Bridge Pier Surface Condition Imaging Using UAS Technology
NCDOT Bridge No. 830050 (NC24/27/73 over Pee Dee River), Stanly County
River Haven, North Carolina
Summary Report

1. Introduction

NCDOT Bridge No. 830050 consists of a six span structure over the Pee Dee River and Lake Tillery, between Stanly and Montgomery Counties, North Carolina. The structure is located on the south side of the alignment and carries NC 24/27/73 eastbound, while a companion bridge on the north carries westbound traffic. This bridge pier surface condition imaging effort was limited to the substructure above water of the south bridge only, which consists of five piers numbered 1 through 5 from West to East.

2. Field Data Collection

On July 10 and 11, 2018, AECOM used a DJI Matrice 210 RTK UAS system to image the five water piers of the southern Lake Tillery Bridge. Each pier was photographed utilizing a 20 megapixel DJI X5S digital camera attached to the top of the drone. This UAS has the option of mounting a single camera on the top of the drone that will allow the operators to look directly up to view bridge components. If required, this UAS also has the option of carrying two cameras underneath the drone that allows the operators to zoom in on areas of concern

The shorelines of the Pee Dee River in this area do not have any public access areas, so it was necessary to operate the UAS from a vessel on the water. The vessel was required for the bridge inspection to act as a safety boat should an emergency situations arise, so it made the opportunity to position it under the bridge very easily. A custom built landing platform was attached to the railing on the stern of the vessel to create a large enough area to safely carry out UAS operations. Winds and other weather factors were favorable during the inspection which made taking off and landing on a vessel a non-issue for the experienced remote pilot.

Each bridge pier was photographed with the UAS over a period of 1-2 hours and consisted of approximately 500 photos. Engineers were particular concerned with the base of each bridge pier at the water line where cracks in the concrete can be of higher concern. In order to accommodate these concerns, each pier base was photographed with handheld Nikon D3200 DSLR camera for additional high resolution imagery that was combined with the UAS imagery. The combination of all these photographs were then incorporated into the 3D models to produce the final models.

In order to properly construct each bridge pier model, it was critical that the photos contained an 80% overlap so that the software would be able to stich them all together correctly. To achieve this overlap, each pier face is flown a minimum of two times, and corners and undersides of the piers are captured from three angles. In addition, the drone is flown in a circle pattern to capture imagery of the entire pier that is combined with the close up photos to provide a precise model. This redundancy assures that enough photos are taken to build the models once back in the office.

3. Creating 3D Pier Models

The commercial software Bentley ContextCapture was used for developing the 3D models of each of the bridge piers. The process started by eliminating any photos that were unfavorable (such as out of focus) to the final outcome as well as images that were not related to the bridge pier being modeled. From there all the photos are pulled into the software and axis constraints as well as scale constraints were entered so the model is built to scale. The software then takes over the process and builds a preliminary model that will allow the user to verify the pier constraints and that the final model will be created correctly. Once the final checks are made, the software then renders the final model which depending on the amount of images included can take from a few hours to upwards of 24-hours. During this time no user input is required.

After the final bridge pier model is built, 3D isometric views from any direction as well as orthographic images from each face can be exported. Engineers can also use the model with a viewer version of the software to pan around to any view of the pier as well as zoom in on areas of concern for further analysis.

4. Final Imagery of Piers

Figures 1 and 2 depict the DJI Matrice 210 RTK UAS that was used for the bridge pier inspections. Also shown is the custom built platform mounted on the stern of the safety boat that was used to take-off and land the UAS.

Figure 3 shows an example of the higher resolution imagery collected for each bridge pier as captured by the UAS.

Figure 4 shows an example of the high resolution imagery collected at each bridge pier base at the waterline captured with handheld DSLR camera.

In Figures 5 through 14, isometric views as well as orthographic views of each bridge pier can be seen. The isometric views are just an example of what is available to engineers who can zoom in and spin the model 360° to get the perfect angle needed to analyze the cracks and look for any deficiencies.

Figure 1. DJI Matrice 210 RTK in Air with Two Camera Systems Mounted to the Bottom

Figure 2. DJI Matrice 210 RTK on Launch Pad with Single Camera Mounted on Top

Figure 3. Single Photograph of Bridge Pier Captured from UAS

Figure 4. Single Photograph of Pier Base at Waterline Captured with Handheld DSLR Camera

Isometric View Looking Northeast

Isometric View Looking Southwest

Isometric View Looking Southwest

Isometric View Looking Northeast

Figure 5. Bridge Pier 1 Isometric Views

Orthographic View West Face

Orthographic View South Face

Orthographic View East Face

Orthographic View North Face

Figure 6. Bridge Pier 1 Orthographic Views

Isometric View Looking Northeast

Isometric View Looking Southwest

Isometric View Looking Northeast

Isometric View Looking Southwest

Figure 7. Bridge Pier 2 Isometric Views

Orthographic View West Face

Orthographic View South Face

Orthographic View East Face

Orthographic View North Face

Figure 8. Bridge Pier 2 Orthographic Views

Isometric View Looking Northeast

Isometric View Looking Southwest

Isometric View Looking Southwest

Isometric View Looking Northeast

Figure 9. Bridge Pier 3 Isometric Views

Orthographic View West Face

Orthographic View South Face

Orthographic View East Face

Orthographic View North Face

Figure 10. Bridge Pier 3 Orthographic Views

Isometric View Looking Northeast

Isometric View Looking Southwest

Isometric View Looking Southwest

Isometric View Looking Northeast

Figure 11. Bridge Pier 4 Isometric Views

Orthographic View West Face

Orthographic View South Face

Orthographic View East Face

Orthographic View North Face

Figure 12. Bridge Pier 4 Orthographic Views

Isometric View Looking Northeast

Isometric View Looking Southwest

Isometric View Looking Southwest

Isometric View Looking Northeast

Figure 13. Bridge Pier 5 Isometric Views

Orthographic View West Face

Orthographic View South Face

Orthographic View East Face

Orthographic View North Face

Figure 14. Bridge Pier 5 Orthographic Views