Introduction
Hello. I'm Mary Lou Ralls, State Bridge Engineer for Texas, and I chair a panel that is promoting the use of prefabricated bridge elements and systems.

AASHTO, the American Association of State Highway and Transportation Officials, formed the Technology Implementation Group, known as the TIG, in December 2000. The TIG is charged with identifying innovative transportation technologies that have the potential for high payoff—and then facilitating the rapid acceptance and implementation of these technologies.

Prefabricated bridge elements and systems is one such technology.

In 2001, the TIG chose to champion the implementation of this technology because of the many advantages that can be realized by bridge owners, engineers, builders, and the traveling public as a result of the use of prefabricated bridge elements and systems.

First, traffic impacts of bridge construction projects are minimized.
Using prefabricated bridge elements and systems means that time-consuming formwork assembly, concrete casting, curing, and other tasks associated with bridge construction can be done off-site in a controlled environment away from traffic. Most of the bridge projects in these video clips minimized traffic disruption to the traveling public.

A second advantage is that construction work-zone safety is improved.
Because prefabrication moves much of the bridge construction work off-site, the amount of time that workers are required to operate near traffic is greatly diminished. Job site constraints such as nearby power lines are also minimized when workers can complete most of their construction off-site.

A third advantage is that construction is less disruptive for the environment.
Using prefabricated elements and systems that are produced off-site and brought to the site to erect reduces the impact to the adjacent landscape and also reduces the amount of time required for construction on-site.

A fourth advantage is that bridge designs are more constructible.
Many job sites impose difficult constraints on the constructibility of bridge designs: for example, heavy traffic on an interstate highway that runs under a neighborhood bridge, extreme elevations, long stretches over water, and restricted work zones due to adjacent stores or other facilities. Using prefabricated bridge elements and systems relieves such constructibility pressures.

A final advantage is that increased quality and lower life-cycle costs are realized.
Prefabricating elements and systems takes them out of the critical path of the project schedule: work can be done ahead of time, using as much time as necessary, in a controlled environment. This reduces dependence on weather and increases control of quality of the resulting elements and systems. Improved quality translates to lower life-cycle costs.

This presentation highlights fifteen bridges in six States and Puerto Rico that were constructed with prefabricated elements and systems. The bridges are discussed according to the types of prefabricated elements and systems.

Superstructure: Partial-Depth Deck Panels
Texas uses partial-depth precast concrete deck panels on most of its prestressed concrete beam bridges. The Louetta Road Overpass is one example.

In the early 1990's Texas State Highway 249 was upgraded from a four-lane, at-grade road to a limited-access freeway. Consequently, two overpass structures were built at Louetta Road near Houston to carry three lanes in each direction, plus shoulders and ramp transitions. The overpass was one of the first projects in FHWA's national high performance concrete bridge implementation program, and it was selected by the Precast/Prestressed Concrete Institute as the 1998 winner of the Bridge Design Award for spans greater than 135 ft.

The use of partial-depth deck panels is an option available to bridge contractors in Texas. Using panels as the stay-in-place forming system means that much of the time-consuming deck formwork assembly and disassembly is eliminated. It means that only half of the deck concrete must be cast at the site. It means that the lower half of the deck is constructed with panels that provide a stronger deck system for traffic loads.

The HPC deck panels were fabricated at the contractor's plant close to the job site, then transported by truck and erected on fiberboard strips. Reinforcement for the cast-in-place portion of the deck was then installed, and the upper half of the deck was cast. Workers ensure that the cast-in-place concrete flows under the panels to provide good panel support.

Using prefabricated partial-depth deck panels provides a number of advantages:

Disruption of traffic is minimized by reduced need for lane closures.

Contractors prefer precast deck panels because they not only eliminate much of the formwork but also reduce by half the amount of deck concrete that is cast on site. This speeds construction.

At the time of the Louetta construction, comparable Texas bridges averaged $27 per square foot of deck area. The Louetta Road Overpass was bid at $24 per square foot.

Houston's Pierce Elevated also uses precast prestressed deck panels, as well as other prefabricated elements including precast bent caps.

When a 113-span section of I-45 in Houston's central business district needed replacing, designers estimated that a conventional bridge system would require more than a year and a half of construction. Estimating user delay costs at $100,000 a day, TxDOT opted to speed construction by using prefabricated elements, including partial-depth deck panels. The bridge consists of twin structures, one northbound and one southbound, and each structure was completed in 95 days, a total of 226 spans replaced in 190 days.

TxDOT's effective use of partial-depth deck panels demands attention to a few key design and construction details. Such details may be found in the Prefabricated Bridge Elements and Systems web pages at the AASHTO-TIG web site.

Superstructure: Full-Depth Deck Panels

The 700-foot long bridge carrying US 27 over Pitman Creek in southern Somerset, Kentucky, is heavily used by vehicle and truck traffic and provides a major north-south artery for the area. When the bridge deck needed to be replaced, the Kentucky Transportation Cabinet opted to do the work at night.

Using proprietary prefabricated full-depth deck panels allowed modular construction, greatly minimizing traffic impacts as well as providing some weight savings by lightening the dead load on the truss.

Traffic was routed to one lane at 6:00 p.m. and opened back to two lanes at 6:00 a.m.

The slab between floor beams was removed and replaced with proprietary prefabricated full-depth deck panels.

Using high-early-strength concrete for the joints between deck panels allowed the bridge to be opened to traffic the next morning. The project was completed in 1993.

The New York State Thruway Authority used a similar approach to redeck the Tappan Zee Bridge over the Hudson River 13 miles north of New York City. The Tappan Zee is the key structure on the toll-supported New York State Thruway system, carrying an average of 130,000 vehicles a day in seven lanes.

Deck rehabilitation in the late 1990's included the through truss and west deck truss spans, bridge rail upgrade, and replacement of the east deck truss span—more than 250,000 square feet of deck, replaced with proprietary prefabricated full-depth deck panels.

For the deck replacement, two lanes were taken out of service at 8 p.m., with a third lane closed to traffic at 10 p.m. A minimum of three to four lanes of traffic was maintained throughout the night, with all seven lanes restored to service by 6 a.m.

The George Washington Memorial Parkway experiences heavy commuter usage by workers traveling from Virginia and Maryland into Washington D.C. The 1996 average daily traffic for the Parkway was 43,000 vehicles, with 54,000 vehicles per day projected for 2016. Because of its heavy commuter use, the bridges over Dead Run and Turkey Run, which are owned by the National Park Service, needed to be kept open to traffic on weekdays during replacement of the bridge decks with prefabricated full-depth deck panels.

The non-composite aspect of the original design, along with the use of precast post-tensioned concrete deck panels, facilitated quick deck replacement and allowed the structures to be kept open during weekday traffic.

The construction sequence was to
- close the bridge on Friday evening,
- saw cut the existing deck into transverse sections that included curb and rail,
- remove the saw cut sections,
- set the new precast panels,
- stress the longitudinal tendons after all panels in a span were erected,
- grout the areas beneath the panels above the steel beams, and
- open the bridge to traffic by Monday morning.

The replacement rate was one span per weekend. The project was completed in 1998.

The key advantage of the prefabricated deck was minimized traffic disruption. Traffic was maintained during weekdays to minimize the impact of construction on commuters from Virginia and Maryland into Washington D.C.

The Illinois Department of Transportation chose full-depth deck panels for its redecking of the Route 29 Bridge over Sugar Creek in 2001. The project minimized traffic delays on the 5-span bridge using precast, post-tensioned concrete deck panels.

Total Superstructure System: Preconstructed Composite Units

As the main North-South route along the East coast, I-95 is one of the busiest corridors in the country. Through Downtown Richmond, the corridor is linked by 13 bridges, the largest of which is the James River Bridge—which carries approximately 110,000 vehicles a day.

Built in the late 1950's, by the late 1990's, it was time to restore the bridge. Traffic was approaching 3 times the design volume and twice the design weight of the bridge, and the use of salt for deicing had taken a toll. Decks and supporting steel needed to be replaced.

The Virginia Department of Transportation faced the challenge of keeping the bridge open during peak traffic hours while rehabilitating it. They needed to find the safest and most cost-effective method of construction. Minimal impact on motorists was a project goal for the replacement of the superstructure of the I-95 James River Bridge. The original design of the bridge facilitated the selected rehabilitation approach: when the bridge was built, the northbound and southbound travel lanes were contained in individual superstructures supported on a common substructure.

After considering several alternatives, Virginia DOT opted for night-only construction, most of which occurred between 7 p.m. and 6 a.m. Sunday through Thursday nights. During the nighttime construction, one superstructure was kept open, carrying both directions of traffic and an emergency access lane.

VDOT chose a totally prefabricated superstructure system for most spans. Composite units consisting of an 8-¾-inch deck over steel plate girders were cast at a nearby casting yard.

Traffic was diverted each evening with cones and moveable concrete barriers to close the superstructure on one side of the bridge. Crews cut the old bridge spans into segments and removed them, prepared the gap for the new composite unit, and set the new unit in place.

By morning both directions of the bridge were open to traffic.

For this bridge project, conventional cast-in-place construction methods would have required loss of travel lanes for 24 hrs a day, 7 days a week, for almost 3 years. Using the preconstructed composite units and working on the deck for the most part only at night, the restoration project was completed in 2002, using partial bridge closures for only 167 nights**.**

Use of the preconstructed composite units also minimized traffic disruption by allowing replacement of the bridge superstructure while allowing the entire bridge to be open during peak traffic periods.

Total Superstructure System: Truss Spans
The George P. Coleman bridge spans the York River, linking the Virginia communities of Gloucester and historic colonial Yorktown. It is the largest double-swing bridge in the United States. Built in 1952 to carry no more than 15,000 vehicles per day, by 1995, more than 27,000 vehicles per day used the bridge. Machinery that rotated the swing spans was having problems.

In 1995, the bridge was rehabilitated in record time.

Engineers decided to reconstruct the existing superstructure, widened from 30 feet to 78 feet. The original piers would remain.

A major goal was to limit bridge closure and avoid disrupting traffic. The Virginia Department of Transportation limited the bridge closure to two 12-day periods for the entire replacement, using a totally prefabricated superstructure system--prefabricated truss spans. The contractor elected to use only one of the 12-day periods.

While the approach spans were widened on site, the truss spans were prefabricated off site.

The steel truss segments, complete with concrete decks, functional machinery, controls, lighting, and highway signs, were constructed at a fabrication site at Norfolk International Terminals, about 40 miles down-river from the original bridge.

As the old truss segments were floated out on barges, the new prefabricated truss segments were floated in. Six old spans were removed and six new ones placed in only one nine-day period.

Although the new spans were heavier and wider, using this innovative process saved the time that would have been needed to assemble the truss and pour the concrete roadway on site, sparing months of downtime and more inconvenience to commuters.

Substructure: Bent Caps
After 40 years of service, the narrow two-lane State Highway 66 bridge over Lake Ray Hubbard had become a congested route for commuters in the suburbs east of Dallas. In 2000, construction began to replace the bridge with two adjacent conventional prestressed concrete I-beam bridges with combined length approaching three miles.

After the project was let for construction, the contractor asked to precast the substructure bent caps as an alternative to the original cast-in-place bent cap design to reduce the amount of time the construction crews would need to work near power lines.

TxDOT designed a precast bent cap option that included a cap-to-column connection and a specific construction procedure that allowed early placement of caps and prestressed beams based on achieved cap concrete and cap grout connection strengths. The connection design included reinforcing steel dowel bars that protrude from the columns into the precast caps through open plastic ducts that are grouted after cap placement.

Using 43 precast bent caps saved nearly a week per cap on the tasks associated with construction of conventional cast-in-place bent caps.

Use of the prefabricated elements in the substructure also reduced the amount of time required for work near power lines and over water. 80% of work on the caps was done off-site.

Total Substructure System: Piers
In the early 1990's Texas State Highway 249 near Houston was upgraded from a four-lane, at-grade road to a limited-access freeway. Consequently, two overpass structures were built at Louetta Road to carry three lanes in each direction, plus shoulders and ramp transitions.

In addition to using prefabricated partial-depth deck panels, Louetta also used individual precast prefabricated piers as the total substructure system.

Each pier consists of several precast hollow-core 10,000 psi high performance concrete segments with six post-tensioned bars.

After foundation construction was completed, placement of the prefabricated segments began. The bottom segment was placed on top of the foundation. Cast-in-place concrete provided a base for the transition from the cast-in-place concrete drilled shaft foundation to prefabricated segment. The bars were coupled. Epoxy was applied. The next segment was placed. This procedure was repeated until the capital segment was set. The bars were then stressed and grouted.

In 1996 the Texas Department of Transportation constructed a direct connector from I – 35 northbound to US – 183 Northbound in Austin using prefabricated piers as the total substructure system.

The columns supporting the balanced cantilever ramp of the U.S. 183 Elevated project were constructed segmentally. Prefabricated piers typically require less overall field time to construct and are particularly suited to segmental superstructures that don't require bent caps.

Prefabrication of several piers minimized disruption to Austin businesses in the construction area.

Total Prefab Bridges
Baldorioty de Castro Avenue Overpasses--To ease congestion on a San Juan road that carries more than 100,000 vehicles per day, the Department of Transportation and Public Works in Puerto Rico constructed two overpasses at each of two intersections: two 700-foot-long overpasses and two 900-foot-long overpasses.

To minimize traffic disruption, each total prefab bridge was built in two stages. Over a weekend, piles were driven and the footings were cast in place, and then asphalt was placed to support traffic. On a subsequent weekend, the footings were uncovered and then the prefabricated substructure components were erected and post-tensioned. Box piers were positioned and post-tensioned to the footings, caps were erected, and the substructure was vertically post-tensioned.

After the first two substructures at the middle of the bridge were completed, the 100-foot-long superstructure span was set in place, complete with seven box beams, wearing surface, and parapets. Using two crews, the overpass spans were then erected simultaneously from the center span toward each end. Each span was post-tensioned transversely as it was completed. The first overpass was erected in 36 hours; the second took as little as 21 hours. Each bridge was built over a weekend, including construction of retaining walls with select fill on the approaches. Friday evening commuters used the old intersection, and Monday morning commuters used the new overpass.

Route 9/Metro North Pedestrian Bridge--Building a pedestrian bridge in a New York village north of Manhattan involved site restrictions, a requirement for aesthetic design, and the need to limit disruption to a heavily traveled highway and a major commuter railroad. The New York State Department of Transportation chose two commercial prefabricated composite superstructure spans complete with concrete parapets to bridge the 4-lane highway, service road, and five sets of railroad tracks. For this total prefab project, twelve-inch diameter precast piles support 3-segment piers made of precast boxes stacked vertically and post-tensioned to a cast-in-place concrete footing. Ramps are 35-foot-long precast concrete units and 20-foot precast stair sections, supported directly on precast columns with cast-in-place seats. Precast concrete's many available architectural treatments allowed project aesthetic goals to be met. The bridge was completed in 1998.

Using prefabrication improved constructibility and minimized traffic disruption by reducing the required staging area and construction time.

I-287 Viaducts in Westchester County--Required to maintain six lanes of congested traffic and limit construction on a restricted site during replacement of two major I-287 viaducts in Westchester County, the New York State Department of Transportation accepted the contractor's value-engineering proposal to incorporate precast segmental voided pier segments for each of the 42 piers. Each pier consisted of 8-foot match-cast segments vertically post-tensioned to the footing. Piers ranged from 20 to 55 feet in height, and a typical pier could be erected in one day. The proposal also changed the cast-in-place deck to 10-foot-long by 9-inch-thick precast panels that were 42 to 50 feet wide to match longitudinal construction stages, supported on pairs of multi-span steel tub girders. Up to 15 panels were erected in a single shift, with 'in-line' erection methods used where side access was not available. Prior to grouting the panels to the girders, the entire deck was post-tensioned longitudinally in a variable pattern that was designed to provide a zero-tension deck under design live loads. The prefabricated deck and pier construction reduced the contract's original 34-month schedule to 26 months. The project was completed in 1999.

Linn Cove Viaduct--The Linn Cove Viaduct was a total prefab project. Precasting each segment of the bridge allowed construction workers to assemble the bridge with little impact to the most environmentally sensitive section of North Carolina's Grandfather Mountain. This bridge also proved that a design could be environmentally sensitive in addition to being utilitarian and economical.

The Linn Cove Viaduct is over a quarter of a mile long and contains 153 superstructure segments, each weighing 50 tons, along with 40 substructure segments weighing up to 45 tons each. The road is at an elevation of 4,100 feet and was designed as an S-shape to wind around the scenic mountains. To avoid placement of heavy equipment in a sensitive environment, the bridge was built in one direction from the south abutment to the north almost entirely from the top down. The only exceptions to the top down method were construction of the initial span on falsework and construction of a temporary timber bridge that enabled the foundation drilling machine to prepare several of the foundation sites ahead of the superstructure erection.

The project was completed in 1983.