Existing Bridge Structure and the Truss Lift Monitoring for the Huey P. Long Bridge Widening Project

Thomas WEINMANN, Practice Area Leader- Structural Health Monitoring,
Geocomp Corporation, 1390 Busch Parkway, Buffalo Grove, IL, USA
tweinmann@geocomp.com

Abstract. As an alternative to the stick-build truss widening specified for the Huey P. Long Bridge, the MTI Joint Venture proposed a pre-built truss erection alternative to reduce impact on public, rail and river traffic requiring the lifting of three sets of paired trusses over 500-ft long, weighing more than 2700 tons. A real-time, remote monitoring system was used during the transport, lift and setting operation to limit truss distortion during the lifting and skidding operation.

Introduction

For the three twin-truss heavy lifts performed as part of the Huey P. Long Bridge widening program, a monitoring program was implemented to monitor, in real-time, truss distortions throughout the lifting and skidding operation. Tilt meters and deflection lasers (using an innovative alternative application technique) were hardwired to a data logging system that continuously collected and transmitted data wirelessly to a base station located on the bridge where control of the lifting operation was performed.

Real-time data was continuously provided, allowing the Contractor (MTI JV) and Engineer (HNTB) to make immediate decisions related to adjustments during the lifting operation. The trusses were built on a stability frame near shore and barged to their location under the bridge and lifted into place. Once the trusses were lifted to the proper elevation, trusses were skidded inward 13-ft and set down onto their final position. During the skidding operation where hydraulic jacks were used at six different locations to pull the trusses inward, the monitoring system verified sequential control of the hydraulic jacking operation to prevent truss distortion.

Background

The Huey P. Long Bridge in Jefferson Parish, Louisiana, is a four-span steel truss bridge that carries a two-track railroad line over the Mississippi River with two lanes of US 90 on each side of the central tracks. The bridge carries more than 50,000 vehicles daily and approximately 30 train per day across the only rail crossing of the Mississippi River within 100 miles. The bridge, designed by Modjeski and Masters was opened in 1935 and is owned by the New Orleans Public Belt Railroad. To enhance economic development in Louisiana, the TIMED (Transportation Infrastructure Model for Economic Development) Program initiated a project to widen the existing Huey P. Long Bridge to carry three lanes of traffic with shoulder in each direction in addition to the existing two rail lines.

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Figure 1 – Huey P. Long Bridge Structure

The $1.2 billion widening project started in 2006 and is expected to be completed in 2013. The current Phase III of the four Phase construction which includes the main bridge truss widening was awarded to the MTI Joint Venture (Massman Construction Co., Traylor Bros. Inc., and IHI Inc.). The widening of the four spans was performed one span at a time. MTI hired HNTB to devise the span-by-span erection method. In November 2009, widening of the West Bank span began using the stick-build method, where each member of the span is individually placed.

Figure 2 – Stick-building of Span I

In order to minimize the use of false work and river closures in the main navigation and auxiliary channels, the widening of the three other spans was completed by fabricating trusses on barges near the shore and transporting the pre-fabricated trusses under the bridge and lifting them into place using strand jacks.

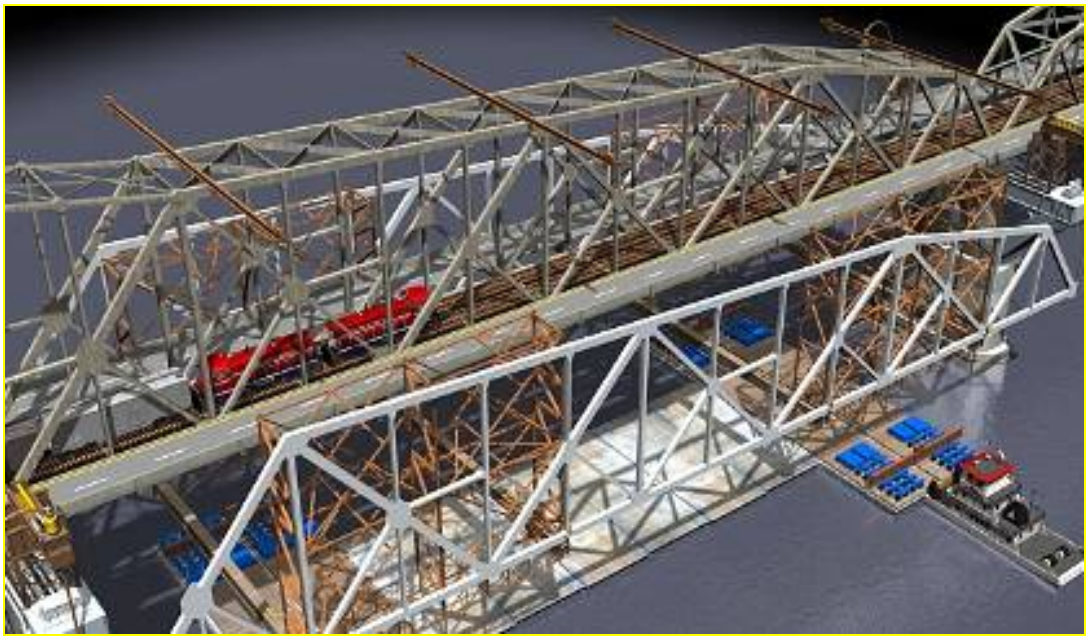

Figure 3 – Lifting of Pre-build Trusses

This required two sides (upstream and downstream sides) of the pre-fabricated bridge span to be lifted and set simultaneously to avoid any unbalance forces on the bridge.

The pre-fabricated pair of trusses in Span II through IV were assembled on barges with stability frames and floor beams near shore. MTI build a four-barge system connected by three sectional barges. HNTB designed the stability frame/floor beam assembly which was built on the barge platform to help support the trusses and keep them plumb throughout erection. The stability frame was also used to help support the twin trusses during transport to the bridge, during the lifting operation and provided a means to skid the trusses laterally for the final setting on the piers.

Figure 4 – Truss Assembly and Stability Frame on Barges Near Shore

Construction of the first pair of twin trusses began in April, 2010 and was completed on May 31st, 2010. The first lift was performed the weekend of June 19th/20th, 2010. Subsequent lifts were performed on November 20th, 2010 and April 9th, 2011.

Table 1 – Lift Span Information

Lift	Span	Length, ft	Weight, tons
1	III	528	2,650
2	II	503	2,550
3	IV	528	2,700

The transport and lift operation required coordination with all four Transportation Departments (FAA- crane heights, Railroad- track closure, DOT- bridge traffic closure and Coast Guard- temporary closure of main navigational channel).

The typical operation required the truss/barge assembly to be floated out to under the bridge on a Friday morning and connected to lifting tendons from the 900-ton strand jacks. Early Saturday morning the bridge and navigational channel was closed and the lifting operation began.

The 130-ft lifting operation for the first lift took approximatly 11 hours with the skidding operation another 6 hours. Subsequent lifts reduced this time down to a total of about 10 hours total for both operations. For all three lifts, the bridge was open to traffic in less than the 48-hour time requirement.

Although Mammoet (lifting sub-contractor) monitored hydraulic pressures and overall lifting and setting displacements during the lifting and skidding operation, the truss (distortions) needed to be monitored to assure buckling or overstressing of the truss did not occur.

Figure 5 – Lift of Span IV. Note Stability Frames and Lifting Points are From Ends of Truss Only

The four critical phases for monitoring included; 1) During the launching and transport of the trusses on the barges to the bridge, 2) Throughout the lifting operation, 3) During the ‘skidding operation’ where the trusses were pulled 13-ft laterally inwards to the bridge and set in place, and 4) The lowering of the stability frames back onto the barges.

The Monitoring System

The biggest concern for MTI and HNTB was out-of-plane distortion, primarily ‘sweeping’ of the truss. Since the truss would be lifted at the end points of the 500-ft plus long truss, any tilting of the truss could initiate buckling. Also, during the skidding operation where the trusses are pulled inward, it is important to verify the jacking operation provides uniform movement of the truss to prevent overstressing of truss members. Therefore, the two most important parameters to measure were tilt and out-of-plane deflection of the truss. Working with MTI and HNTB, an instrumentation layout was developed that utilized tilt meters and laser distance sensors as shown below.

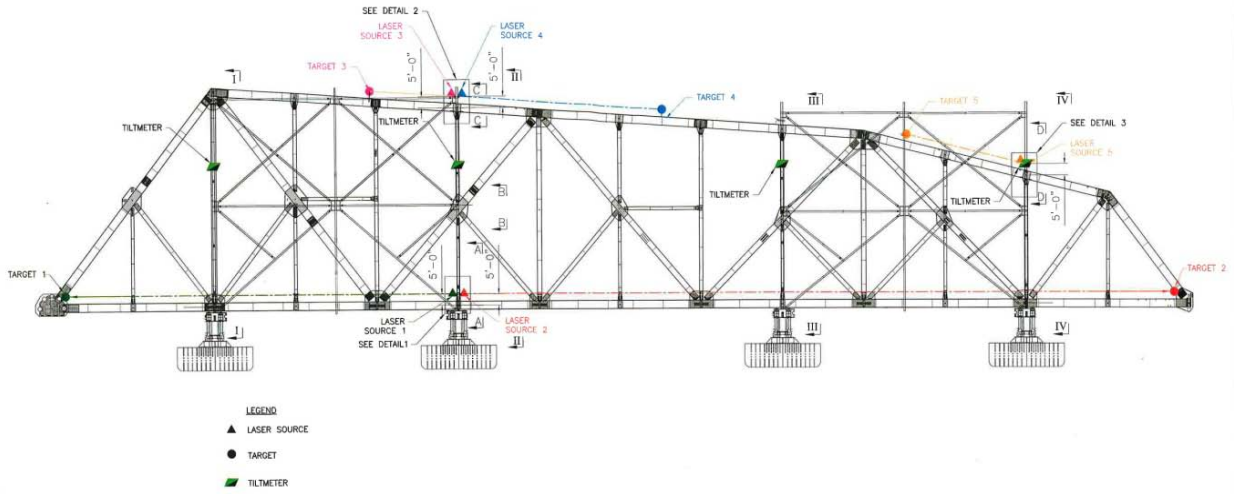

Figure 6 – Truss Instrumentation Layout

The tilt meters were located on the vertical stability frame members and measured tilt in both the longitudinal and transverse directions of the truss. Since the truss was fixed to the stability frame during transport and lifting, measurement of the vertical member of the stability frame was representative of the truss tilt. A total of eight (four on each truss/frame) biaxial tilt meters were used.

Figure 7 – Tilt Meter Fixed to Stability Frame

Laser distance sensors were used to measure truss out-of plane distortion. The concept of using distance sensors to measure deflection was developed specifically for this project. The principle is based upon the assumption that the distance does not change between the fixed laser and the fixed target, only deflection occurs. The target is mounted at 45 degrees from the deflection measurement of interest. As the truss deflects, the laser reflects at a different location (closer or further) on the target and records a difference in distance. Since the target is placed at 45 degrees, the distance change is equal to the deflection change. This concept was verified prior to implementation.

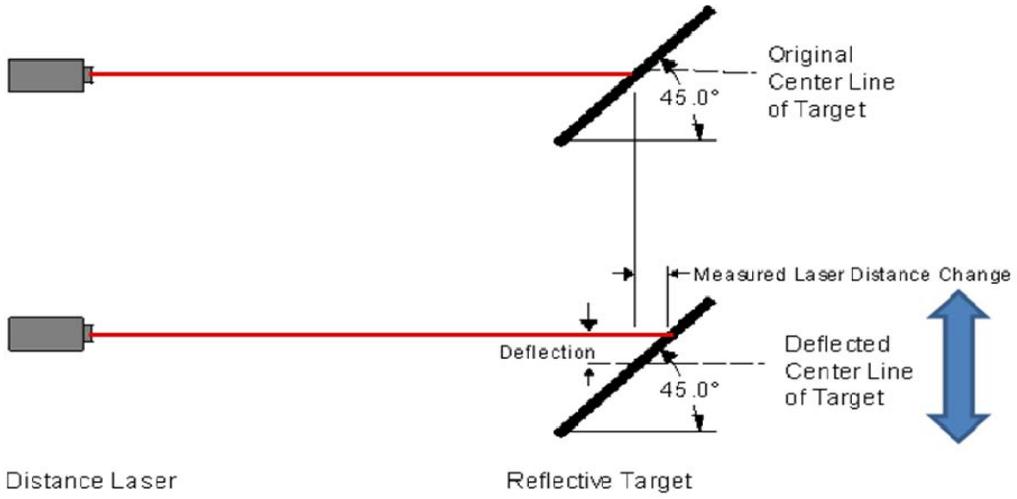

Figure 8 – Plan View of Deflection Measurement using Distance Laser

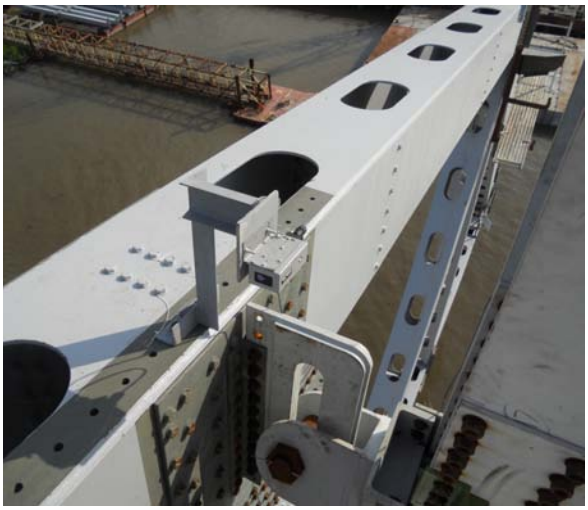

Figure 9 – Distance Laser Fixed on Top Chord

Figure 10 – Setting of Bottom Chord Target

A total of ten lasers were used (five on each truss) to measure out-of-plane truss distortion. The overall bottom chord end deflections were measured and three top chord deflections were measured on each truss.

All sensors were hardwired to a data logger placed on the stability frame/truss. The data logger used a 900MHz spread spectrum radio to transmit collected data to a laptop computer with multiple displays at a remote location on top of the pier. Since the truss and data logger system would be remotely positioned on the barge during transport, lifting and setting, up to 16 hours of battery backup was required for data collection and transmission.

Figure 11 – Monitoring System Components

The monitoring station was setup under the bridge deck on top of the Pier. From this location (white box in Figure 11), communication could be maintained throughout the barging and lifting operation. Data was continuously transmitted and updated approximately every 2 seconds. Data was under constant review by HNTB Engineers and decisions made for controlling lift were based on real-time truss tilt/deflection measurements.

Truss Monitoring

To aid in the review of data, a custom graphical representation of truss tilt and deformation was developed. For each truss a 'birds eye' (plan) view of the truss was displayed on separate screens to show 'sweeping' of the truss during the lifting and skidding operation.

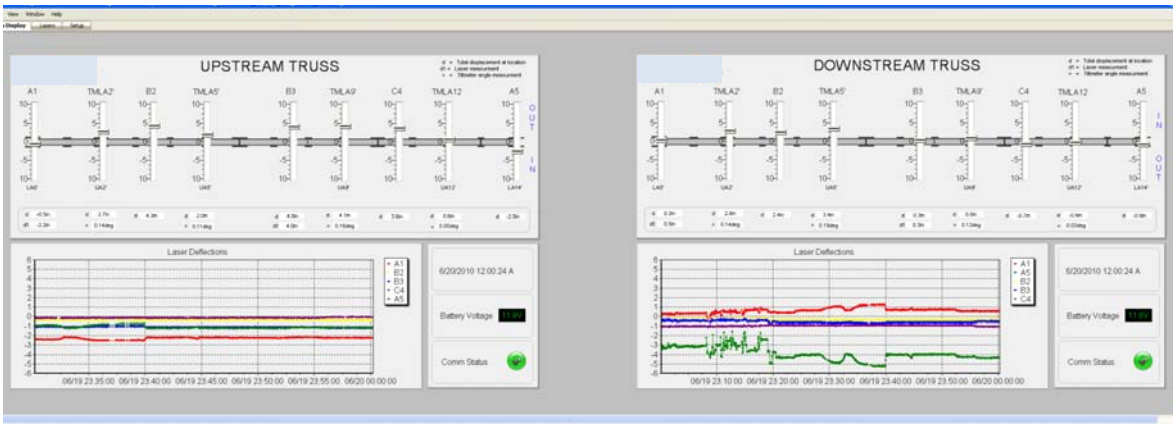

Figure 12 – Twin Screen Display Showing Plan View of Truss Distortion and Tilt

The horizontal bar on the display indicates the plan view of the top chord. The slider bars indicate the in/out deflection of the top chord at that location on the truss. For the bottom chord ends, this value is simply the deflection measured by the lasers. For the locations on the top chord, the deflection is the combination of the tilt angle x the height + laser deflection.

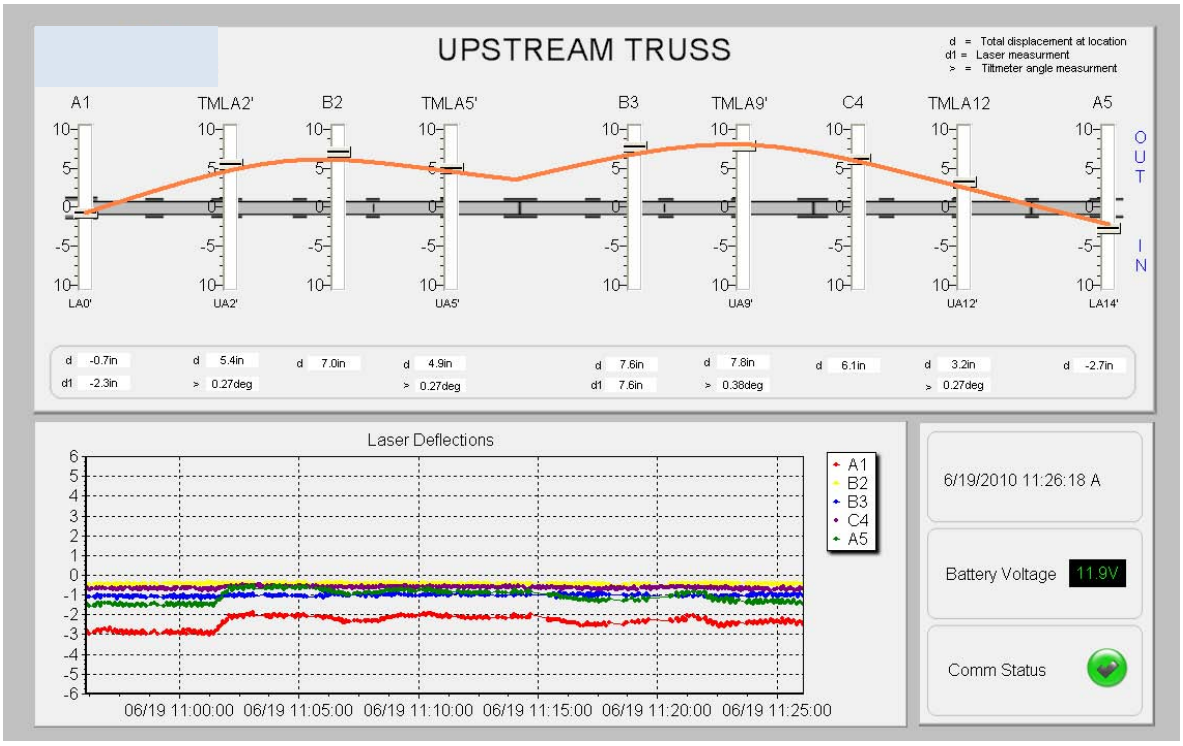

Figure 15 – Single Screen Display for Upstream Truss with Truss Distortion Superimposed

Figure 15 shows the graphical representation for the combination of truss tilt and out-of-plane deflection from tilt and laser measurements. The slider bars on the graph show displacements in inches at points along the length of the truss. The orange line is superimposed on the figure above to highlight the approximate deflected shape of the top chord of the truss as seen from a 'birds-eye' view. The bottom graph shows the time history of the laser deflections. Throughout the 12 to 18-hour lifting and setting operation, radio transmission of data to the remote monitoring station was never lost- providing constant information for the decision making process throughout the operation.

Conclusion

"The monitoring system was vital to the lift operation. We were able to use it in real time and know exactly what was happening with the lift. It allowed us to make adjustments to the attitude of the truss "on the fly" without slowing down the operation. This could not be achieved with traditional survey methods. Once we confirmed that the monitoring system was giving us results that agreed with survey and visual inspection if gave us the confidence to know how the truss was behaving at any given time. The system also allowed us to monitor the truss while it was sliding laterally into position over the bearings, which was as critical if not more critical to monitor than the lift itself." – John Brestin, Vice President and Bridge Group Director, HNTB.