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Accelerated construction technique: Moving entire bridge using Self Propelled Modular Transport (SPMT) Tamiami Canal Bridge Replacement

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MARRIOTT'S RENAISSANCE HOTEL AT SEAWORLD
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Figure-1: Bridge on SPMT at Junction of NW 27th Ave. & NW 14th Street

ABSTRACT

The technical paper and presentation reviews recent work completed by contractor Archer Western and their team on moving the historic Tamiami Canal bridge to its new location to preserve the history. This historic bridge is a bob-tailed, Warren pony truss swing bridge type and only a handful of this left in the United States.

The owner (Miami- Dade County and Florida Department of Transportation) awarded the contract to Archer Western to build new Tamiami Canal bridge to replace the aging existing swing bridge. As a part of this contract, old bridge with its historic significant required to be dismantled piece by piece and reassemble at a nearby park which was 1.4 miles away from the bridge. Instead of using this piecemeal

method, the contractor Archer Western decided to move complete bridge in its entirety to save time and keeping the history virtually untouched.

The author will attempt in this paper to explain various areas of this method like: -

- Why the contractor chooses this method?
- Various technical aspect of the entire operation.
- What were various hurdles and how those have been resolved during the planning process?
- The benefit of this method to all stakeholders.
- Lesson learned for future.

INTRODUCTION

In December 2015, Archer Western was awarded the contract for the replacement of the existing Tamiami Canal Swing Bridge in Miami, Florida, USA. As a part of the contract, the existing swing bridge needs to be relocated to nearby parks where it will be used as "Fixed Pedestrian" bridge joining Fern Isle Park and newly planned Miami Police Benevolent Association (PBA) Park. Although the bridge will be used as a "Fixed bridge" all the existing machinery and superstructure of the bridge in its entirety need to be installed to show bridge's history. The substructure of this bridge was planned to be newly built to Support this historic bridge.

Constructed in 1921, the Tamiami Canal Swing Bridge originally crossed the Miami River at NW 27th Avenue. In 1938, the bridge was dismantled, stored and replaced with a wider bridge that could carry increased vehicular traffic. Two years later, the bridge was taken out of storage, reduced in length, and put back together at the NW South River Drive and Tamiami Canal. The swing bridge remained at the Tamiami Canal crossing from 1940 until it was relocated to a new site in 2016. As a bob-tailed, Warren Pony Truss Swing Bridge, the Tamiami Canal Swing Bridge is a rare bridge type and is one of the oldest Bridges on the Miami River system.

The Tamiami Canal Swing Bridge is a movable bridge that rotates or "swings" open on a pivot pier to allow boats that cannot pass under the Bridge to proceed through the channel. This bridge is a bob-tailed swing bridge, as the pivot pier is off-center. The weights on the bob-tail balance the bridge on the pivot pier, making it easy to turn. The gears attached to the Bridge are called Pinions. The large gear that rests on the pivot pier is called the Rack. The Pinions are turned manually or by motors against the Rack to rotate the bridge open or closed. The Bridge is designed as a Warren Pony Truss consisting of beams that form triangles along its length.

METHOD SELECTION

Archer Western evaluated various methods to accomplish moving this historic bridge to its new location. All methods were evaluated based on their merits and constructability aspects before finalizing to use Self-Propelled Modular Transport (SPMT). The following methods were considered:

1) **Dismantle Bridge in small pieces (Original Concept Approach):** Bid documents suggested this method to accomplish this work. Under this method, the bridge needed to be supported temporaril and dismantled into a smaller manageable piece. These pieces would be transported to a temporary location to be painted and then relocated to the new site where it would be reassembled again using temporary supports.

Advantages:

- Easiest method on paper to execute.
- Easy to bid due to cost history.
- Least amount of engineering risk.

Disadvantages:

- Require the longest duration for work. This work was in the critical path of the project.
- Temporary support work would affect the marine traffic.
- Engineering challenges to support the partial structure during the demolition process.
- Picking of the concrete counterweight required heavy hoisting and transportation.
- Required marine equipment which adds significant cost to the operation.

2) **Dismantle Bridge in two or three big pieces:** As method-1 had the challenge of removing and moving concrete counterweight, this method was evaluated for its merit. In this method, the bridge was planned to cut in two or three big heavy pieces and lifted with heavy machinery and transported to the new site to be reassembled. This method still had most of the similar advantages and disadvantage as method-1.

Advantages:

- Faster than method-1.

Disadvantages:

- Temporary support work would affect the marine traffic.
- Engineering challenges to support the partial structure during the demolition process.
- Picking of the concrete counterweight required heavy hoisting and transportation.
- Transportation of these big pieces safely (stability of pieces).
- Required marine equipment which adds significant cost to the operation.

3) **Slide the entire bridge onto a barge and move bridge by water:** In this method, the bridge would slide on to barge(s) in its entirety and be moved to its new location, and slide back to a newly constructed pier in its entirety. This method has some advantages over SPMT method. This method was abandoned due to a fatal flaw at the new site the water stream was very narrow and shallow to float the barge(s).

Advantages:

- As fast as the SPMT method (Method- 4).
- Easy to bid due to known cost history and fewer unknowns (utility, permit, route restrictions etc.)
- No temporary support required, reducing impacts to marine traffic significantly.
- Risk of cost overrun is lesser than method-4.

Disadvantages:

- Required marine equipment which adds significant cost to the operation.
- Bridge painting would be performed over water adding environmental challenges.

4) **Slide the entire bridge onto a SPMT and move bridge over the road:** In this method, the bridge is slide on to Self- Propelled Modular Transport (SPMT) and moved through city and state roads to its final site. This method was selected due to a faster speed of construction and more manageable risk profile than other methods.

Advantages:

- Faster than method-1 and 2.
- No temporary support required, reducing impacts to marine traffic significantly.
- No marine equipment needed.

Disadvantages:

- Hard to bid due to the soft cost of moving bridge through a heavily urbanized environment (utility, permit, route restrictions, etc.)
- Risk of cost overrun was the greatest out of all methods.
- The most number of stakeholders' co-ordination required
- Co-ordinate and convince all stake-holder for viability and success of this operation.

PLANING

As soon as Archer Western was awarded the contract, we started working on this operation as this operation needed to be done as soon as possible to make the room to construct the new bridge. Following subcontractors were selected to assist Archer Western in completing this operation:

- Mammoet USA South, Inc- Rosharon, TX- Slide and Move bridge using SPMT.
- Seacoast Inc- Tampa, FL.- Remove and reattach machinery components of the bridge.
- Solares Inc.- Miami, FL- Remove electrical components from the bridge.

A complete marine closure was requested from 3/30/16 to 4/3/16. This was necessary because the bridge needed to be slide out of the channel in the closed position and once all electrical and mechanical component removed, the bridge was not operable until it is completely removed from waterways. The bridge was planned to move by road on 4/3/16 (Sunday) early morning to its final site. The move was decided to be carried out in the morning due to safety reasons (reduced traffic, better visibility etc.) as well as some of the traffic signals needed to be disabled to pass this bridge through.

Utility obstruction and co-ordination was large risk item during the bid process. There was not enough time to do a complete survey of the route, and the route itself was unknown pending approval from FDOT. Archer Western considered multiple routes after the award of the contract and once the route was finalized and approved by FDOT, Archer Western completed a survey of utility obstructions on the highly urbanized route.

Figure-2: Bridge Move – Complete Route

Multiple surveys were made along the planned route to determine heights and widths clearances for the bridge. Twenty (20) utilities were identified in the route to be problem area to have the bridge travel through a clear and safe trail. These utilities belong to various stakeholders, and individual meetings were held with each stakeholder to decide the best time to temporarily relocate the utility. Most of the utilities were temporarily relocated before the closure time, but certain utilities were temporarily relocated night before the move to reduce the effect of the relocation. Moreover, a representative from each utility with major obstructions was present the day of the bridge move to aid in any unforeseen problem.

The Archer Western team had several meetings reviewing all components of the bridge move, such as: equipment, material, deliveries, maintenance of traffic, subcontractors, crews, utility issues and miscellaneous tasks.

These components were then organized into the days that they would be needed and furthermore down to the hour they would be used in a micro-schedule. Once the micro-schedule was established by the Archer Western team, we communicated our plan with all subcontractors and developed a final and detailed schedule. Scheduling was a vital part to make sure this operation was completed safely and within given time frame.

The final coordination meeting included all the parties involved in the bridge move. Representatives from the following organizations were present: Unites States Coast Guard, City of Miami, Miami-Dade County, Florida Department of Transportation, Utility Owners, City of Miami Police Department, Pinnacle Consulting, Hardesty and Handover, Mammoet USA, Solares Electrical Services, and Seacoast Inc.

The micro-schedule was reviewed chronologically so that it would be known where everyone would be and what tasks would be completed. Any questions anyone had about the schedule or any part of the move were answered. Finally, all the precautions were communicated and further developed, such as:

- Back up plans for various tasks on the schedule.
- Competent contact person for each department involved.
- Emergency congregation point.
- Further review of all standards from all departments involved.

This meeting allowed for any discrepancies to be cleared at any point of the scheduling process and left everyone involved confident for the much anticipated Historic Tamiami Canal Bridge move.

Because the bridge move occurred in a heavily populated area, much attention was given to keeping the public distance from the bridge and the workers. Plenty of notification was given to the public through marine radio, VMS signs, certified letter, flyers, and posters.

WHAT IS SPMT?

Self-Propelled Modular Transporters consist of different modules with multiple axle lines. Each module can be fitted with its own engine and control (steering) system. The modules can be connected side-by-side and/or head-to-tail, to form large ‘platforms on wheels’. SPMT’s have the possibility of 360 degree steering of the wheels. This allows carrousel and sideway movements. Their deck height can hydraulically be adjusted by enabling vertical lifting or lowering of the load. Due to their variety of combinations, SPMTs can lift and move virtually every heavy load. These trailers are mainly used for on-site transportation over limited distances.[1]

[1] www.mammoet.com

EQUIPMENT SPECIFICATIONS

- **Self- Propelled Hydraulic Platform Trailer (SPMT)**

Type:	Goldhofer THP-SL.
Length:	Distance between axle lines longitudinally 1.5 meters
Width:	Width overall 3.00 meters (when in normal driving mode)
Height:	1.175 meters transport height plus/minus 30 cm
Self-Weight:	Average 3.5 Te per axle line

- **Hydraulic Jack 150 Te**

Type:	Climbing Jack- Double Action 150 Te
Length:	1’10-13/16”
Width:	1’10-13/16”
Height:	1’6-7/16”
Self-Weight:	540 kg
Stroke:	129 mm
Pressure:	250 bars

- **Hydraulic Jack 250 Te**

Type:	Climbing Jack- Double Action 250 Te
Length:	2’-6”
Width:	2’-6”
Height:	20”
Self-Weight:	626 kg
Stroke:	130 mm
Pressure:	400 bars

- **Slide Equipment**

Type:	Push/Pull Cylinder	
Components:	Cylinder:	
	Lock:	Supplied with Cylinder
	Shoe:	Varies
	Skid Beam:	Length Varies

MATERIAL LIST

NUMBER	QTY	DESCRIPTION	DIMENSIONS	WEIGHT (EACH) (IN LBS.)
1	7	Boxes Hardwood	100 Pcs. /Box	
2	4	Climbing Jack 150 Ton	1'10"X1'10"X1'6"	1170
3	8	Crane Mat 20'	20'X4'X1'	5240
4	6	Crane Mat 24'	24'X4'X1'	6302
5	2	Skid Shoe L= 12'	12'X1'6-1/8"X8-11/16"	1058
6	6	USA Skid Track 40'	40'4"X1'4"X9"	3680
7	6	Support Cylinder 4'	4'X 3'4"X4'	2100
8	2	USA Skid Shoe 3'	3'X1'6"X9"	178
9	2	Load spreader 40'	40'X4'X1'	10400
10	1	30 Ton Ballast		
11	2	Skid track cylinder short		
12	2	Skid track lock		
13	2	Climbing Jack 250 Ton	2'6"X2'6"X1'8"	1380
14	2	Load spreader 15'	15'X4'X6"	3400
15	2	Load spreader 17'	17'X4'X12"	4712
16	1	Misc. Shim Box		
17	1	Misc. Hardwood Cribbing		

PROCEDURE

1) Area underneath the bridge where the jacking location was established was compacted and prepared.
2) Once the marine closure started, the bridge electrical system was removed. Mechanical components were detached from the bridge to allow for bridge lifting. Machinery was left on the pier until the bridge was removed due to the accessibility of machinery by crane.
3) Jacking & Skidding system was positioned and installed as shown in Figures-3 & 5. Hydraulic jacks were positioned directly underneath the bridge main beams.

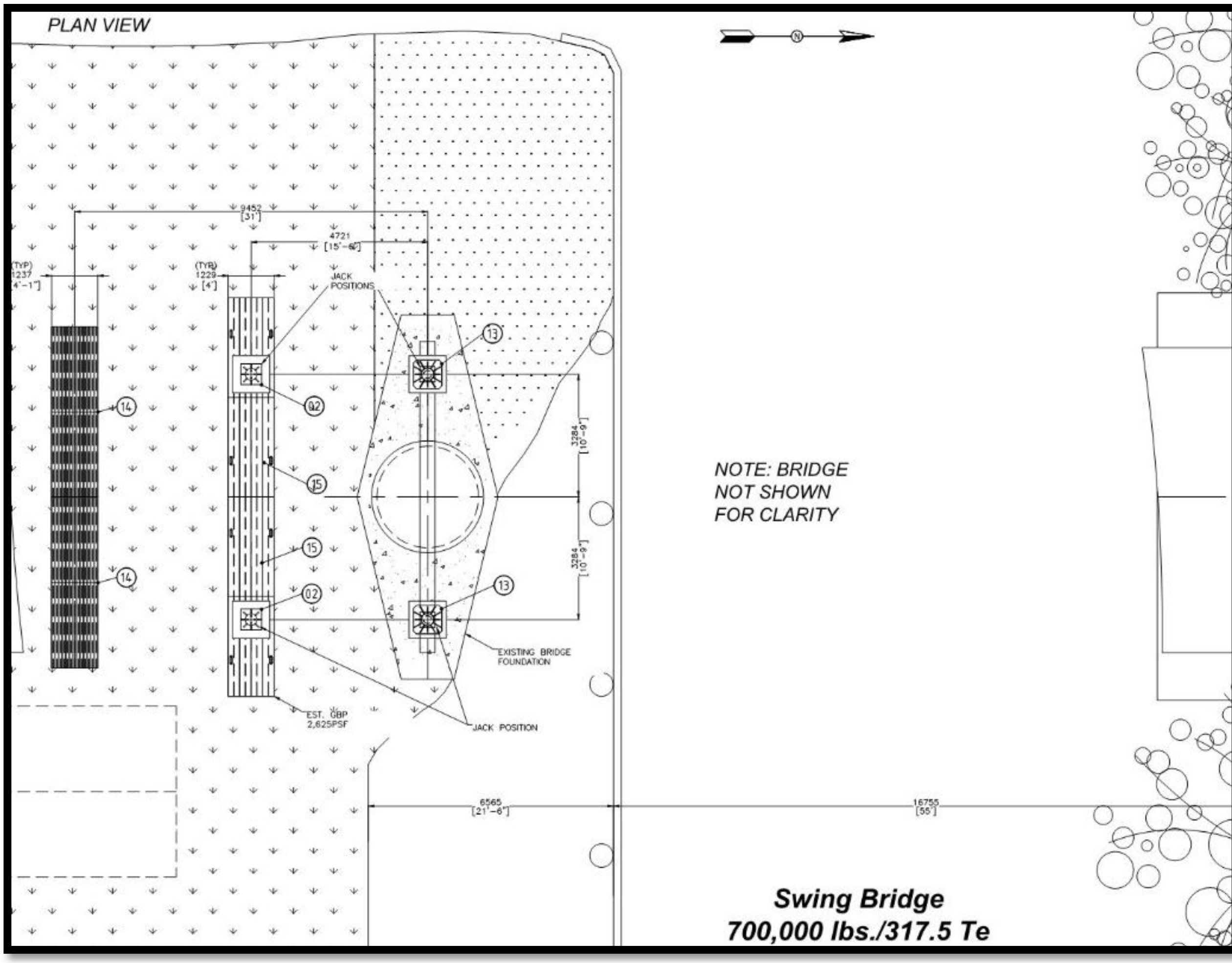
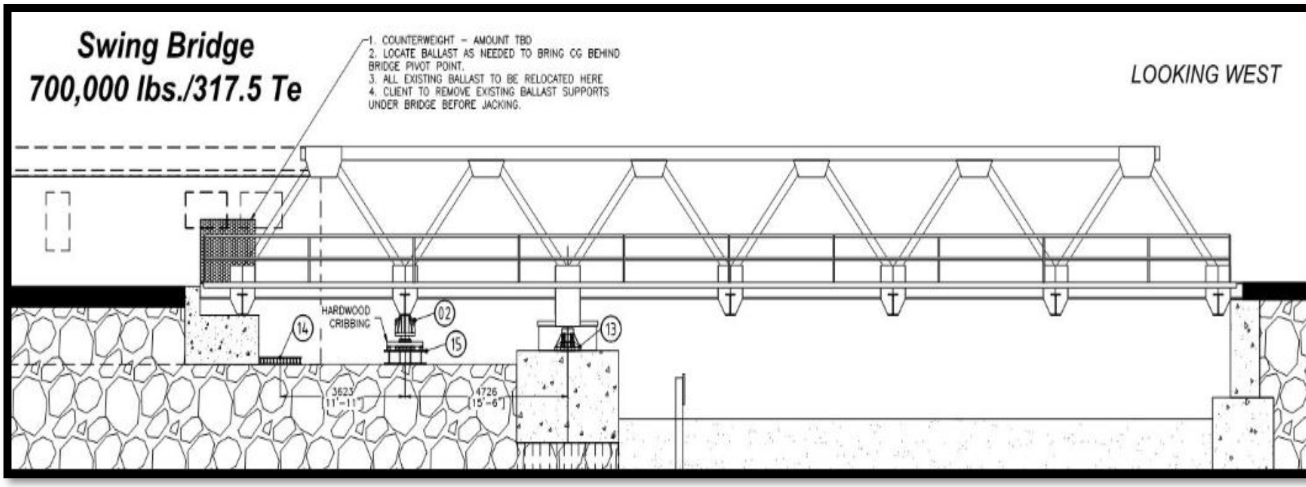


Figure-3: Plan view of Skidding & Jacking Material under the bridge[2]

4) 30 tons of temporary weight was installed on top of the deck so the Center of Gravity of the bridge can be brought behind the pivot point. As this bridge was balanced, this step was necessary for the stability of the jacking and sliding operation (Figure-4). Some additional weight was kept on hand for any required adjustment.

[2] For call out in the drawing, see material list



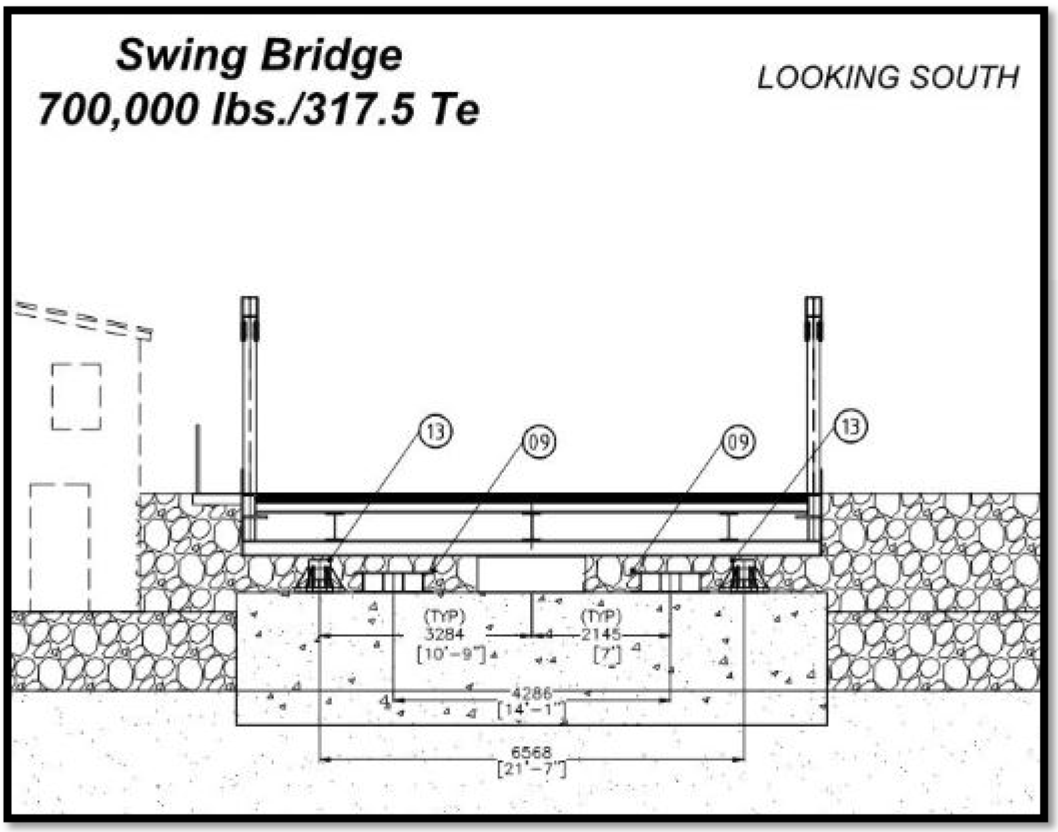


Figure-4: Temporary weight added to bring CG back of pivot pier[3]

[3] For call out in the drawing, see material list

Figure-5: Climbing Jack position underneath the beam and on the Load spreader beam

5) Start jacking up on Bridge and add hardwood blocking as needed (Figures- 6 & 7).

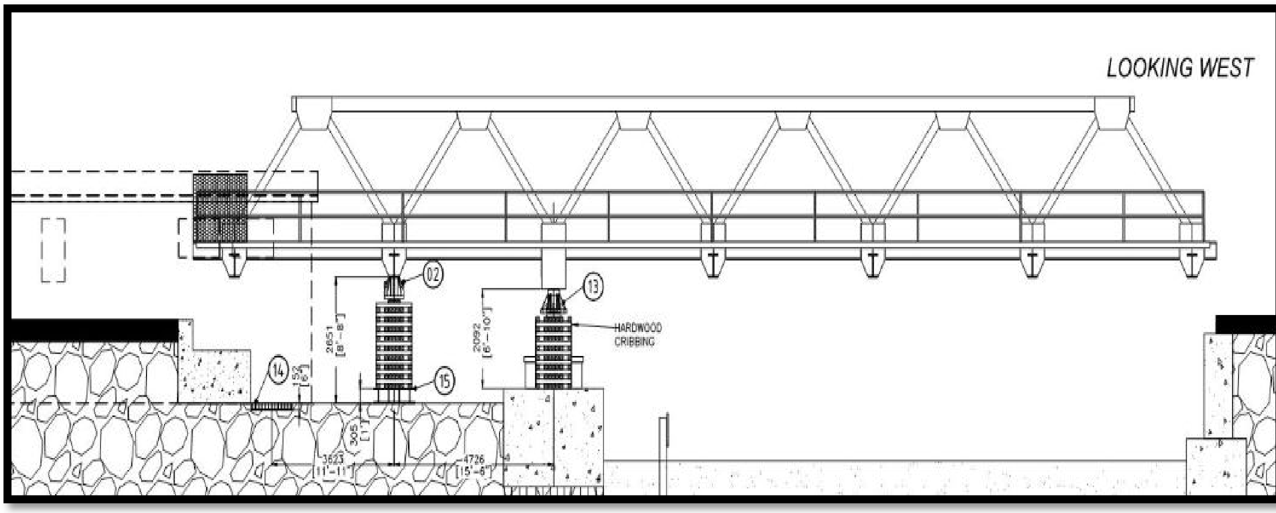


Figure-6: Jacking of the bridge to proper height to clear roadway[4]

Figure-7: Project Photo of Jacked up Bridge

[4] For call out in the drawing, see material list

6) Skidding equipment was placed underneath the bridge and bridge was lowered onto skid-shoes (Figures-8 &9).

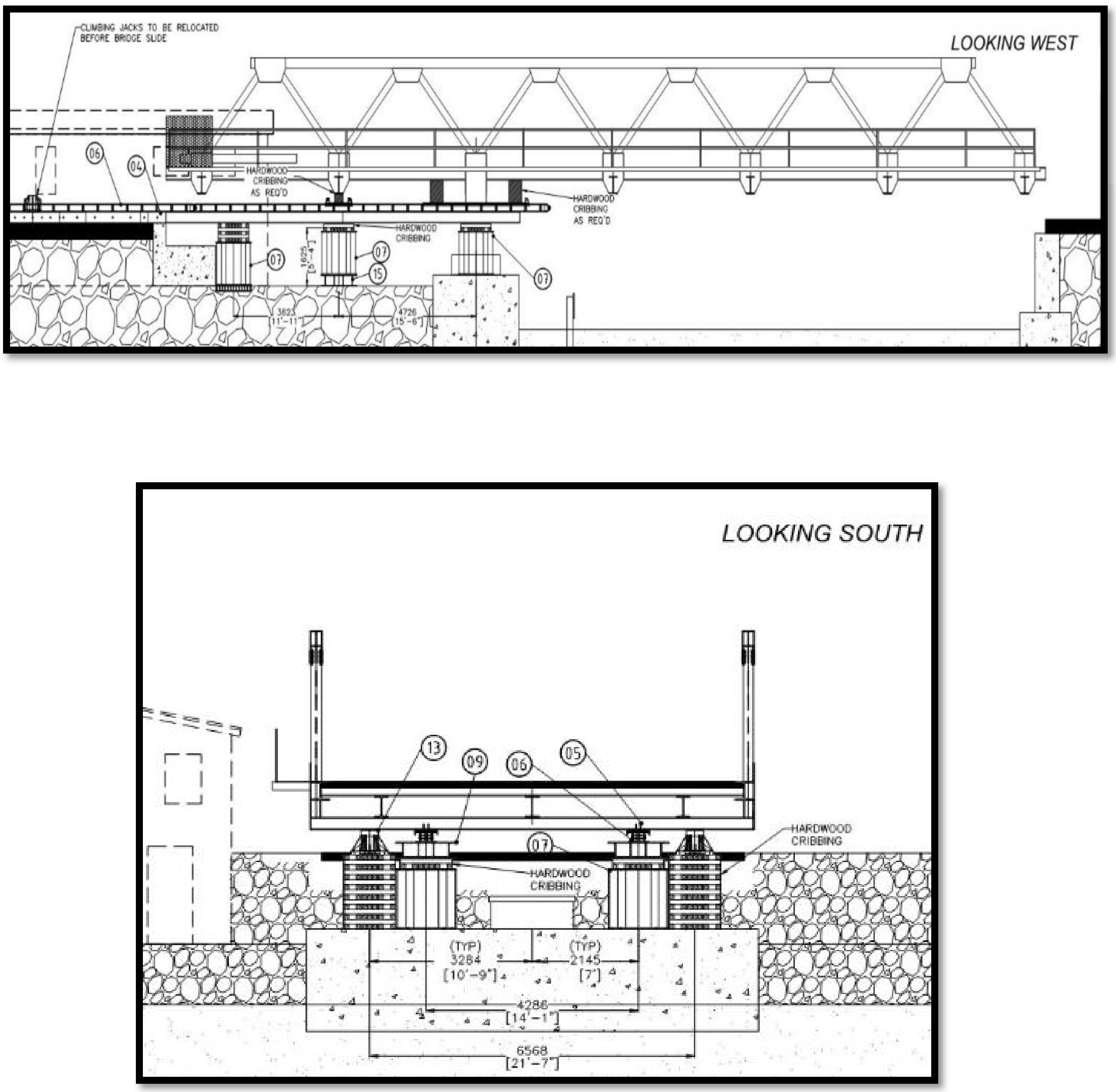


Figure-8: Bridge lowered onto Skid-Shoes[5]

[5] For call out in the drawing, see material list

Figure-9: Project Photo of Skidding System installation

7) Start skidding the bridge using the push-pull units of the sliding system towards the transporter (Figures-10 & 11).

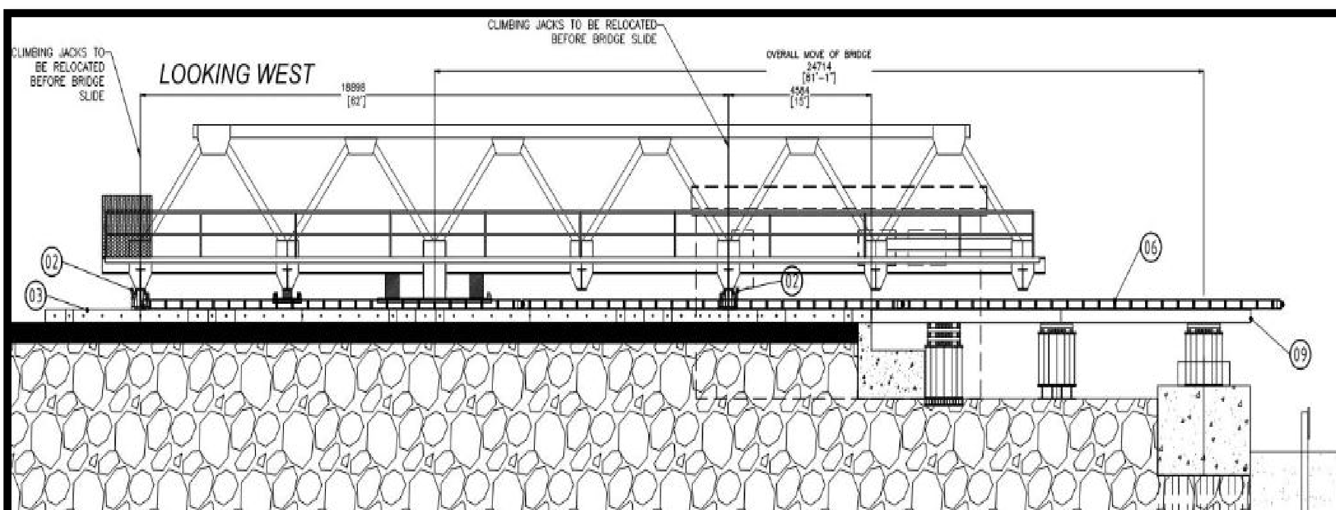


Figure-10: Bridge Skidding Operation[6]

[6] For call out in the drawing, see material list

Figure-11: Project Photo of Bridge Skidding

8) Set jacking system underneath the defined jacking point of the bridge and start jacking bridge using climbing jack to get over the transporter height (Figure-12)

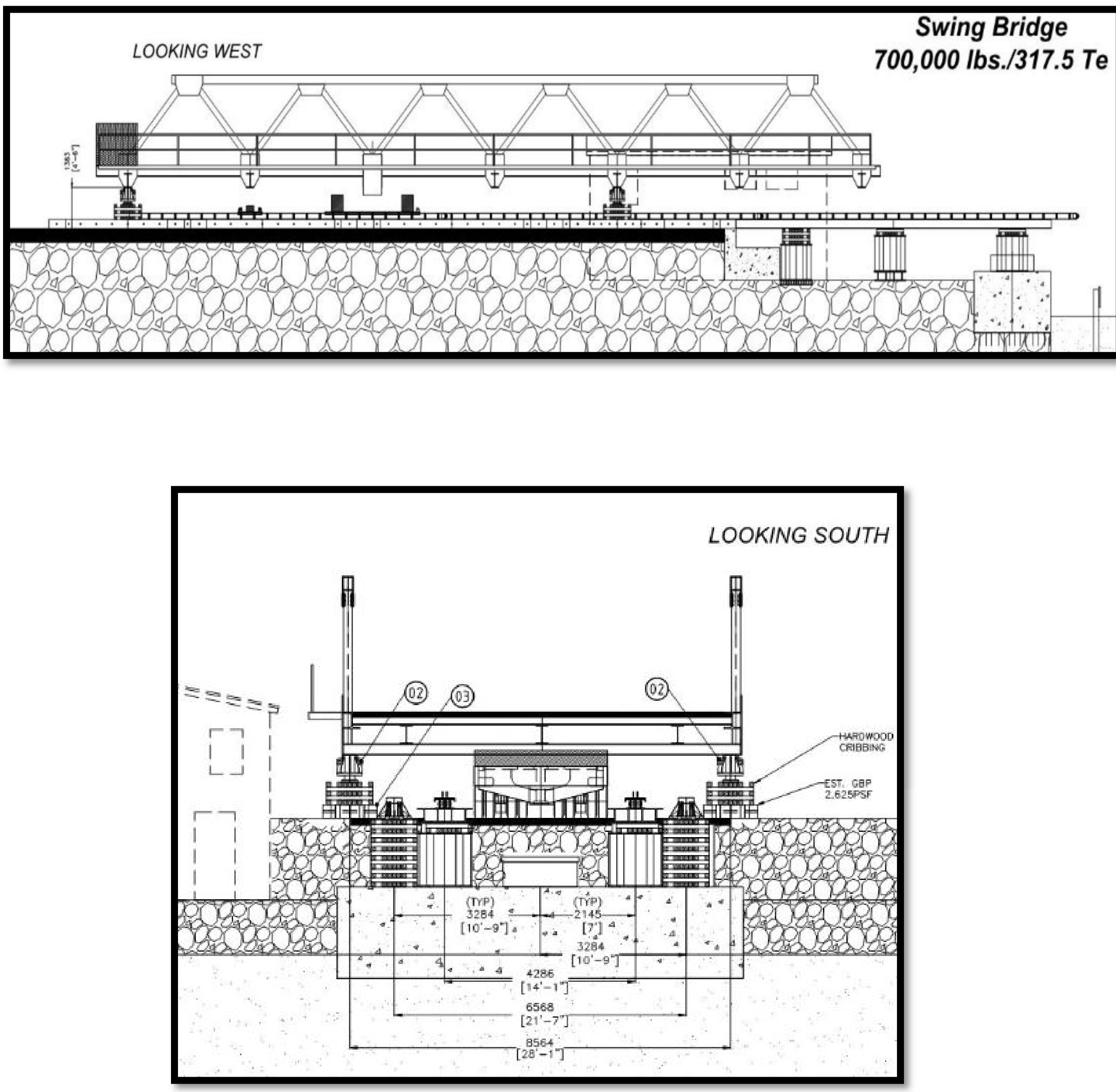


Figure-12: Bridge Jacked to clear the Transporter height[7]

[7] For call out in the drawing, see material list

9) Proper cribbing was placed on the transporter and transporter was slid under the load. Bridge was than lowered on to the transporter (Figure 13)

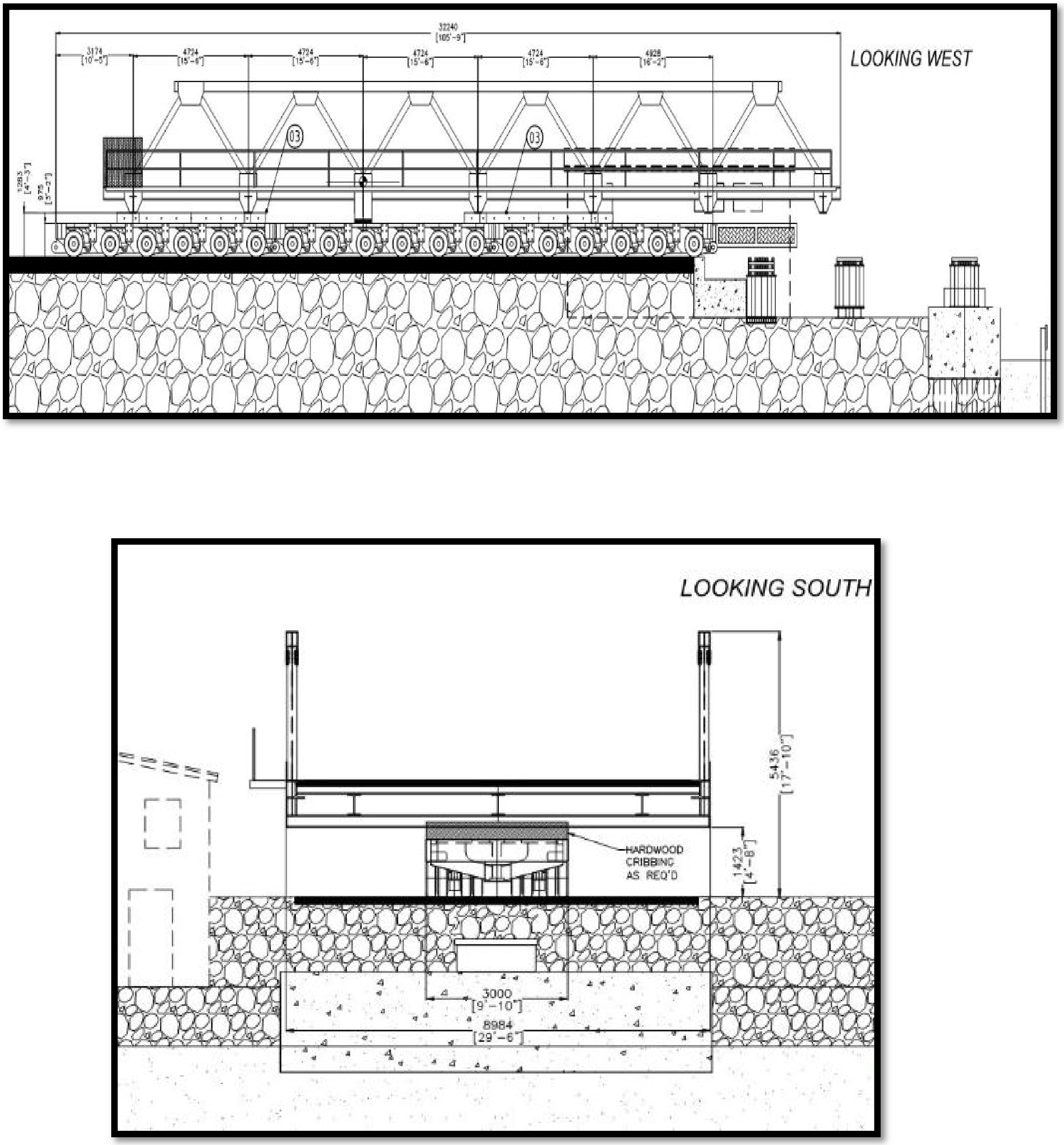


Figure-13: Bridge lowered on to transporter (SPMT)

10) On the day of the move, the bridge was lashed to predetermined places using chains & turnbuckle.
11) The night before moving, final temporary signal relocations were performed at major intersection, so the load could pass underneath the monotube. Law enforcement was used to direct traffic when the signal was non-functioning until the load passed underneath it and the signal was placed back in service.
12) On the day of the move, a safety meeting was held before sunrise and the Maintenance of Traffic plan was reviewed with everyone.
13) A rolling road closure was used during the bridge move along with law enforcement escorts in front and back of the bridge.
14) Utilities were surveyed again ahead of the transporter to confirm sufficient clearance (Figure-14).
15) The bridge was transported on the pre-determined route in less than 4 hours to the new site.

Figure-14: Utility check as bridge goes through streets

16) The bridge was offloaded at the lay down area on stands & beams in preparation for restoration and painting.
17) Once the bridge was restored and painted, a similar procedure was followed in reverse to install the bridge on the newly built sub structure at the new site (Figure-15).

Figure-15: Bridge restored at new location (as pedestrian bridge)

CONCLUSION

There are several factors to consider when selecting the accelerated construction techniques, many of them are site/project specific. Although it offers faster completion of the project, some inherit risk comes with speed and should be considered carefully before selecting this method. Some of the risks are:

- Cost overrun due to soft cost (utility relocation; unknown nature of work etc.)
- Engineering-intensive operation.
- Convincing all the stakeholders the viability & safety of Accelerated Construction.

Although if properly planned and managed, accelerated construction not only can reduce the overall time but can be very cost comparable to conventional construction.

The successful use of accelerated construction on the Tamiami Canal Bridge demonstrated the effectiveness of this technique. Use of this technique not only helped reduced the down time for marine traffic and reduce overall construction time, but it also allowed to move the history virtually untouched.