RECLAMATION
Managing Water in the West

U.S. Department of the Interior
Bureau of Reclamation

Research Update

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Bottom Line

This research project explored advanced photogrammetric techniques to help assess the condition of Reclamation's structures.

Better, Faster, Cheaper

New techniques allow investigators to examine the condition of structures using very few pictures (even cell phone pictures). This saves tremendous time and resources because difficult, in person investigations are unnecessary. In addition, potential infrastructure issues can be determined more quickly and accurately.

Principal Investigator

**Matthew Klein, Ph.D.
Civil Engineer
Concrete, Geotechnical, and Structural Laboratory
Technical Service Center
303-445-2368
mjklein@usbr.gov**

Research Office Contact

**John Whitler
Science and Technology Program Manager
303-445-2241
jwhitler@usbr.gov**

The photogrammetric model of Kortes Dam, Wyoming, using data collected from a smartphone.

Using Photogrammetry to Assess Reclamation's Structures

Applying specialized three-dimensional modeling to analyze Reclamation's structures more efficiently

Problem

Most of Reclamation's concrete structures were built between 1930 and 1960. Many of them are exposed to harsh environments with corrosive soils and water, as well as large temperature variations that can accelerate concrete deterioration. As these structures begin to approach the end of their design life, Reclamation engineers must accurately inspect and evaluate their concrete elements and perform necessary repairs. Reclamation structures are often difficult to access and may require specialized equipment, training, and safety considerations. By using advanced photogrammetric techniques, inspections and analysis can take place from the convenience of the office and allow the investigator access to optimal orientations for quality analysis.

Photogrammetry is a low-cost, three-dimensional (3-D) modeling solution that can be used for condition assessment of Reclamation structures; however, using it requires specialized and advanced techniques. This research update describes some of the techniques that were researched and applied to Reclamation projects in fiscal year 2015 (FY15). The project will continue in FY16.

Photogrammetric tools enable Reclamation to advance its knowledge of photogrammetry. Applying these tools in a practical manner can reduce costs, improve safety, and improve the quality of condition assessments on Reclamation structures.

Solution

Reclamation has practiced photogrammetry for several years. Geologists at Reclamation's Technical Service Center have consistently experienced great success performing basic photogrammetry processes. As photogrammetric technology evolves, this research project is evaluating how Reclamation could successfully adapt and apply this new technology to photogrammetry in the field, particularly for assessing the condition of concrete structures.

Application and Results

This Reclamation Science and Technology Program research project investigated the following aspects of photogrammetry to determine the most effective ways for Reclamation to use this technology:

1. **Four-Dimensional Analysis.** Four-dimensional (4-D) analysis refers to time-based photogrammetry that involves collecting data sets at specific time intervals. All sets of the models are then combined to provide an animated model that demonstrates changes over time. This method was applied to the Canal Breach Test performed in the Hydraulics Laboratory in Reclamation's Technical Service Center in Denver, Colorado. The photogrammetry data collection required that eight cameras be set up to take pictures simultaneously every 30 seconds for the 2-hour duration of the test. The models were

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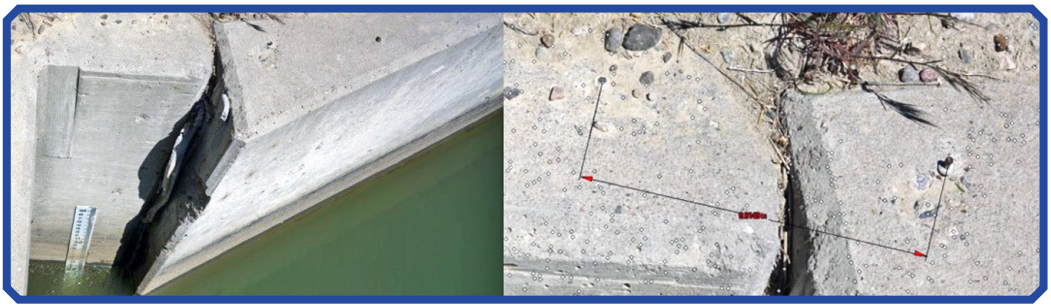
then generated for every 30 seconds, and a time-lapse 3-D model was generated showing the succession of failure within the canal.

2. **Smartphone Camera Data Collection.** Photogrammetry is best performed using quality camera sensors and lenses; however, technological advances now enable photogrammetry to be performed on images collected from smartphones. For example, during a facility review, data were collected from Kortes Dam, Wyoming, using an iPhone 6S Plus. The images were used to create a detailed 3-D model of the structure, including the downstream face and spillway.

3. **Measuring Extent of Damage.** Measuring volumes of damage and distances of movement within structural elements is often time consuming and inaccurate. Using photogrammetry, however, permits volumes, areas, and distances to be measured quickly and accurately. Typically, only a few pictures are required to determine the volume of a spall or settlement distances. Using pictures from Webster Dam (Kansas) and the Upstream Canal Control Structure at Tunnel No. 5 near Farmington, New Mexico, the volume of a concrete spall and distance between survey pins on offsetting concrete canal walls was determined with efficiency and accuracy.



Left: An offset joint at the Upstream Canal Control Structure at Tunnel No. 5 near Farmington, New Mexico.

Right: Measured distance is 9.149 inches between the two survey points.

4. **Feature Extraction.** Photogrammetry can generate large point clouds representing the position of each colored pixel in 3-D space. Because the points are colored, they can be filtered by color or a range of colors. This technique was applied to the downstream face of Hubbard Dam, Idaho, to identify corrosion formation. Using this automatic routine, areas of corrosion were easily and safely identified on the 130-foot-high structure.

This research project clearly demonstrates the value of photogrammetry for Reclamation, especially for determining the condition of much of its aging infrastructure.

Future Plans

These techniques are being integrated into the Technical Service Center's Concrete, Geotechnical, and Structural Laboratory's current inspection and condition assessment program and recommended as a required component of a facility review. As the technology evolves, further research will continue to explore and apply advanced photogrammetric techniques to condition assessments, including:

- **Combining Virtual/Augmented Reality With Photogrammetry.** Using pictures to create a high resolution, photorealistic texture on a photogrammetric 3-D model, the inspector can don virtual reality glasses and interact with the structure without leaving the office.

- **Using a 360-Degree Spherical Camera to Collect Indoor Imagery.** With a spherical camera, a minimum of two positions may be all that is required to solve the 3-D model of an interior space. This has tremendous application for tunnels since tunnels are simply rooms without any end.

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Civil Engineer
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3-D rendering of the concrete spillway damage at Webster Dam, Kansas.

Quantification of area (11.8 ft2) and volume (0.42 ft3) of damaged material.

More Information

http://www.usbr.gov/research/projects/detail.cfm?id=4413

For printable version see: www.usbr.gov/research/docs/updates/2016-13-photogrammetry.pdf