New Techniques for Earthquake Reconnaissance

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SUMMARY

Earthquake reconnaissance provides primary data that drives the development of procedures and codes for earthquake engineering practices. Visual documentation of post-earthquake damage can validate code design provisions, or reveal flaws in structures that can lead to the enhancement of structural designs. This project explored a new technique for assessing post-earthquake damage to buildings and bridges. Canon EOS 5D Mark II camera photographs of damaged structures from the Mw 7.0 2010 Haiti earthquake were stitched together using PTGui software to create spherical panoramas and three-hundred and sixty degree .mov files. Those photographs were also superimposed onto the Leica Scan Station 2's laser scanned images, using Cyclone software, to both mathematically and visually reflect the damaged state of the structures. The resultant images provide earthquake engineers with a true representation of the damaged structures and provide accurate measurements. This investigation suggests a precise method of analyzing earthquake damage to buildings and infrastructure. It offers government, construction companies, civil engineers, and architects a new tool to use when gathering data after earthquakes. Refining post-earthquake structure damage analysis practices will aid in coming earthquake aftermath investigations.

MATERIALS & METHODS

- **Canon EOS 5D Mark II**

- **PTGui Software**

- **Leica Scan Station 2**

- **Cyclone Software**

Data Collection

Eduardo Fierro[1], Eduardo Miranda[2], Khalid Mosalam[3] and Shakhzod Takhirov[4] went to Port-au-Prince, Haiti to collect data from the January 12th, 2010 earthquake. They collected 1,031 photographs with a Canon EOS 5D Mark II camera and their coordinates with a Photo GPS, and ran 15 scan positions and a total of 9 projects with a Leica Scan Station 2.

Fig. 1 Leica laser scanned image of the intersection of Mirand and Grand, Port-au-Prince, Haiti.

Fig. 2 High- definition camera's image of a corner building on the intersection of Mirand and Grand.

Fig. 3 High-definition of Asscotia Hotel on the same intersection.

The high-definition photographs were superimposed upon the Leica Laser scanned images. Fig. 1 was the base image and Fig. 2 and 3 were then overlaid.

Photographs such as Fig. 4 and 5 were stitched together through the creation of control points. The images were then aligned and warped to create a three-hundred and sixty degree spherical panorama.

Fig.4 View 1 of a damaged Port-au-Prince bridge. Photograph via high-definition camera.

Fig. 5 View 2 of the same bridge via high-definition camera.

RESULTS

Fig. 7 Aerial view of Mirand and Grand intersection, Port-au-Prince, Haiti via Google Earth after earthquake.

Fig. 6 Resultant image of high-definition photographs superimposed upon laser scan of Mirand and Grand intersection. This image demonstrates the advantage of having scanned and high-definition images to show earthquake damage as apposed to a satellite's aerial view.

Fig. 8 Resultant three-hundred and sixty degree spherical panorama of bridge. Fisheye lens for high-definition camera was used.

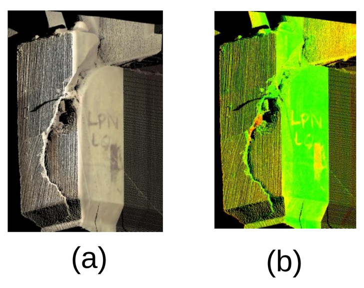


Fig. 9 Station 2: fine and coarse scans colored by colors from camera on board (a) and based on intensity of received light (b).

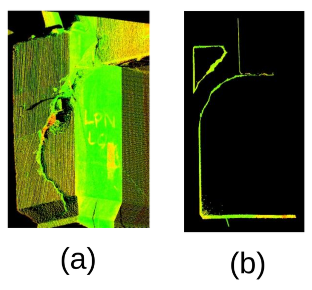


Fig. 10 Station 2: Shear key's face (a) next to cross section of key's face (b).

Fig. 10 High-resolution photograph of a collapsed building.

Fig. 11 Close-up of a collapsed level inside of Fig. 10.

Fig. 12 Close-up of a column inside of Fig. 10.

ANALYSIS

Residual displacement can be calculated and deformation can be measured in structural elements. For example, in Fig. 13 residual displacement of a cracked piece in station 2. It measured 0.092m on the scan.

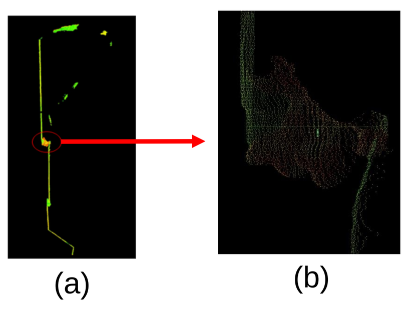
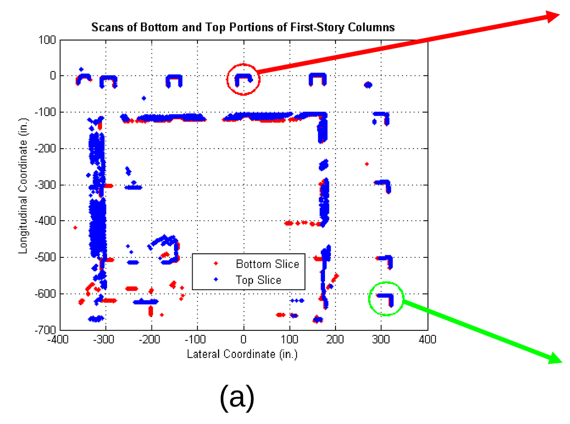


Fig. 13 Station 2: Middle cross section (a) and zoomed view of the same section (b).

MATLAB was used to generate and display the residual displacement of the columns or beams of damaged buildings (Fig. 14). A code was used to interpret the image's information into points on a graph.



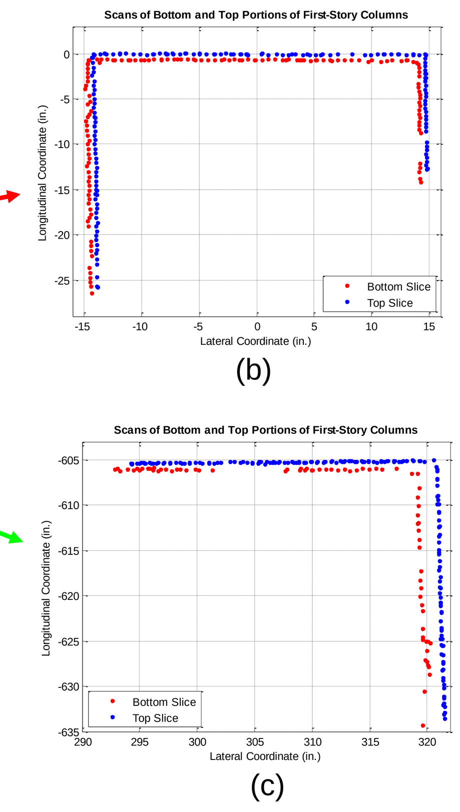


Fig. 14 Residual displacement of the Asscotia Hotel shown through MATLAB software (a). Alignment difference from top and bottom of columns (b) and (c).

CONCLUSION

- The methods used in this project aim at improving the preparedness in situations of similar catastrophes in the US or worldwide.
- It is anticipated that techniques employed for this project in gathering and disseminating critical information will have a major impact on revolutionizing the reconnaissance efforts by the earthquake engineering community in the event of a major earthquake in the US.
- The photographs, scans, panoramas, and videos have been stored in a common repository, where future researchers can use the data to investigate the damaged structures of the 2010 Haiti earthquake.
- Earthquake engineers can calculate residual displacement or measure deformation in structural elements using these reconnaissance techniques.

ACKNOWLEDGEMENTS

This research project was overseen and partially supported by the Pacific Earthquake Engineering Research (PEER) Center as a part of the 2010 PEER Internship Program. Financial support for the author was provided by the Transfer Alliance Project (TAP) and the Jack Kent Cooke Foundation. The author gratefully acknowledges the support of Stephen Mahin and Shakhzod Takhirov for their mentorship during the research process. The author would also like to thank Clayton Sorensen and Sean Wade because this project would not have been possible without their assistance. Special thanks are also due to Donald Patterson, Patricia Lin, and Heidi Faison for their valuable suggestions and advice throughout the project.

REFERENCES

- Lewis, Ajita. "The Newcastle Earthquake Library and Database: An Initiative of the Newcastle Region Public Library" Australasian Public Libraries and Information Services, Vol. 6, No. 3, Sept 1993: 101-106. Academic Search Complete. EBSCO. Web. 14 July 2010.
- The National Research Council. "Revolutionizing Earthquake Engineering Research Through Information Technology." Preventing Earthquake Disasters: the Grand Challenge in Earthquake Engineering : a Research Agenda for the Network for Earthquake Engineering Simulation (NEES). Washington, D.C.: National Academies, 2003. 84-101. Print.
- Shusto, Lisa, and John Osteraas. "Earthquake Damage Assessments." Claims Magazine Covering The Business Of Loss. Summit Business Media, 5 Nov. 2009. Web. 27 July 2010. <http://www.claimsmag.com/Issues/2009/NOVEMBER-2009/Pages/Earthquake-Damage-Assessments.aspx?page=1>.

FOOTNOTES

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