3-D Optical Bridge-evaluation System (3DOBS)

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3DOBS is an easily deployable bridge evaluation system (Figure 1) used for rapidly assessing surface condition indicators such as the area, volume, and location of spalls and scaling. The system consists of a vehicle-mounted digital SLR camera, such as a Nikon 5000, that takes frequent, regularly-spaced pictures as the vehicle drives across the bridge. This enables creation of very high-resolution 3-D models of the bridge deck surface, using a 60% overlap of the photographs. To assess one standard 12-foot (3.7m) lane width per collected pass, the camera is at a height of 9 feet (2.7m) above the bridge deck.

Figure 1: 3DOBS deployed for data collection from the back of a moving truck

Photographs collected in the field (Figure 2) are processed with close-range photogrammetry software, such as Agisoft Photoscan®, into a high-resolution 3-D model of a lane. A Digital Elevation Model (DEM) is then created after adding reference points and setting up a coordinate system. A merged DEM for the entire bridge is created using GIS software, such as ESRI® ArcGIS®.

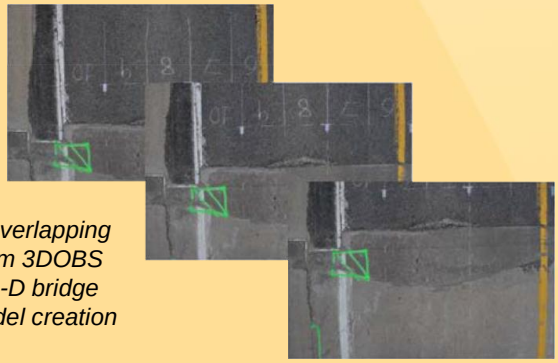

Figure 2: Overlapping photos from 3DOBS used for 3-D bridge surface model creation

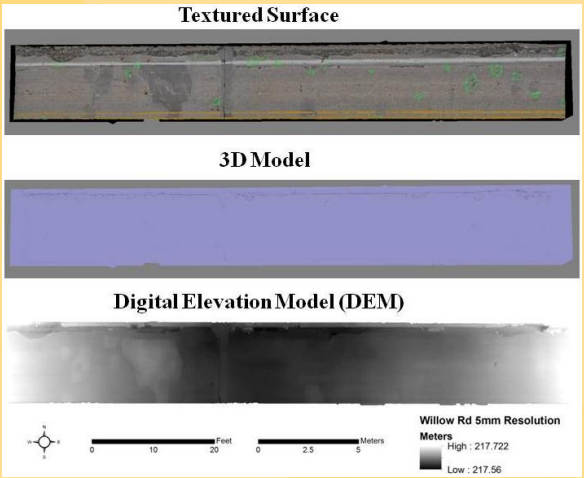

Figure 3: The merged, composite photograph showing a bridge's textured surface, a 3-D model of the surface, & the resulting high-resolution DEM, all created from 3DOBS data.

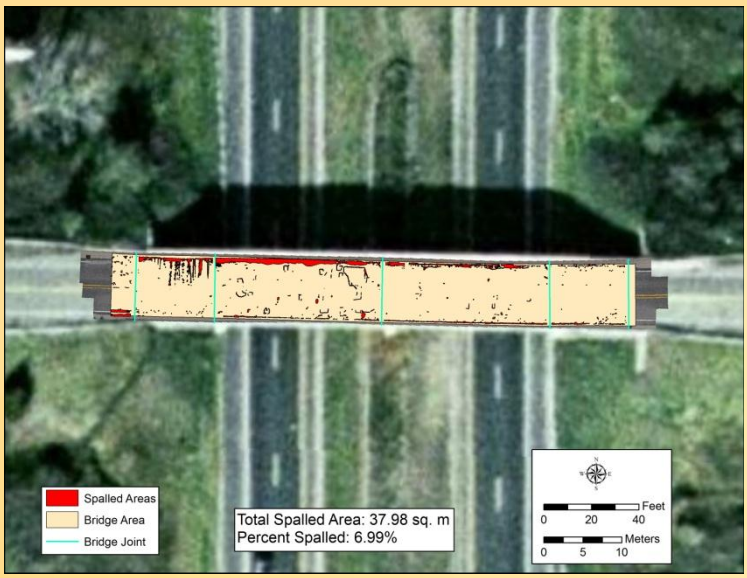

Figure 4: Automatically mapping spalls on bridges using 3DOBS data.

After a merged high-resolution DEM is generated, it is then analyzed in ArcGIS to map the volume, location, and area of spalls across the bridge deck surface. Individual spalls are characterized and the total percent spalled for a surface is calculated automatically (Figure 3).

Figure 4 is an example of automatically mapping spalls for a bridge using 3DOBS data: the red areas indicated spall locations on the bridge, which total 6.99% of the bridge area. This provides a critical indicator on the condition of the bridge surface using a low-cost system. These data can be integrated into existing and new transportation Decision Support Systems (DSS).

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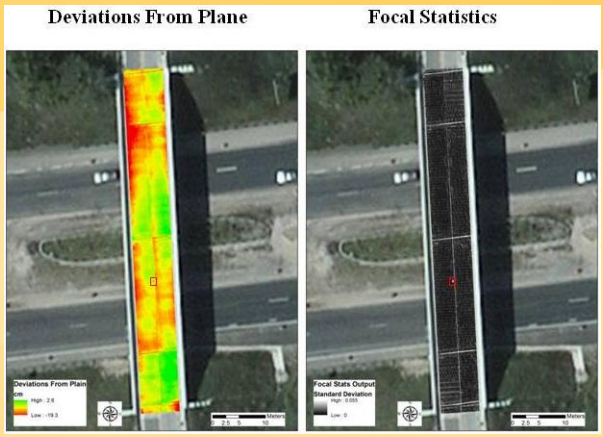

Figure 5: The 3D Optical Bridge Deck-evaluation System includes the automated calculation of bridge surface condition information .

As shown in Figures 5 and 6, 3DOBS used focal statistics on the DEM to determine the change in cell values as it relates to a specified neighborhood of cells. This function is used as the major component of the automated spall detection algorithm.

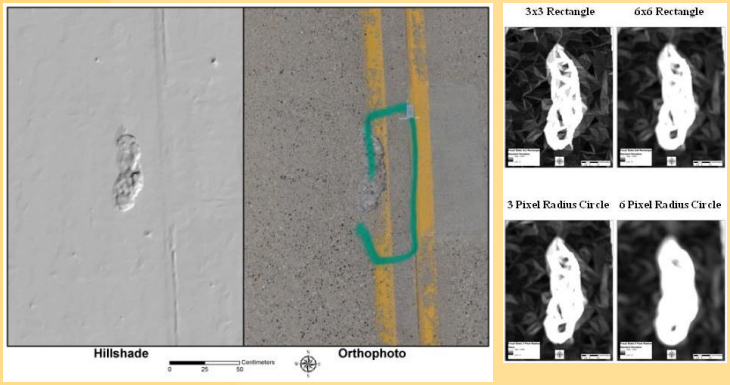

Figure 6: An individual bridge spall shown in a hillshade DEM, from a high-res photo taken with 3DOBS, and as analyzed in the spall detection algorithm at 4 different focal statistics settings. The spall stands out clearly in the 6-pixel radius circle analysis method.

With a DEM resolution of 5mm horizontal and 2-4mm vertical (depending on setup and processing parameters), spalls can be detected at various sizes down to approximately 1.5 in^2 (10cm^2), displayed in Figures 7 and 8.

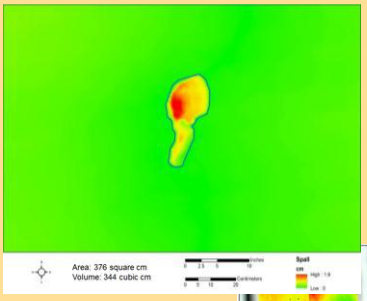

Figure 7: An analysis of an individual spall using 3DOBS data: it's 350 cm^2 in size and 299 cm^3 in volume; these data are available for all spalls across an analyzed bridge deck.

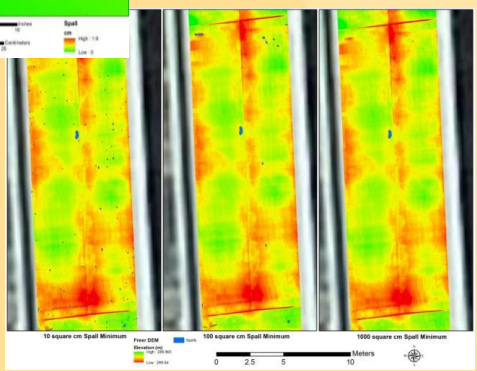

Figure 8: The 3DOBS output algorithms can be tuned to enable calculations of different minimum sizes of spalls depending on the needs of individual transportation agencies; this example shows the different sizes of spalls that can be detected using a 10cm^2, 100 cm^2, and 1000 cm^2 minimum mapping area.

3DOBS is available for immediate deployment by transportation agencies to assess the surface conditions of their bridges, in collaboration with MTRI. 3DOBS is a low-cost system for 3-D data collection compared to alternatives such as LiDAR; the entire 3DOBS system as currently deployed costs less than $5,000 for all hardware & software components.

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