BRIDGE REPLACEMENTS IN MINUTES!

Mary Lou Ralls, Ralls Newman, LLC, Austin, TX
Benjamin Tang, Federal Highway Administration, Washington, DC
Bill Halsband, Mammoet USA, Rosharon, TX

ABSTRACT

Bridge replacements in minutes! Although this may seem impossible, it is exactly what has been done this year in a couple forward-thinking State Departments of Transportation to minimize traffic disruption and improve safety on bridge replacement projects that impact traffic on their Interstate highways. The Florida Department of Transportation (FDOT) was the first bridge owner in the country to remove existing bridge spans and install new bridge spans crossing an Interstate highway using self-propelled modular transporters (SPMTs). The Louisiana Department of Transportation and Development (LaDOTD) was the first bridge owner in the country to remove existing Interstate bridge spans and install new Interstate bridge spans using SPMTs. Each move took only minutes, and the total impact to Interstate traffic during each move was limited to just hours!

This paper discusses these projects and the manual that is being developed for FDOT, the American Association of State Highway and Transportation Officials (AASHTO), and the Federal Highway Administration (FHWA) to document this work for future use by FDOT, LaDOTD, and other bridge owners.

Keywords: Bridge Replacement, Minimized Traffic Disruption, Self-Propelled Modular Transporters

INTRODUCTION

Bridge replacements in minutes! This is exactly what has been done this year at two progressive State Departments of Transportation to minimize traffic disruption and improve safety on bridge replacement projects that impact traffic on their Interstate highways. The Florida Department of Transportation (FDOT) was the first bridge owner in the country to remove existing bridge spans and install new bridge spans crossing an Interstate highway using self-propelled modular transporters (SPMTs). The Louisiana Department of Transportation and Development (LaDOTD) was the first bridge owner in the country to remove existing Interstate bridge spans and install new Interstate bridge spans using SPMTs. Each move took only minutes, and the total impact to Interstate traffic during each move was limited to just hours!

What makes this possible are the SPMTs, a lifting and hauling technology that has been used for many years by other industries but which has only recently seen multiple use for bridge replacements. The SPMTs are computer-controlled multi-axial platform trailers that can be configured to quickly and safely lift bridge spans that weigh thousands of tons and move them in any direction with precision to a fraction of an inch.

FDOT faced the challenge of quickly and safely removing and replacing its Graves Avenue bridge over Interstate Route 4 (I-4) northeast of Orlando prior to widening both I-4 and Graves Avenue. In January 2006 FDOT used SPMTs to remove the existing span over I-4 East during a 20-minute rolling roadblock one night, followed by a similar process two nights later to remove the existing span over I-4 West. I-4 was then widened and the new substructure built while the new lengthened and widened Graves Avenue spans were built adjacent to the bridge site. In June 2006 the spans were installed on consecutive Saturday nights, with I-4 closed and traffic detoured for just a few hours each.

Later in January 2006 a similar accelerated bridge replacement project was accomplished by the Louisiana Department of Transportation and Development (LaDOTD), this time removing the damaged span and installing the new span in approximately 30 minutes for each of two Interstate Route 10 (I-10) bridges near Lafayette. The replaced spans were on I-10, crossing LA 35 at Rayne. Total I-10 detour time to service roads was less than 10 hours for each exchange.

This paper discusses these projects and the manual that is being developed for FDOT, the American Association of State Highway and Transportation Officials (AASHTO), and the Federal Highway Administration (FHWA) to provide guidelines for bridge moves using SPMTs for future use by FDOT, LaDOTD, and other bridge owners.

GRAVES AVENUE BRIDGE SPAN REMOVALS AND INSTALLATIONS OVER I-4

By 2000, Florida’s population growth to almost 16 million made it the fourth largest state in the nation. Population growth in the current decade (2000 to 2010) is projected to be 3.6

million, the largest absolute population increase of any decade in Florida's history. From just 2001 to 2004, Florida saw an increase of more than 1.5 million persons[1].

The impact of this population increase on Florida's transportation system has caused FDOT to aggressively pursue innovative technologies to maintain and upgrade its highway system while minimizing traffic disruption and improving safety in the work-zone. Accelerated bridge construction is part of this effort, and the Graves Avenue bridge span removals and installations over I-4 are one example of this effort.

The concept originated in 2004 to use SPMTs for moving bridge spans in Florida. William N. Nickas, P.E., FDOT State Structures Design Engineer, was a team member of the 2004 AASHTO / FHWA / National Cooperative Highway Research Program (NCHRP) International Scan on Prefabricated Bridge Elements and Systems[2]. On the scan the team saw SPMTs being used in Europe to quickly move single-span and multiple-span bridges, and brought the technology home as the team's top implementation recommendation from the scan. Shortly after his return from the scan, Nickas led the successful use of conventional modular transporters to re-position spans for a quick re-opening of I-10 over Escambia Bay following damage by Hurricane Ivan. He then pursued use of the more sophisticated SPMTs for a land application. Amy D. Scales, P.E., Resident Engineer for FDOT District 5 Interstate Construction, responded to Nickas' request. Her ongoing Graves Avenue over I-4 bridge replacement project in Volusia County in central Florida became the first U.S. demonstration of this technology to move bridge spans that crossed the Interstate. A change order incorporated the use of SPMTs.

SPAN CONFIGURATIONS

The existing 2-lane, 215-ft long Graves Avenue bridge was being replaced to accommodate the widening of I-4 from 4 lanes to 6 lanes. The bridge's 4 spans (37 ft – 70.5 ft – 70.5 ft – 37 ft) were being replaced with 2 spans, each 143-ft long, for a total new bridge length of 286 ft over I-4.

Graves Avenue was also being widened. The 30-ft width of the existing bridge was being increased to 59 ft to accommodate two 10-ft shoulders and two 5-ft sidewalks in addition to its two traffic lanes. The cross section of the bridge was changed from the four or five AASHTO Type III beams in each span of the existing bridge to eight 78-inch deep Florida Bulb-T beams with 8-inch concrete deck in each span of the new bridge.

Figure 1 shows the previous and new Graves Avenue bridge cross sections. The weight of each of the previous 70.5-ft middle spans was 250 tons. The weight of each of the new spans was 1,300 tons. Analysis of the spans prior to fabrication indicated that no design changes were required to lift and move the new spans with SPMTs.

SPAN REMOVALS

The two 37-ft end spans were removed using conventional means since they were outside the I-4 traffic lanes. One 6-axle SPMT unit was then pre-positioned in the median under one end of the existing span over I-4 East, as shown in Fig. 2.

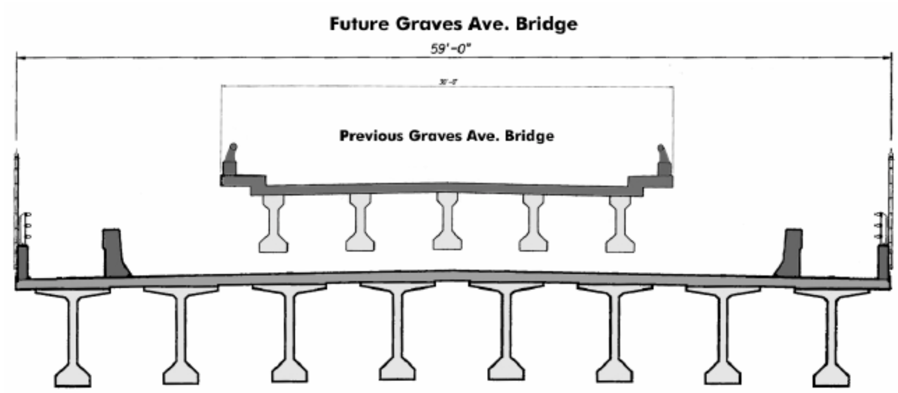

Fig. 1 Previous and New Graves Avenue Bridge Cross Sections

Fig. 2 Pre-positioned SPMT Unit at Existing Span over I-4 East, Florida

On January 9, 2006 the outside lane of I-4 East was closed at 10 p.m. until midnight to position the second 6-axle SPMT unit into position under the other end of the span. At midnight, a 20-minute rolling roadblock began. A cross-frame connecting the two SPMT units was attached and the span was removed, as shown in Fig. 3. The span was moved a short distance down I-4 East to an adjacent site off the traffic lanes on the right; the site is visible in the background on Fig. 2.

The process was repeated two nights later for removal of the existing span over I-4 West. Its removal required two rolling roadblocks. A rolling roadblock on I-4 West provided the time required for the SPMTs to lift the span off its supports, move it slightly west on I-4 West, and then perpendicularly into the median. At that point a rolling roadblock on I-4 East began. The span was then moved perpendicularly onto I-4 East, and the I-4 West traffic was opened while the span was moved down I-4 East to the demolition site. Less than an hour was required from the start of the first rolling roadblock until the span arrived at the demolition site.

Fig. 3 Removal of Existing Span over I-4 East, Florida

Removal of the existing spans required three rolling roadblocks of less than a half hour each, and less than 48 hours was needed to demolish each span at the adjacent site and remove the rubble. Conventional demolition would have required 12 nights of lane closures and 6 rolling roadblocks for beam picks.

SPAN INSTALLATIONS

From January to June 2006, the new spans were being built 5 ft off the ground on temporary supports at the adjacent demolition site while I-4 was being widened and the abutments and interior bent were being built onsite. This concurrent construction saved 4 months of onsite construction time.

Several days before the scheduled move, the span to go over I-4 West was raised to its setting height at the staging area. Each end of the new span was supported by a set of four 6-axle SPMT units, four times the number of units required for removal of the smaller previous spans. The SPMTs were driven under the span, the SPMT hydraulic system lifted the span approximately 2 ft off its temporary supports, cribbing to the new height was placed on the temporary supports, and the SPMT hydraulic system lowered the span back onto the temporary supports. The SPMTs were then driven from under the spans, cribbing was placed on the SPMTs, the SPMTs were driven back under the span, and the lifting process was repeated until adequate clearance was available for the self-climbing jacks to sit on the temporary supports under the beams to incrementally lift the span to its setting height. The contractor had sectional barges on site for other purposes and decided to set them on the SPMT units to support the span at its setting height instead of the planned cribbing, after analysis ensured adequate barge strength. Figure 4 shows the sectional barges supporting the span during its installation.

On June 3, a Saturday night, both directions of I-4 were closed shortly before midnight. In about half an hour the SPMTs carried the span along I-4 to the bridge site, straddling both directions of I-4 before moving over to the I-4 West lanes for the installation. Proper alignment of the beams onto the bearing seats took approximately 2 hours.

Fig. 4 Installation of Graves Avenue Span over I-4 West, Florida

The process was repeated the following Saturday night for installation of the new span over I-4 East, with only an inch clearance at each end. The SPMTs again moved the new span to its final location in about half an hour, with proper alignment of the beams and neoprene pads on the bearing seats taking approximately 1.5 hours. Figure 5 shows the span as it approaches the bridge substructure.

No cracking was observed in the spans following their installation. A 5-ft length of deck on each side of the interior support was cast after the spans were installed to facilitate their installation; the cast-in-place closure pour provided a continuous deck with good rideability across the support.

COSTS

The supplemental agreement for a change order to incorporate the use of SPMTs into the existing project cost approximately $570,000; of this amount, approximately 60% went to the SPMT subcontractor. The Graves Avenue detour was reduced from 12 months to 8 months, for a delay-related user cost savings of $2.2M. Lane closures on I-4 were reduced from 32 nights to 4 nights, with an approximate $47,000 user cost savings. Using this technology, FDOT obtained a new 2-span bridge over I-4 four months sooner and with only hours of impact to Interstate traffic. They plan similar projects in the future.

Fig. 5 Installation of Graves Avenue Span over I-4 East, Florida

I-10 BRIDGE SPAN REMOVALS AND INSTALLATIONS OVER LA 35

Interstate highways are the lifeblood of the nation's economy. They provide the means for goods and services to be efficiently transported to locations across the country. If damaged, they must be quickly repaired. The LaDOTD faced the challenge of quickly replacing two spans on I-10 when in September 2005 an over-height load traveling under I-10 hit and damaged both the I-10 East and I-10 West bridges over LA 35 at Rayne, near Lafayette.

The damaged I-10 bridges were evaluated following the accident and found to require emergency replacement. LA 35 was partially closed and the I-10 bridges shored while spans identical to the damaged ones were fabricated adjacent to the site. Use of SPMTs to remove the damaged spans and install the new spans was chosen to minimize the closure time of both I-10 and LA 35. This project became the first use of SPMTs to replace damaged spans on an Interstate bridge.

SPAN REMOVALS AND INSTALLATIONS

On January 24, 2006 the I-10 East bridge was closed and traffic detoured via an off-ramp onto a service road before the bridge and then an on-ramp back onto I-10 after the bridge. Two sets of 6-axle SPMT units were waiting to lift the existing I-10 East span, and another two sets of 6-axle SPMT units were loaded with the new I-10 East span. The temporary shoring was removed from under the existing span. The two SPMT units then moved under the bridge, lifted the damaged span, moved it away from the bridge, rotated it before crossing the median to a nearby demolition site. As soon as the existing bridge was out of the way, the new span was moved into position, as shown in Fig. 6. The entire process from moving in the SPMTs to remove the damaged span to setting of the new span took approximately 30 minutes.

Fig. 6 Installation of New I-10 East Span, Louisiana

The process was repeated two nights later for removal of the damaged I-10 West span and installation of the new I-10 West span. For each night, the maximum time of I-10 traffic detour was 10 hours, and the detour time could have been further reduced by doing more of the preparatory work before the closure.

COSTS

The emergency replacement of the two spans cost $1.0M, including materials, equipment, subcontractors, labor, and state police services. The SPMT subcontractor cost was approximately 13% of the total cost. Using this technology, the LaDOTD was able to replace the damaged I-10 spans with only hours of impact to Interstate traffic. They will consider the use of this technology for future projects that require short closure windows.

MANUAL FOR USE OF SPMTS TO MOVE BRIDGES

A manual is being written to document the critical activities required to effectively use SPMTs to remove and install bridges, as briefly delineated in this section. The manual will include project selection criteria and a description of the equipment. Also included will be a discussion of benefits and costs, considerations during planning and design, contracting issues, and specification requirements. A section on lessons learned will be included, as will case studies including the two projects discussed in this paper.

SPMTs are multi-axle computer-controlled platform trailers that have the capability of moving in any horizontal direction with equal axle loads while maintaining a horizontal load without distortion of the load[3]. A single SPMT has either four or six axle lines; each axle line has two pairs of wheels. The computerized steering capability allows movement in any direction: straight forward and backward, transversely, diagonally, and at any angle as well as carousel steering. Loads transported on SPMTs have been as heavy as 3,600 tons.

Not every project is appropriate for the use of SPMTs to move bridges. A decision-making framework is available on the FHWA website to assist owners in determining whether prefabricated bridges will provide benefit for their specific project[4]. This framework in combination with analysis of delay-related user costs and the use of the upcoming manual should provide the guidance that the bridge owner needs to determine whether the use of SPMTs will provide benefit relative to the cost of using this technology. While the use of this equipment may be perceived as increasing initial construction costs because of the mobilization costs of getting the equipment to the site and setting it up, substantial offsetting savings can be obtained from the drastic reduction in costs for maintenance of traffic and detours because of the much-shortened onsite construction time. When combined with the reduction in delay-related user costs, the use of this technology can be the most economical.

Proper planning and coordination is essential for successful projects that use SPMTs to move bridges. For example, a staging area and right-of-way must be available to build the bridge near site and move it to its final location. Adequate ground pressure and/or use of steel plates is required along the path to resist the heavy loads. Design considerations include whether the bridge should be built as a single span or multiple spans, and allowable temporary lift points and stresses and deflections. Contracting issues include providing an achievable construction scheme and allowing the contractor to innovate, and specifying SPMT subcontractor qualifications. Specifications should include temporary support requirements and SPMT capabilities.

Multiple SPMT suppliers are now available in the U.S. for projects that require competitive bidding, and they have engineering departments that can develop detailed moving plans. For bridge moves with SPMTs in the U.S. to date, the SPMT supplier has typically been a subcontractor to the contractor. The SPMT supplier is given the bridge dimensions and weight, the face-to-face distances between obstacles, and the staging area location. The SPMT supplier handles the details related to the actual move, including lift points and other engineering, site surveys, crew and equipment scheduling, equipment assembly operations, and transport route.

CONCLUSIONS

The use of SPMTs to move bridges was the top implementation recommendation from the 2004 AASHTO/FHWA/NCHRP International Scan on Prefabricated Bridge Elements and Systems. Their use offers the least possible traffic disruption for bridge replacement projects, with removals and installations possible in just minutes. With proper planning and coordination of all required activities, the total detour time during these replacements can be limited to a few hours or less.

This year FDOT and LaDOTD proved the efficiency and time savings that can be achieved with the use of SPMTs to move bridge spans crossing the Interstate and on the Interstate, respectively. Significant reduction in Interstate traffic disruption and improvement in work-zone safety were achieved. A manual will soon be available from FHWA to assist bridge owners in achieving successful projects such as those described in this paper.

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