Notes and Observations of the South Napa Earthquake
August 24, 2014

Case Study: Pre- and Post-Quake 3D Laser Scanning
Of the Historic Gordon Building

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The Historic Gordon Building is located in Napa's Downtown Historic District at the corner of Coombs and First Street, as denoted in Figure 1. The building was surveyed using a High Definition 3D Laser Scanner for the purpose of an as-built survey on January 15, 2014. The deliverables included a 3D Point Cloud (a set of vertices in a 3D coordinate system, defined by X, Y, Z coordinates) as seen in Figure 2, as well as a Building Information Model (BIM) that was created from the point cloud as seen in Figure 3.

Figure 1 – Pre-Quake, Southwest corner

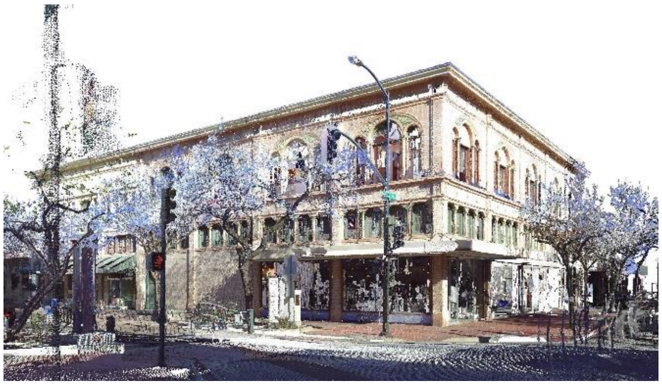

Figure 2 - 3D Point Cloud

Figure 3 – 3D Model

After the South Napa Earthquake on August 24, 2014, our team re-scanned the historic Gordon Building on September 3, 2014 in an attempt to compare and analyze the scan data pre- and post-quake. Figure 4 shows the north building façade.

Figure 4 – Post-quake photo-textured 3D Point Cloud

Summary of Observations

The pre- and post-quake 3D building scans were aligned with point cloud analysis software. A 9-level Octree Algorithm was used to assess the distance between the pre and post- quake scans and the following observations were made:

1. The distances are color-coded from blue to green to red to show the increasing distance between the two point clouds (Scalar Field Analysis).
2. The scalar field image shows how the walls are aligned at the lower corners, but then move gradually out of alignment from the lower street level to the diagonal upper cornice corner, as observed at the South and West wall surfaces, indicating the building's torsional rotation clockwise around the Z-axis (see Figure 5). **Note:** The red areas are where the pre-quake scan point cloud data was not captured when compared to the post-quake scan and is not indicative of displacement between the two point clouds.
3. Building cracks pre- and post-quake are observed and can be measured (see Figure 6).
4. The Southwest profile and cornice detail shows a displacement of the cornice of approximately 1" (see Figure 7).
5. The long horizontal cracks were measured and compared to the 3D model / 2D drawings. The observation concludes that the cracking occurred below the floor/roof levels, which the dimensioning confirms (see Figure 8, 9 & 10).

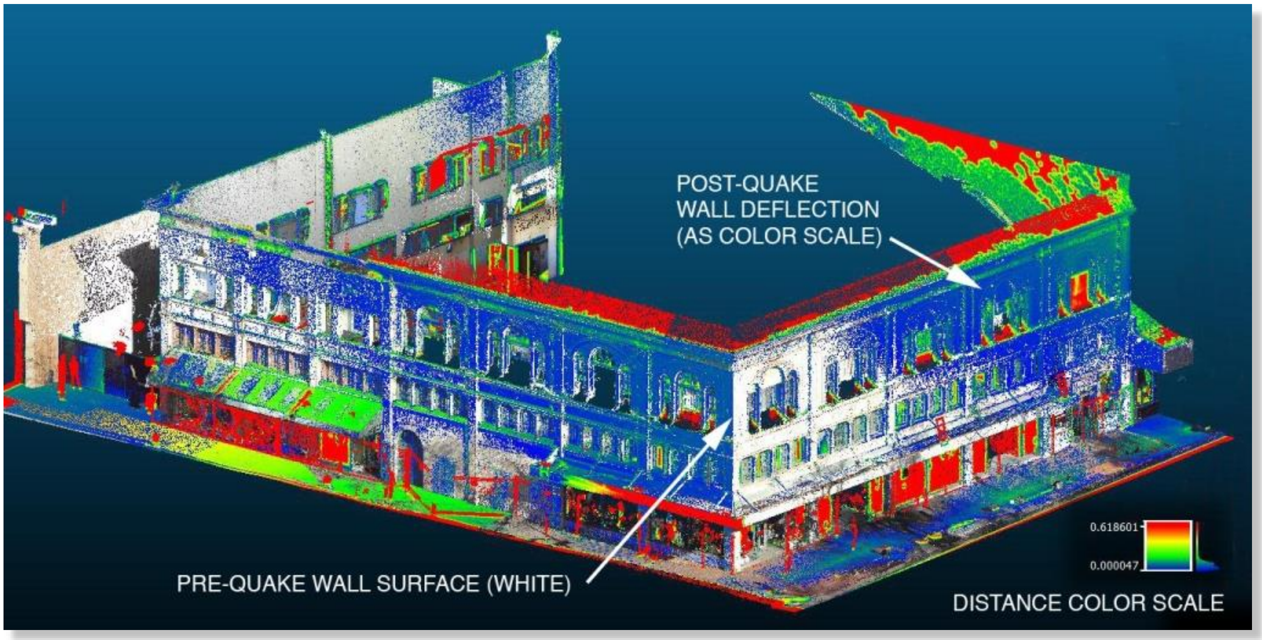

Figure 5 – Post-quake South and West wall surfaces

Figure 6 – Post-quake West wall showing pre- (yellow) and post-quake (orange) cracking

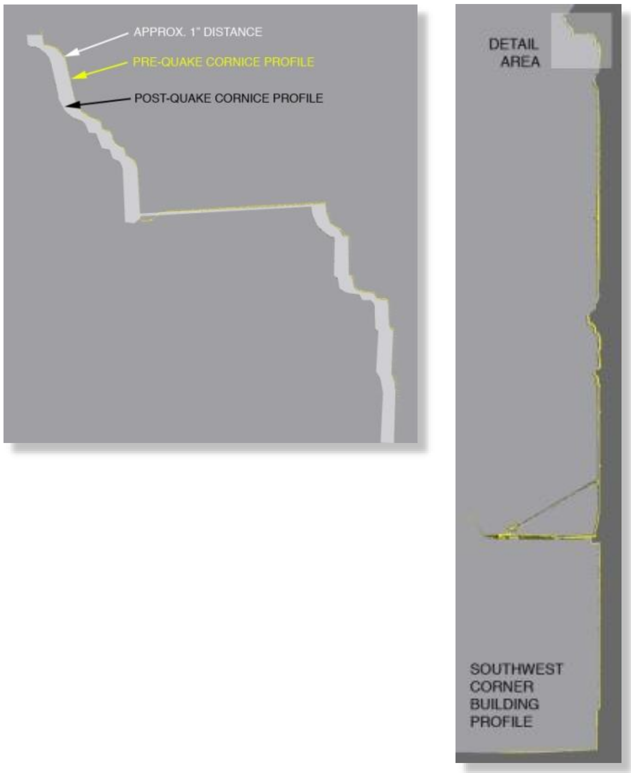

Figure 7 – Post-quake Southwest cornice profile detail. The yellow outline represents the scanned building profile.

Figure 8 – North wall Ground to underside Level 2 = 4.99m

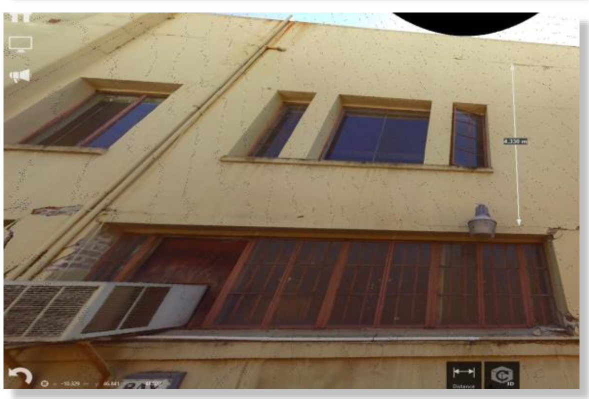

Figure 9 – North wall Level 2 to underside Roof = 4.33m

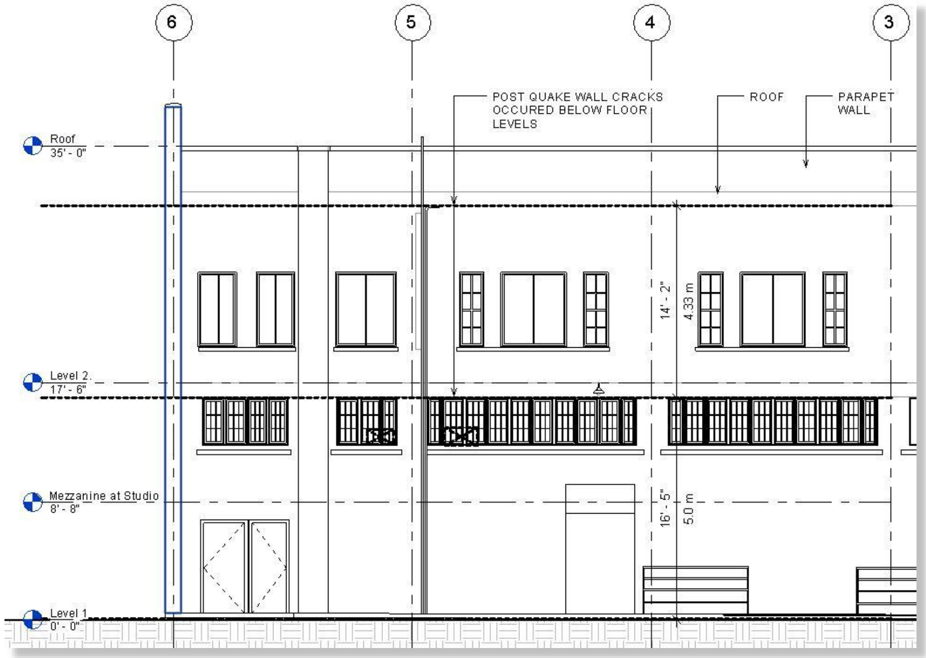

Figure 10 – North wall 2D drawing with dimensions showing below floor cracking

Rapid and Minimally Invasive Safety Evaluation

Our team was able to safely survey three sides of the red-tagged building in a half-day, and were able to evaluate the scan data 24 hours later. Within 48 hours, we could compare the pre-quake point cloud against the post-quake point cloud and identify which areas of the building suffered new damage or had further deteriorated.

The typical process for evaluating buildings after an earthquake is highly subjective. In California, building safety inspectors rely on industry standard protocols for determining if a building is safe, unsafe or may have limited use after a seismic event. Human error and time are the two factors which could result in less accurate field evaluations. After the Napa Earthquake, many green-tagged buildings (presumed to be safe and fully operational) were 48 hours later re-classified as red-tagged (unsafe). The 3D laser scanning technology allowed our team to measure and provide detailed data of the damaged building structures quickly, safely, and with precise accuracy.

Conclusions & Comments

1. Because the pre-quake scans were not taken with the intention to be used for comparison purposes, some false information is detected. The scan shadowing, chatter, and stray points show up as a deviation between the two scans (yellow and red). These are not indicative of deviations, but are highlighting where the post-quake point cloud has data points that the pre-quake point cloud does not.
2. Suggestion for future Cloud to Cloud comparisons: Use the same (or as close as possible) scanner locations for pre- and post-scanning.
3. Some of the major cracks on the North wall (Rear) existed prior to the Earthquake. It appears that the Earthquake expanded some already known weak areas and created new ones.

Note:
The observations, opinions, findings, and conclusions expressed in this case study are those of the authors' alone, to demonstrate the possibilities of utilizing 3D laser scanning for building assessment after an earthquake, and is inconclusive to the actual structural integrity of the subject building, as it has not been reviewed by a structural engineer. The information, data, and images contained in this report are published by 3DVDT and may not be shared elsewhere without the express permission of the authors.

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