ABC-UTC May 2023 Monthly Webinar: ABC of Detroit’s Network Tied Arch using SPMTs		
#	**Questions**	**Responses**
	Pre-Webinar Questions	
1	Could you spend some time talking about the transfer from the first SPMT to the second one? Is there good video of the transfer?	The handoff was shown during the two-minute timelapse that is available online. (See link in this Archive.)
2	Are there other design examples where SPMTs were used to move a network arch?	Yes, there are a handful examples where SPMTs are used in conjunction with barges to float an arch span into place and lift the bridge into place. One of the biggest benefits of a tied arch span is the ability to assemble it offsite and move it into place in a safe and controlled fashion. As far as we know, this is the first time a bridge has been moved like this in a grade-separation situation. If there are others, I would be interested to learn more about them. Prior to joining HDR, I worked on a tied arch move in Manama, Bahrain that featured a 120-meter tied arch span, but there was no elevation difference between the staging area and the abutments. The SPMTs were set up to simply straddle the top of the abutments and lower the span into place.
3	Can you comment on the stability during the move?	The tied arch span and temporary works system were checked for stability at all stages during the erection engineering process. Note that the temporary bracing of the arch ribs remained in place until after the move and after the bridge was lowered onto the permanent bearings.
4	What types of monitoring (if any) were used during the bridge move?	The monitoring was covered in the presentation. The erection engineer was required to monitor the bridge during the move (total station and crossed wires). In addition, Western Michigan University installed a variety of sensors throughout the bridge to monitor the performance long-term. Dr. Upul Attanayake will be publishing a series of papers in the future on this.

5	Were any proprietary materials used in this bridge such as high performance steel/concrete/coatings/etc.?	The final concrete mix design was used in the tie girder, end diaphragm and knuckle. This concrete was not truly self-consolidating concrete, but was made quite flowable through the use of admixtures. As such, the concrete was not proprietary but was a special design mix.
6	What were the deflection and twist limits imposed on the move? How were they developed?	We limited the maximum deflection of any one corner of the bridge to three inches, and we had a hold point established if the movement reached two inches at any time. Basically each time the SPMTs stopped moving, the survey team would take a series of elevation shots of the four corners of the bridge and adjust the hydraulic jacks as needed to return the bridge skeleton to the correct plane. The bridge could likely withstand more warping than the three-inch limit, but we wanted to be very conservative and not allow any problems to get started. The crossed wires mentioned in the presentation are as simple and effective in terms of real-time monitoring during a bridge move. The trickiest part of the warping issue was not when the bridge was on the SPMTs, but when the bridge was being slid onto the abutments on both ends of the move.
7	What were the owner's MOT (Maintenance of Traffic) requirements?	I-94 was closed for seven days during the bridge move and again for a few days during the stressing of tie girder post-tensioning (stage 2) and the hanger adjustments. When we started the design, MDOT was hopeful to achieve as short a closure time as possible, but we wanted to ensure that time pressure was not driving the need to rush the process.
	Questions during Webinar	
8	Were the arch ribs shop assembled in laydown condition to ensure fit / geometry across the splices?	Yes, each arch rib was fully assembled in the shop. This assembly was done with the rib in a horizontal position.
9	Did you consider a steel truss-type bridge?	We did not look at a truss bridge for this location. MDOT and the designer did not think that a truss-type bridge would provide the signature look for this location.

10	Were there any issues with driving the SPMTs over any underground utilities?	A buried water line was located in the bridge staging area, and our geotechnical engineer was consulted regarding the loading of SPMTs. The ground pressure beneath the wheels of the SPMTs is actually less than that of an 18-wheel truck, so the utilities were not adversely affected by the loading.
11	Was there any interaction between this project and engineering students at Wayne State University?	Yes, we contacted Dr. Fatmir Menkulasi at Wayne State University during the design stage and met with his bridge engineering students for guest lectures and site visits. Furthermore, Dr. Upul Attanayake at Western Michigan University used this bridge project as a capstone project for his senior civil engineering students. MDOT and HDR served as mentors for the student groups.
12	What is the compressive strength of the wood supports?	The azobe (or ekki) wood that was used has as compressive strength of over 16 ksi.
13	In regard to the arch transverse beams, we see them during placement of the tied-arch bridge on site, and then at the service stage of the project. Did you remove these arch transverse beams that serve as wind bracing, or did you keep them on the completed bridge?	The contractor used temporary lateral bracing between the arch ribs during the assembly in the staging area. These remained in place for the bridge until after the bridge was lowered onto the permament bearings and the deck concrete was cast.
14	Since the arches will work in compression, what governed their dimensions? Was it the forces (moment and shear), or the instability induced by buckling of the arch?	We looked at a variety of conditions for the arch ribs, both during construction and in-service. The controlling condition of the original design was neither buckling nor in-service forces. Instead, it was the demand on the arch rib created by the assumed loading during that "hand bag" configuration with the SPMTs positioned more than 40 feet inboard from each end of the span. That assumed loading case was picked because it would allow any of the heavy lift firms to perform the construction. After the contractor was selected, their SPMT supplier had specialized equipment available that didn't require the handbag stage of lifting and moving the bridge. That was the reason for my comment about using CM/GC (Construction Manager / General Contractor) or PDB (Progressive Design-Build) contracting would have been beneficial for this project.

15	One of the common issues observed for tied arch bridges is the connection between the arch and the hangers. Did you check the fatigue of these connections?	Yes, the hangers (and their connections to the rib) were checked for fatigue during design. The internal hanger connections inside the rib are designed to be co-linear with the hanger line of action, so the hanger itself does not experience any flexure.
16	Could you tell us more about the arch rib weld detail at the four corners of the trapezoidal box? Was it four Complete Joint Penetration (CJP) groove welds, or two fillet welds with two CJP groove welds, or something else?	The welds from the web to bottom flange are double-sided fillet welds. The connection from the web to the top flange was made completely from the outside of the rib section (after the internal hanger connections were installed), and they are CJP (Complete Joint Penetration) groove welds.
17	What was the total cost, and cost per square foot for the bridge?	The construction cost of the bridge was about $26M or about $1100 per square foot.
18	Is the inside of the box accessible for future inspection?	The interior of the arch rib is not accessible for inspection due to the internal hanger connection diaphragms. The space inside the rib is large enough for a human inspector to walk or crawl, but there is not room to pass over the diaphragms. There are access ports along the length of the arch rib for a camera or borescope inspection. It would also be possible to insert a borescope through the slots at each hanger connection.
19	The bridge deck seems very wide. Did you observe exceptionally high torsional moment in the tie girder during design? If so, what special design details were utilized to accommodate this?	The most challenging part of the tie girder design was the transition region between the knuckle and the prismatic tie girder section. We evaluated a number of post-tensioning and deck casting sequences to ensure that we would not create an unmanageable stress condition. The tie girder post-tensioning was completed in stages to manage these stresses: one tendon after the arch rib was erected, five tendons after the skeleton and hangers were installed, and the final six tendons after the bridge move and deck casting was complete. The tie girder does not carry a lot of torsion from the floorbeam loads. The hanger connection picks up those loads at the end of the floorbeam and transfers them to the arch rib. The tie girder itself is more of a stiffening element for the ends of the floorbeams and, of course, carries the tension component in the post-tensioned tendons.

20	At what level(s) of plan development were the peer reviews conducted?	The independent peer review team was brought on at about the 60-70% design stage. That team remained part of the project throughout the remainder of the design, the bridge erection engineering work, and the construction as well. They had staff onsite during the bridge move and participated in all of those decisions as well.
21	The tie beams for this project consist of post-tensioned concrete sections. Why did you opt for concrete instead of steel sections?	The post-tensioned concrete tie girders were chosen at the very beginning of the project. MDOT wanted a strucure that was internally redundant.