completion before “Critical Duration”:
 - ☑ \$85,000 per day
 - ☑ Cap of \$2,000,000
- ☑ Disincentive for completion after “Critical Duration”:
 - ☑ \$85,000 per day
 - ☑ No dollar limit

Incentive/disincentive and liquidated damages clauses were included in the contract to help ensure early completion of critical activities to minimize traffic disruption. The contract specified an incentive of \$85,000 per day for completion before the “Critical Duration,” with a cap of \$2M. Also specified was a disincentive of \$85,000 per day for completion after the “Critical Duration,” with no dollar limit.

Belt Parkway Bridge over Ocean Parkway Construction Costs

☑ Engineer's Estimate	\$ 60.0 M
☑ Number of bidders	5
☑ Low Bid	\$ 47.9 M
☑ Awarded Bid *	\$ 55.5 M
☑ Savings - 8 % =	<u>\$ 4.5 M</u>

* **Best Value: only 285 "Critical Duration" days**

The engineer's estimate for this project was \$ 60.0M. The awarded bid of \$55.5M from Granite Halmar Construction Co., Inc., was 8% or \$4.5M less than the engineer's estimate. There were 5 bidders on this project. The awarded bid proposed a "Critical Duration" of only 285 days, which was 300 "Critical Duration" days shorter than the low bid. Therefore, at \$85,000 per day, the awarded bid was the best value, with a delay-related user cost that was \$25M lower than the low bid.

The 14-month construction schedule began September 2003 and included a 3-month winter shutdown. "Critical Duration" work began in March 2004 and was completed in November 2004, in one construction season. The bridge was completed 29 days ahead of the "Critical Duration" of 285 consecutive calendar days that was bid in the contract. The actual number of "Critical Duration" days was just 256 days, with no lane closures during peak traffic hours. The contractor received the maximum \$2M incentive.

The bridge work on this design-build project was approximately a third of the total project cost. The project replaced the existing high-traffic-volume bridge with a longer and wider bridge, reconfigured the interchange, and completed other rehabilitation and upgrade work in significantly less time than conventional construction, and it was completed under budget.

U.S. Route 22 Bridge over Scioto River, Ohio – 2003



The State of Ohio has the second largest number of bridges in the United States and the seventh largest highway system. Like many states, portions of the system are outdated, overburdened and in need of repair. Many areas of the Buckeye State are becoming highly populated and developed, resulting in increased traffic volumes. The additional motorists on the roadways necessitate adding lanes on many of the routes. To accomplish this task, road crews have to close or restrict lanes during the construction process. Such closures and restrictions negatively impact motorists in terms of lost time, higher fuel costs, and lost revenues. The Ohio Department of Transportation (ODOT) is committed to the continuous movement of traffic through all work zones by the elimination or reduction of delays.

ODOT's U.S. Route 22 Bridge over the Scioto River, in Pickaway County 30 miles south of Columbus, provides access for the 12,900 vehicles that cross it each day. It is a vital link for the local school district, the local trucking industry transporting harvest crops to mills, and emergency response services. The existing 45-year old concrete slab and steel girder bridge, built in 1957, had deteriorated girders and a roadway width that was too narrow for the local farm equipment. A 2003 design-build project replaced the deteriorated superstructure with a wider bridge, in one of ODOT's first accelerated construction projects under its Fast Track Bridge Program strategic initiative to build bridges faster, smarter, and better.

Adjacent site constraints required that the new superstructure be constructed in the same location as the existing bridge. The design-build team of Ruhlin Construction Company and E.L. Robinson Engineering Company developed a new superstructure consisting of high performance steel girders and high performance concrete deck, and a galvanized steel pier cap replacement for the rehabilitated and widened substructure, in combination with other innovations to achieve the required accelerated onsite construction timeline. The bridge was completely closed during construction, which began when school closed in mid-June 2003, and it was required to be back in service in 60 days, by the beginning of the fall harvest in August. Traffic was maintained on a 20-mile detour during the closure.

The U.S. Route 22 Bridge was completed in just 48 days, despite heavy rain and flooding. Construction would have taken 18 months using conventional methods.

U.S. Route 22 Bridge over Scioto River, Ohio – 2003

Replaced existing 6-span
634-ft long 35-ft wide
superstructure with 44-ft
wide new superstructure



... having
HPC deck &
HPS girders



The existing 6-span 634-ft long, 35.4-ft wide U.S. Route 22 Bridge superstructure was replaced and widened to 44.2 feet to upgrade the 2-lane bridge by increasing the two shoulders from 3 ft to 4 ft, and by adding an 8-ft sidewalk.

While much of this bridge replacement project used conventional design and construction methods, adjustments were made to maximize onsite construction speed. The five new girders per span were made of high performance steel and fabricated by Stupp Bridge Company in Kentucky. They were designed to be simply supported to streamline erection, and made continuous with integral concrete diaphragms over the piers. The integral abutments on this bridge make it ODOT's longest bridge without expansion joints. Galvanized permanent metal deck forms provided a stay-in-place deck forming system instead of the traditional wooden deck forms that would have to be removed.

The widening of the substructure was also designed and constructed to shorten the onsite construction time. The existing piers were saw-cut below the pier-stem construction joint and replaced with galvanized steel plate girder bent caps that extended to groups of four concrete-capped galvanized steel 18-inch diameter pipe piles under the widened portion of the bridge. Pipe piles for several of the piers under the widening were driven before the bridge was closed to further shorten the bridge closure time.

Other details to speed onsite construction included demolition of the existing deck beginning at the middle of the bridge and simultaneously working toward the abutments because environmental restrictions prevented river access. Other details included beginning the retrofit work on each pier as soon as the existing girders were removed, shipping and erecting the new girders as soon as the pier retrofits were completed, and using two concrete pumps to avoid delays during the deck pour.

The bridge is expected to see a 75-year service life due to the use of high performance concrete in the deck, high performance steel girders, galvanized steel plate girder bent caps, galvanized steel pipe piles, and good construction practices. ODOT has partnered with the University of Cincinnati to evaluate the piloted features of the contract.

U.S. 22 Bridge over Scioto River Contract Requirements

- ☑ Maximum 60 days of closure
- ☑ Liquidated savings for early completion:
 - ☑ \$50,000 per day
- ☑ Liquidated damages for late completion:
 - ☑ \$20,000 per day for 61-65 days
 - ☑ \$30,000 per day for 66-70 days
 - ☑ \$40,000 per day for 71-75 days
 - ☑ \$50,000 per day for 76 or more days

The Ohio DOT awarded this design-build project based on responses to a bid package that included a Scope of Services and a set of the existing bridge plans from 45 year ago. The Scope of Services required that the bridge be closed a maximum of 60 days.

In addition, incentive/disincentive clauses were included in the contract to help ensure completion of critical activities to open the bridge on the accelerated schedule.

The contract specified Liquidated Savings of \$50,000 for each day that all necessary work was completed prior to the maximum 60-day closure requirement, with maximum Liquidated Savings of \$500,000.

The contract also specified Liquidated Damages for completion after the specified maximum 60-day closure. The Liquidated Damages were assessed at \$20,000 per day for opening the bridge in 61-65 days, \$30,000 per day for 66-70 days, \$40,000 per day for 71-75 days, and \$50,000 per day if the bridge remained closed for 76 or more days.

U.S. 22 Bridge over Scioto River – 2003 Construction Costs

☑ Engineer's Estimate	\$ 5.0 M
☑ Number of bidders	4
☑ 2 nd Lowest Bid	\$ 3.2 M
☑ Low Bid	\$ 2.7 M
☑ Savings – 46 % = <u>\$ 2.3 M</u>	

New Widened Superstructure in 48 days!

The engineer's estimate for this project was \$ 5.0M. The low bid of \$2.7M from Ruhlin Construction Company was 46% or \$2.3M less than the engineer's estimate. There were 4 bidders on this project, with the 2nd lowest bidder 19% or \$500,000 higher than the low bid.

The bridge was completed in 48 days, 12 days ahead of schedule and without a single lost-time injury. The contractor received the maximum \$500,000 incentive. This Ohio DOT Fast Track design-build project replaced the existing deteriorated bridge with a wider superstructure in significantly less time than conventional construction, and it was completed significantly under budget. It demonstrates quite effectively that cost-effective, long-lasting accelerated bridge construction projects can be built through the innovative use of conventional construction in combination with high performance materials and good contracting strategies. ODOT has continued their Fast Track Bridge Program with subsequent accelerated bridge construction projects.

State Highway 66 Bridge over Lake Ray Hubbard, Texas – 2003



Precast bent caps
saved 215 days
of onsite construction



In 2000 the Texas Department of Transportation's State Highway 66 over Lake Ray Hubbard in Rockwall County northeast of Dallas was a narrow, congested, 40-year-old 2-lane bridge. It was replaced with a pair of bridges, completed in early 2003. The new 4,360-ft long, 40-ft wide eastbound bridge has two traffic lanes and shoulders, and precast bent caps as part of its substructure due to a contractor-initiated field change.

Precasting 43 identical caps resulted in a time savings of 5 to 7 days per cap, at least 215 days of effort. Forming, concrete placement, and curing for conventional bent caps would have required 7 days of critical path activity per cap. This represented a total potential delay of 9 months for the 43 bent caps, a delay that would have required additional overhead costs and slower project delivery.

State Highway 66 Bridge over Lake Ray Hubbard, Texas – 2003



First the new westbound bridge was built adjacent to the existing bridge using conventional construction. Traffic was then moved to the new bridge, the old bridge was demolished, and the eastbound bridge was built approximately on the bridge's original alignment.

The contractor fabricated the 43 identical caps adjacent to one end of the bridge. The precast reinforced concrete caps are 37.5-ft long with beveled ends and a 3.25-ft square cross section. Each cap is supported by three 3-ft diameter cast-in-place columns, and provides the bearing for five AASHTO Type IV beams per typical 100-ft span. TxDOT designed grouted-duct connections between the precast caps and the cast-in-place columns based on previous research at the University of Texas at Austin. Seismic design was not required.

In addition to speeding onsite construction, fabricating the bent caps off the critical path allowed the use of a normal-strength high performance concrete mix design that results in greater durability but with a slower strength gain due to the 35 percent replacement of cement with ground-granulated blast-furnace slag.

State Highway 66 Bridge over Lake Ray Hubbard Contract Requirements

- ☑ Contract specified cast-in-place concrete bent caps
- ☑ Contractor proposed field change to precast concrete bent caps for eastbound bridge
- ☑ TxDOT accepted proposed field change, with no change in funding

The contract specified conventional cast-in-place construction for the substructures. Early in the project the contractor, Traylor Bros., Inc., proposed a field change to precast reinforced concrete bent caps as a way to speed construction of the eastbound bridge, to avoid the difficulties in handling formwork and materials over water, and to minimize the construction workers' exposure to high-voltage transmission lines running adjacent to the bridge. TxDOT approved the contractor's proposal with no change in funding.

The contract did not include incentives or disincentives.

State Highway 66 Bridge over Lake Ray Hubbard – 2003 Construction Costs

☑ Engineer's Estimate	\$ 48.2 M
☑ Number of bidders	8
☑ 2nd lowest bid	\$ 43.1 M
☑ Low Bid	\$ 40.9 M
☑ Savings – 15 % =	<u>\$ 7.3 M</u>

Onsite Time Savings: 215 Days

The engineer's estimate for this project was \$48.2M. The low bid of \$40.9M was 15% or \$7.3M less than the engineer's estimate. There were 8 bidders on this project, with the 2nd lowest bid about 5% or \$2.2M more than the awarded low bid. Using the 43 precast bent caps reduced onsite construction time by 215 days. TxDOT obtained the bridge ahead of schedule and under budget.

Interstate 95 Bridge over James River, Virginia – 2002



... with no lane
closures during
rush-hour traffic

102 superstructure
spans replaced
in 137 nights ...



Interstate 95 over the James River in the City of Richmond, Virginia, consists of twin 4,185-ft long bridges with 3 lanes in each direction and a total width of 90 ft. In 1997 the bridges carried 110,000 vehicles daily. Nearly 50 years old, the superstructures had significant structural deterioration and needed to be replaced.

In 2002 the Virginia Department of Transportation completed replacement of the superstructure and rehabilitation of the substructure. The 102 superstructure spans were replaced in just 137 nights during 17 months, with no impact to rush-hour traffic. Conventional construction would have required 24 to 36 months and significant impact to traffic.

Interstate 95 Bridge over James River, Virginia – 2002



Public participation was solicited at the beginning of plan development to limit the impact to motorists. A community advisory group was given several construction options for the replacement. Their preferred option, which VDOT used, was night construction with all three lanes open in each direction during the day. Construction took place from 7 p.m. to 6 a.m. only. During the night work, traffic was shifted to one of the bridges, with one lane in each direction remaining open.

The bridges are composed of multiple steel plate girder simple spans ranging from 44 ft to 114 ft in length, and a 243-ft truss span. The typical steel plate girder span was replaced with 2 full-span-length prefabricated superstructure segments. Each prefabricated segment consisted of 3 steel plate girders with an 8.75-inch deck, complete with bridge railing, and weighed approximately 100 tons. The segments were fabricated by the contractor at a nearby casting yard.

During the night, the existing superstructure was cut longitudinally at every other girder. The old segments were removed using high-capacity cranes and conventional flatbed trailers. The cranes then installed the new prefabricated superstructure segments. After the two segments were in place, the span was transversely post-tensioned and connected longitudinally with bars running through pockets cast into the ends of the segments. The deck of the truss span was replaced with a filled-grid deck system because mechanical and geometrical requirements precluded the use of the prefabricated superstructure segments. The substructure was also rehabilitated as needed.

Interstate 95 Bridge over James River Contract Requirements

- ☑ “A” + “B” Bidding Method
 - ☑ “A” = bid items
 - ☑ “B” = calendar days to replace superstructure
- ☑ VDOT considered bids to be non-responsive if days > 240 days

VDOT utilized the “A” + “B” bidding method, where “A” equals the bid items and “B” equals the number of calendar days with nighttime lane closures for the superstructure replacement and rehabilitation.

The Department considered bids greater than 240 days to be non-responsive.

Interstate 95 Bridge over James River Incentives / Disincentives

- ☑ Incentive for early completion:
 - ☑ \$30,000 per day
 - ☑ Cap of \$2,000,000
- ☑ Disincentive for late completion:
 - ☑ \$30,000 per day
 - ☑ No dollar limit

The contract included an incentive of \$30,000 for each day the work was completed ahead of the time that was bid in the contract, not to exceed \$2.0M. The contract also included a disincentive of \$30,000 for each day the work was completed past the bid time, with no dollar limit.

Interstate 95 Bridge over James River Additional Disincentive

Failure to Restore All Traffic Lanes by	Amount	Cumulative Amount
6:00 A.M.	\$ 5,000	\$ 5,000
6:15 A.M.	\$10,000	\$ 15,000
6:30 A.M.	\$35,000	\$ 50,000
6:45 A.M.	\$40,000	\$ 90,000
7:00 A.M.	\$25,000	\$115,000
7:15 A.M.	\$10,000	\$125,000
7:30 A.M.	\$10,000	\$135,000
7:45 A.M.	\$10,000	\$145,000
8:00 A.M.	\$ 5,000	\$150,000
8:30 A.M.	\$ 5,000	\$155,000

VDOT wanted all lanes open to traffic from 6 a.m. to 7 p.m. To achieve this, an additional disincentive was included for not having all lanes of the bridge open to traffic on time.

Interstate 95 Bridge over James River Additional Disincentive, continued

Failure to Restore All Traffic Lanes by	Amount	Cumulative Amount
9:00 A.M.	\$ 5,000	\$160,000
10:00 A.M.	\$ 5,000	\$165,000
11:00 A.M.	\$ 5,000	\$170,000
12:00 Noon	\$ 5,000	\$175,000
1:00 P.M.	\$ 5,000	\$180,000
2:00 P.M.	\$ 5,000	\$185,000
3:00 P.M.	\$15,000	\$200,000
4:00 P.M.	\$20,000	\$220,000
5:00 P.M.	\$20,000	\$240,000
6:00 P.M.	\$10,000	\$250,000

This additional disincentive accumulated up to \$250,000 per day. Disincentives of this magnitude help ensure the contractor's buy-in to the owner's accelerated construction schedule and encourage the contractor to innovate.

Interstate 95 Bridge over James River – 2002 Construction Costs

☑ Engineer's Estimate	\$ 48.5 M
☑ Number of bidders	5
☑ 2nd lowest bid	\$ 44.9 M
☑ Low Bid	\$ 43.4 M
☑ Savings	- 11 % = <u>\$ 5.1 M</u>

Closures: Only 137 nights

The engineer's estimate for this project was \$48.5M. The low bid by Archer-Western Contractors, Ltd., was \$43.4M and 179 days calendar days with nighttime lane closures. The low bid was 11% or \$5.1M less than the engineer's estimate. There were 5 bidders on this project, with the 2nd lowest bid about 3% or \$1.5M more than the awarded low bid.

The contract specified that the contractor would receive \$30,000 per day for early completion. The contractor replaced the 102 superstructure spans during only 137 night closures of half the roadway width. He received \$30,000 for each of 42 nights, for a \$1.3M incentive.

VDOT obtained a new superstructure ahead of schedule with less impact to the traveling public and with improved safety, and obtained it under budget.

State Route 433 Lewis and Clark Bridge over Columbia River, WA/OR – 2004

Replaced 3900 ft of deck using SPMTs during 124 nights plus 3 weekend closures ...

SPMTs with frame carrying panel



After deck replacement



... with no impact to rush-hour traffic

The Lewis and Clark Bridge on State Route 433 over the Columbia River spans the state line between Longview, Washington and Rainier, Oregon and is jointly owned by the Washington State Department of Transportation and the Oregon Department of Transportation. The 1929 steel through-truss bridge was designed by the famed engineer Joseph B. Strauss and is listed in the National Register of Historic Places. It provides access across state lines for 18,000 vehicles each day.

In early 2000 its deck was severely deteriorated and required replacement. Accelerated onsite construction was needed to limit the impact to emergency services and to avoid extended use of a 40-mile detour west to the town of Cathlamet that included a ferry ride or an 80-mile detour south to Portland.

In 2004 WSDOT completed replacement of the bridge deck on this mile-long bridge with no impact to rush-hour traffic. Self-propelled modular transporters (SPMTs) were used to replace 3,900 ft of deck during 124 night closures plus 3 weekend closures. A helicopter with landing pad was provided on the south side of the river for emergency crossings during the closures. Construction using conventional cast-in-place methods would have required 4 years.

The deck replacement extended the life of the bridge another 25 years.

State Route 433 Lewis and Clark Bridge over Columbia River, WA/OR – 2004

103 full-width, 6-inch
full-depth precast
lightweight concrete
panels, each 36 ft wide
& 20 ft to 45 ft long



Removal of old deck section
& installation of new panel
in avg. 6.5 hours overnight

In the contract plans, the Washington State DOT had designed prefabricated full-width full-depth deck panels and a placement procedure to accommodate the required rapid construction schedule. One contractor, Max J. Kunej Company of Spokane, partnered with an SPMT supplier in the development of his bid, assuming a revised placement procedure that used SPMTs in combination with a specially-designed steel truss frame for lifting and transporting. Their bid was considerably lower than the other bidders. Kunej was awarded the contract, and WSDOT accepted their proposed system.

The 5,478-ft long bridge included 3 deck-truss spans at 168 ft, 337 ft, and 337 ft; 3 through-truss spans at 760 ft, 1200 ft, and 760 ft; plus approach spans. Of this total length, 3900 ft of the deck was replaced with 103 prefabricated deck panels that were 36 ft wide and 20 ft to 45 ft long (20 at 45 ft, 45 at 40 ft, 20 at 35 ft, 14 at 30 ft, and 4 at 20 ft). The lightweight concrete panels were 6-in. thick plus 1-in. thick overlay. Each panel was supported on two longitudinal steel support beams and had a maximum panel weight of 96 tons. The new deck eliminated the existing 3-ft-wide raised sidewalks, providing 5-ft shoulders at road level for bicyclists and pedestrians as well as additional room for traffic to maneuver around disabled vehicles.

The bridge was closed on Sunday through Thursday nights from 9:30 p.m. to 5:30 a.m. The SPMTs with truss frame moved a new panel to the top of the bridge, lifted the old panel out, and then lowered the new panel into place before taking the old panel off the bridge. Each panel movement took an average 6.5 hours. Use of this prefabricated deck system in combination with the innovative SPMT equipment reduced construction workers' exposure to traffic during construction, improved the constructability of the bridge, and allowed the bridge to remain open for normal weekday operations.

SR 433 Lewis and Clark Bridge over Columbia River Contract Requirements

- ☑ “A” + “B” + “C” Bidding Method to determine lowest responsible bidder
 - ☑ “A” = bid items
 - ☑ “B” = bridge closures @ \$8,000
 - ☑ “C” = single lane closures @ \$2,000

WSDOT utilized an “A” + “B” + “C” bidding method to determine the lowest responsible bidder, where “A” equals the bid items, “B” equals the total number of bridge closures established by the bidder to complete the work times the Total Bridge Rental Closure Cost of \$8,000, and “C” equals the total number of single lane closures established by the bidder to complete the work times the Bridge Single Lane Rental Cost of \$2,000. The “B” and “C” parts of the bid were only used to determine the lowest responsible bidder, not to determine final payment to the contractor.

SR 433 Lewis and Clark Bridge over Columbia River

Incentives for Early Completion

- ☑ \$100,000 for completion by April 2004
- ☑ \$55,000 per Weekend Bridge Closure less than 4
- ☑ \$4,000 per Total Bridge Closure less than number bid
- ☑ \$1,000 per Single Lane Closure less than number bid

The contract included several incentives for early completion. If the contractor finished all work requiring Weekend or Total Bridge Closures by April 30, 2004, he would receive \$100,000. In addition, for each Weekend Bridge Closure less than 4, the contractor would receive \$55,000. For each Total Bridge Closure less than the number bid in the contract, the contractor would receive \$4,000. For each Single Lane Closure less than the number bid in the contract, the contractor would receive \$1,000.

SR 433 Lewis and Clark Bridge over Columbia River Liquidated Damages

- ☑ \$16,000 per Total Bridge Closure more than number bid
- ☑ \$4,000 per Single Lane Closure (SLC) more than number bid
- ☑ \$1,700 per 15-min period beyond times specified for Weekend or Total Closure
- ☑ \$900 per 15-min period beyond SLC

The contract also included liquidated damages for not meeting the time constraints for accelerated construction. This included a penalty of \$16,000 per Total Bridge Closure more than the number that was bid, and a penalty of \$4,000 per Single Lane Closure more than the number that was bid. In addition, penalties would be assessed for any late opening of closures. A \$1,700 penalty per 15-minute period would be assessed for time beyond that specified for Weekend Closure or Total Bridge Closure, and a \$900 penalty per 15-minute period would be assessed for time beyond that specified for Single Lane Closure.

SR 433 Lewis and Clark Bridge over Columbia River – 2004 Construction Costs

☑ Engineer's Estimate	\$ 28.8 M
☑ Number of bidders	6
☑ 2nd lowest bid	\$ 29.2 M
☑ Low Bid	\$ 18.0 M
☑ Savings – 38 % = <u>\$ 10.8 M</u>	

Closures: Only 124 nights & 3 weekends

The engineer's estimate for this project was \$ 28.8M. The low bid of \$18.0M was 38% or \$10.8M less than the engineer's estimate. There were 6 bidders on this project, with the 2nd lowest bid about 62% or \$11.2M more than the awarded low bid.

The contractor completed all work requiring Weekend or Total Bridge Closures by the end of April 2004 and, therefore, received the \$100,000 incentive. He also received an incentive of \$55,000 for using 3 instead of 4 Weekend Bridge Closures, and an additional \$30,000 for having 30 fewer Single Lane Closures than the 173 allowed. The contractor received a total incentive of \$185,000. No liquidated damages were assessed.

3900 linear feet of deck were replaced during only 124 nights plus 3 weekend closures, with no impact to rush-hour traffic. The Washington State DOT not only obtained the new deck ahead of time with less impact to the traveling public and with increased safety, but also obtained it significantly under budget.



The details for these nine projects clearly show that prefabrication in combination with effective contracting strategies can result in the completion of bridge replacement projects on an accelerated timeline and under budget. The projects included various prefabricated bridge elements and systems that provide quality, long-lasting bridges. The projects also included bidding methods and incentives/disincentives that provided an economic reason for the contractor to innovate and to buy in to the owner's accelerated onsite construction timeline.

Prefabrication and effective contracting strategies result in cost-effective rapid bridge construction projects. Their use helps the owner accomplish its mission of efficiently moving people and goods.

Thank you for your attention.

2006 PBES Cost Study: Accelerated Bridge Construction Success Stories

Project Contact Information

State	Year	Project Name	Participants	Contacts
CO	2002	CDOT's State Highway 86 Bridge over Mitchell Gulch between Castle Rock and Franktown in Douglas County southeast of Denver	<u>Owner:</u> Colorado DOT <u>Contractor:</u> Lawrence Construction Company, Littleton <u>Design Engineer:</u> Wilson & Company, Denver <u>Prefabricator:</u> Plum Creek Products Co., Inc., Littleton	Tom Hunt, P.E. Colorado Department of Transportation Tel: (303) 365-7244 Email: Thomas.Hunt@dot.state.co.us
MD	2001	Maryland State Highway Administration's MD Route 24 over Deer Creek	<u>Owner:</u> Maryland DOT <u>Contractor:</u> JJID General Contractors, Delaware <u>FRP Supplier:</u> Martin Marietta Materials	Jeff Robert, P.E. Project Engineer Bridge Development Office Maryland State Highway Administration Tel: (410) 545-8327 Email: JRobert@sha.state.md.us
NH	2004	Town of Epping's Mill Street Bridge over Lamprey River	<u>Owner:</u> Town of Epping <u>Design Engineer/Construction Inspection:</u> New Hampshire DOT <u>Contractor:</u> R. M. Piper Construction, Plymouth, NH <u>Prefabricator:</u> J. P. Carrara & Sons, Inc., Middlebury, Vermont	Peter E. Stamnas, P.E. Senior Project Engineer, Bureau of Bridge Design New Hampshire Department of Transportation Tel: (603) 271-2171 Email: PStamnas@dot.state.nh.us
NJ	2005	NJDOT's Route 1 Bridges over Olden Avenue Connector & Mulberry Street in Trenton	<u>Owner:</u> NJDOT <u>Contractor:</u> Neshaminy Constructors, Inc., PA <u>Design Engineer:</u> NJDOT & The Fort Miller Co., Inc. <u>Prefabricator:</u> The Fort Miller Co., Inc., NY	Harry A. Capers, Jr. P.E. Previously State Bridge Engineer, NJDOT Tel: (609) 985-2689 Email: HACapers@aol.com Seth Ahiekpor, P.E. Project Engineer, Structural Engineering New Jersey Department of Transportation Tel: (609) 530-5564 Email: Seth.Ahiekpor@dot.state.nj.us Helene Bowman, P.E. Division Bridge Engineer FHWA - New Jersey Division Office Tel: (609) 637-4230 Email: helene.bowman@fhwa.dot.gov
NY	2004	NYCDOT's Belt Parkway Bridge over Ocean Parkway in New York City (Brooklyn)	<u>Owner:</u> NYCDOT FHWA's Representative: NYSDOT <u>Contractor:</u> Granite Halmar Construction Co., Inc. <u>Design Engineer:</u> Gannett Fleming, Inc. <u>Prefabricator:</u> The Fort Miller Co., Inc. <u>Superstructure Erector:</u> Imperial Ironworks, Inc. <u>Temporary Bridge Supplier:</u> Acrow Corporation of America <u>Resident Engineering & Inspection Services:</u> HAKS Engineers & Land Surveyors, PC	Christothia (Chris) Sklavounakis, P.E. [costs] Director, Design-Build New York City Department of Transportation Tel: (212) 788-2078 Email: csklavounakis@dot.nyc.gov Charles R. (Chuck) Norrish, III, P.E. [technical] Vice President, Regional Office Manager Gannett Fleming Engineers and Architects, P.C. Tel: (212) 967-9833 Email: cnorrish@gfnet.com

State	Year	Project Name	Participants	Contacts
OH	2003	Ohio DOT's U.S. Route 22 Bridge over Scioto River in Pickaway County south of Columbus	<u>Owner:</u> Ohio DOT <u>Contractor:</u> Ruhlin Construction Company, Sharon Center, Ohio <u>Design Engineer:</u> E.L. Robinson Engineering Company, Dublin, Ohio <u>Steel Fabricator/Detailer:</u> Stupp Bridge Company, Bowling Green, Kentucky	Carole Howell Project Coordinator Ohio Department of Transportation Tel: (740) 833-8261 Email: Carole.Howell@dot.state.oh.us
TX	2003	TxDOT's State Highway 66 Bridge over Lake Ray Hubbard in Rockwall County northeast of Dallas	<u>Owner:</u> Texas DOT <u>Contractor:</u> Traylor Bros., Inc. <u>Design Engineer:</u> Texas DOT <u>Prefabricators:</u> Bent caps - Traylor Bros., Inc.; Beams - Texas Prestressed Concrete, Inc., Elm Mott, Texas; Panels - Austin Prestressed Co.	Lloyd M. Wolf, P.E. [technical] Bridge Design Engineer Texas Department of Transportation Tel: (512) 416-2279 Email: lwolf@dot.state.tx.us Michael S. O'Toole, P.E. [costs] Bridge Project Development Section Director Texas DOT Tel: (512) 416-2240 Email: MOToole@dot.state.tx.us John C. Jameson [contract] Construction Division Texas DOT Tel: (512) 416-2432 Email: jjameso@dot.state.tx.us
VA	2002	VDOT's Interstate 95 Bridge over James River in the City of Richmond	<u>Owner:</u> VDOT <u>Contractor:</u> Archer-Western Contractors, Ltd. <u>Design Engineer:</u> URS Corporation <u>Prefabricator:</u> Archer-Western Contractors, Ltd.	Malcolm T. Kerley, P.E. Chief Engineer Virginia DOT Tel: (804) 786-4798 Email: Mal.Kerley@VDOT.Virginia.gov
WA	2004	WSDOT's SR 433 Lewis & Clark Bridge over Columbia River	<u>Owner:</u> WSDOT & Oregon DOT <u>Contractor:</u> Max J. Kuney Company, Spokane <u>Design Engineer:</u> WSDOT <u>Prefabricator:</u> Max J. Kuney Company <u>SPMT Supplier:</u> Mammoet USA	J. A. Weigel, P.E. Bridge and Structures Engineer Washington State DOT (retired) Amy Revis, P.E. Lewis & Clark Project Engineer Washington State DOT Tel: (360) 357-2745 Email: RevisA@wsdot.wa.gov



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