Laser-View Technologies®
Smart non-contact measurement solutions for industry

LASER-VIEW TECHNOLOGIES
Bridge Deflection Monitoring

Structural Engineering: Bridge Deflection Testing Using Non-Contact Laser Sensors in Place of LVDT Gauges

Bridges that are suspected to be structurally deficient require technical analysis for deflection and strain under loading conditions to determine acceptable load limits and general structural worthiness. Traditionally, this type of analysis requires combinations of non-contact and contact measurement techniques.

DIMETIX
LASER DISTANCE SENSORS

Summary

Laser-View Technologies recently had the opportunity to work with AECOM on a bridge deflection test over rail tracks in New England. The bridge in question handles traffic over a set of commuter rail lines. The bridge load limit had been lowered as a measure of caution since the structural members of the bridge had deteriorated. The structural test had been ordered to determine the actual load capacity of the aging bridge under the existing conditions.

Overview

In this test, we introduced Dimetix laser distance sensors coupled with interface modules produced by Laser-View Technologies. These were crucial tools to acquire deflection accurately, without contact, with less overall equipment, and with less set-up and tear down time.

Considerations for structural testing of a bridge under load can be:

- Access under bridge
- Structure type
- Weather conditions
- Types of defections
- Permissible right of way closures

Testing can be done as long term testing for structures that are known to be structurally deficient and the degradation needs to be tracked over time. This often falls under the category of structural health monitoring (SHM). The majority of bridge testing are single events that evaluate a structure under controlled loading conditions. The single event test is what is being discussed in this paper.

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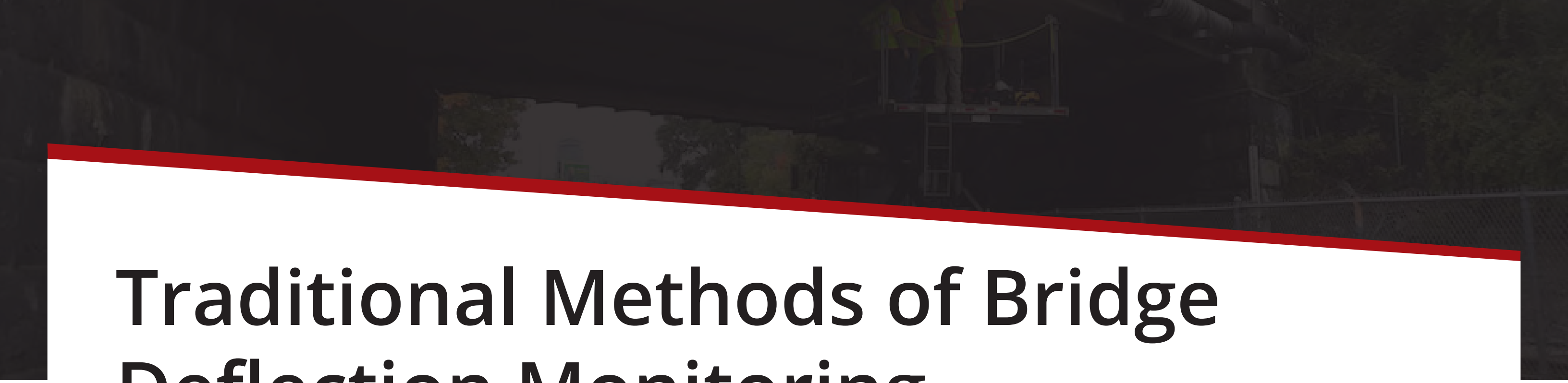

Traditional Methods of Bridge Deflection Monitoring

Traditionally, the test is done using two sets of measurements:

- Strain
- Deflection

Strain measurements across key structural members are taken with strain gauges usually connected to a remote monitoring system. In this case, the strain gauges are connected to a wireless node also mounted under the bridge.

Deflection measurements typically would have been performed using LVDT (linear variable displacement transducer) probes mounted on tripods and scaffolding. Each LVDT would have been positioned at each predetermined point of interest. The LVDT sensor would have then been wired back to a central system directly or via remote nodes.

This method requires a significant amount of preparation time to set up scaffolding and mount each sensor. This becomes increasingly difficult when the bridge test is in a more confined and less accessible location, such as a rail line.

New Technique: Measuring Bridge Deflection Using Laser Distance Sensors

In this most recent test, we utilized an arrangement of four Dimetix DAN-10-150 laser distance sensors as the method of determining deflection at predetermined places under the structure. Since this test was for a bridge over commuter rails, the base was constructed completely of ballast. The challenge was to strategically position the sensors, avoiding the rails and hot connections, yet keeping the laser stable on the ballast.

Working with AECOM, a method was that used included the mounted laser and bracket on a pipe, which was driven into the ballast for stability. Four lasers were mounted on independent posts driven into the ballast. We found that this method was stable enough to be left overnight between the setup day and test day. No additional adjustment was needed on the day of the test. Another adjacent live commuter rail was present and in operation while this test was being performed. Preliminary tests proved that vibrations from the adjacent rail as trains passed did not affect the laser sensor deflection readings.

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New Technique: Remote Interface Module

Each laser was cabled to a remote interface module. Out of the interface module, a 0-2V DC signal was produced that could be acquired by the BDI remote data acquisition hardware. The 2V signal was scaled to a predetermined deflection range.

New Technique: Positioning

It is important to position the laser spot on a solid section of the bridge beam so that the laser detects deflection as opposed to a change in surface. The laser spot is shown circled. You can see that it is bright and visible. The small concentrated laser spot makes it easy to aim the laser at the desired position.

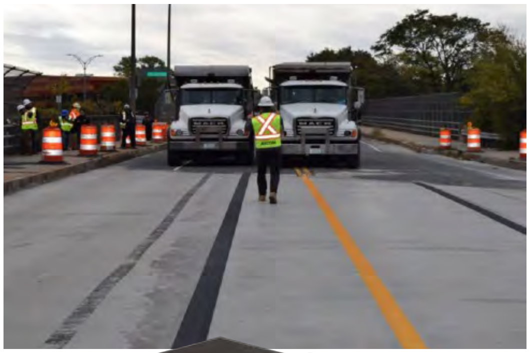
For this test, a plumb line was hung from the desired point under the bridge beam. The laser was aimed to be aligned with the plumb line to assure perpendicular alignment. This required only two personnel to setup. One held the plumb line and the other adjusted the laser sensor.

After the sensors were placed and measurement response confirmed to be within valid ranges, the test is performed by running trucks or sets of trucks over the bridge at a predetermined constant speed and in predetermined load increments. Trucks filled with wild aggregate or sand is a common method.

Test Results

The test was performed in increments of approximately 10 Tons per lane by running trucks filled with sand at a constant speed over the bridge as described previously. During this test, each truck was loaded to 90 T each at its max load.

Each of the four deflection channels fed by the Dimetix laser sensors was recorded in real-time. A sample chart from one of the runs is shown below. It was exciting to see the data repeat, follow expected trends, and return to zero consistently after the load was removed. It is very important that the laser readings returned to their original zero points because unlike other sensors that have been previously used, including the strain gauges that are used to measure strain, the lasers do not typically demonstrate drift. This means that the laser readings do not have to be reserved due to the testing process.



Outcome

Fortunately, the deflection and strain results of the bridge under load matched the model that AECOM had predicted. As a result, the bridge load rating was increased to permit larger vehicles, such as commuter busses to cross safely.

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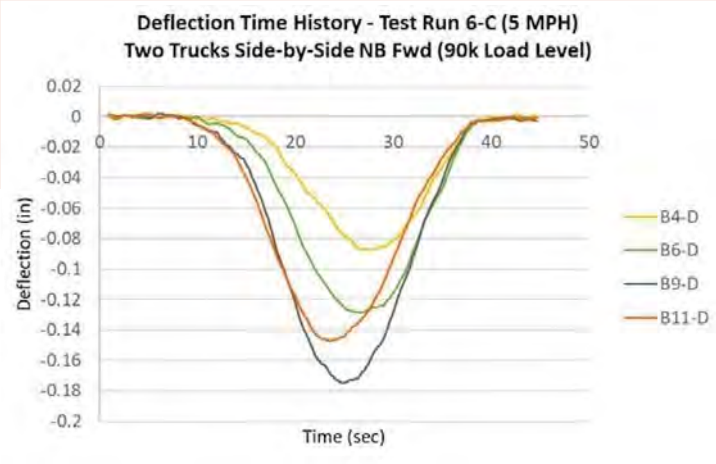
Conclusion

Deflection curves charted after running load over the bridge proved valuable for validating the aging bridge's strength and traffic worthiness. We have proven the effectiveness of Dimetix laser sensors for long term and permanent installations for structural health monitoring health in other applications.



In this test, we proved the effectiveness of Dimetix laser distance sensors coupled with interface modules produced by Laser-View Technologies as a crucial tool to acquire deflection accurately in real-time. The laser system provided methods that will be beneficial across many bridge testing practices.

Users will benefit in several ways:

- Non-contact measurement
- Measure from the ground without any controls mounted on the structural beams
- No need for bulky equipment, like scaffolding
- Minimal room needed in tight access areas
- Quick set-up
- Quick tear down
- Consistent, resolute readings without drift
- Connects to most popular data recording equipment

Dimetix lasers coupled with controls from Laser-View Technologies simplifies and improves data reliability for bridge defection testing and can be applied to other structures in similar manners.

Contact Laser-View Technologies to discuss your bridge testing needs by calling or emailing our team.

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