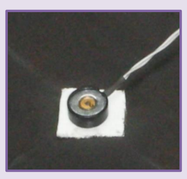
Evaluation of the Optotrak System For Concentrically Braced Steel Frames

PEER Internship Program – Summer 2013

Undergraduate Intern: Kelli Slaven, University of Washington
Graduate Mentors: Molly Johnson, Dan Sloat, and Andy Sen, University of Washington
Faculty Mentors: Charles Roeder, Jeffrey Berman, and Dawn Lehman, University of Washington
This research was conducted at the University of Washington

1. Motivation and Background

Concentrically Braced Frames:
The Optotrak system was used on a series of concentrically braced steel frames to evaluate the reliability of the system for this purpose. The braced frames had different braces and connection designs and were being tested for seismic performance. The first two frames tested used a connection design that does not meet the current design code. It is based off of common designs found in a survey of older steel frame buildings that was completed last summer. There has not been much research on these older steel frames, and since many of these buildings are still in use it is important to know how they will perform.



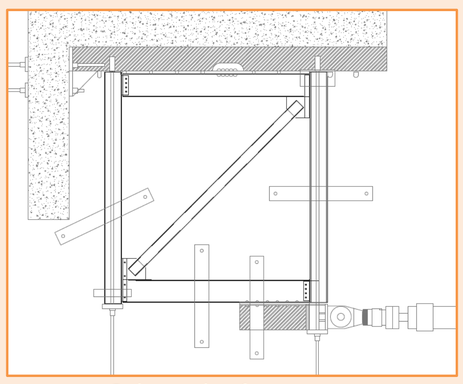
Optotrak Position Sensor[1] (above) and LED marker (right).

Optotrak System:
The Optotrak system uses LED markers and a position sensor camera to obtain the 3-D coordinates of points. The markers are connected to the frames and the position sensor is set up so that it can record the markers.

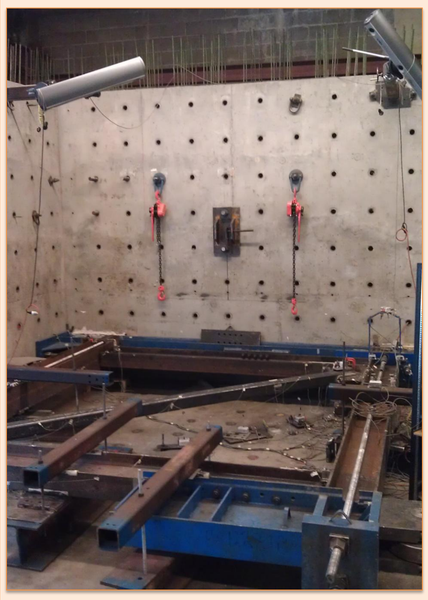
According to NDI documentation, if the position sensor is set up 2 meters from the LED markers, the system has an accuracy of 0.1 mm for movement in the plane perpendicular to the camera and an accuracy of 0.15 mm for movement out of that plane[1]. This is much more accurate than other instruments used on the specimens. If the system can obtain accurate data on the position of points on the frame, it can replace many other instruments.

2. Methods

Test Set Up:
- -12'X12' frames
- -Different braces and connections
- -Attached to strong wall through channel assembly
- -Out of plane restraints attach to strong floor
- -Cyclic loads of increasing displacement applied by actuator



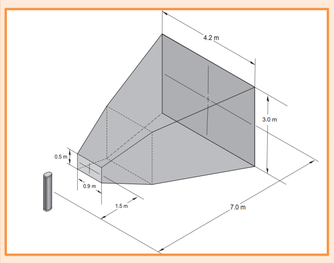
Schematic of test set up



Optotrak position sensors mounted on strong wall above test specimen.

Optotrak System:
- -LED markers placed in a grid pattern on frame – focus on connection
- -Position sensors mounted on the strong wall above the specimen
- -Using two sensors gives higher accuracy, but they must have a large shared volume for calibration

Matlab:
- -Use a rotation matrix to transform the coordinates from the default to the desired coordinate system
- -Plot marker positions in x-y plane for frame movement, or z-plane for brace deflection
- -With the coordinates of points on the frame, many values can be calculated (displacement, strain, rotation, etc.)



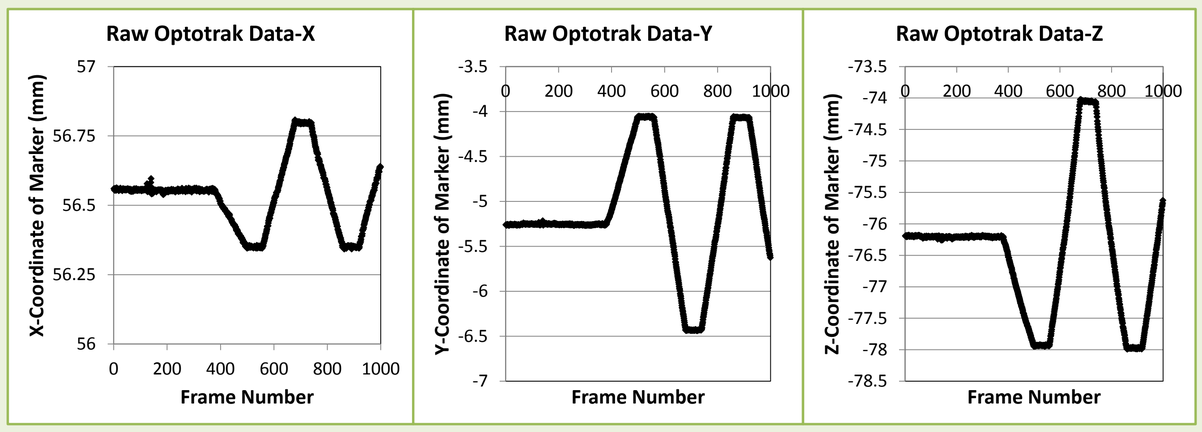
Volume detected by a position sensor[1].

Optotrak LED markers on two story frame connection.

3. Results

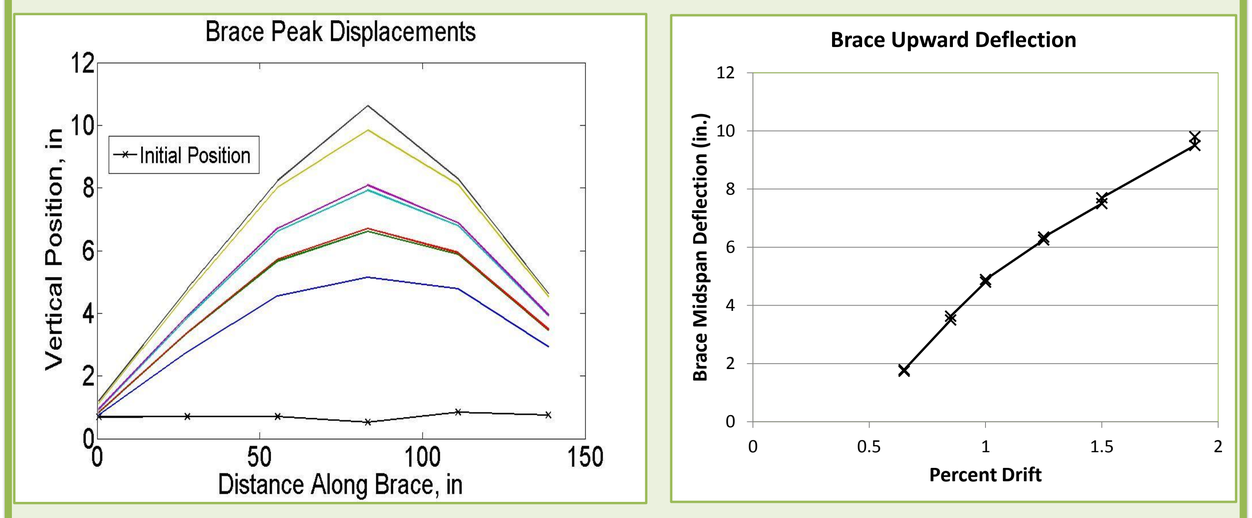
Overall, the Optotrak system gave data with very little scatter that matched closely with the data from other instruments as well as observations of the tests.

The scatter in the Optotrak data was very small. The plots below show the raw Optotrak data for a marker on the brace of a frame. This plot shows the position in millimeters in the first 1000 frames of the test in each of the default coordinate system directions. For this marker, the X-coordinate data had the most variance. In particular, the points around frame 140 seem to vary greatly. However, the difference between the top and bottom point in this region is only 0.055 millimeters. The scatter in the other two directions is even smaller than this, as seen in the middle and right plots.



Very little scatter in raw Optotrak data.

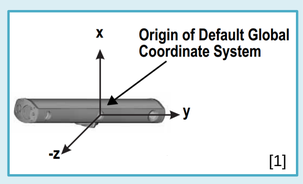
The plot below on the left uses the Optotrak data to show the deflected shape of the brace at the peaks of the last several cycles of the test. The plot on the right shows the brace midspan deflection values observed and recorded at different drift levels during the test. It can be seen that the Optotrak data follows the recorded brace deflection values. The brace behavior and values from the two sources are very similar.



Brace displacement from Optotrak (left) compared to observations (right).

4. Conclusions and Future Research

- -The Optotrak system is accurate and precise
- -Coordinate system alignment is very important, and transforming a misaligned system could result in large errors
- -Future tests will rely more on the Optotrak system, and will see what information can be gained that other instruments cannot record
- -Position sensors will hopefully be arranged so more of the frame can be seen



[1]

Acknowledgements

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References

1. (2009). *Optotrak User Guide,* Northern Digital Inc., Canada.

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