Vibration-based Structural Health Monitoring of Two Vertical Lift Bridges

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Extended Abstract
Vibration-based structural health monitoring (SHM) can provide useful information for condition assessment of in-service bridge structures. The value of this type of monitoring program is increased for movable bridges, such as vertical lift bridges that raise bridge spans to allow vessel traffic. Unlike most other existing bridge monitoring systems that study random traffic and ambient vibrations, the lift span and mechanism will allow engineers to conduct long-term studies on structural responses caused by repeatable excitation inputs in real world settings with harsh marine environment. In this paper, the authors detailed the analyses of vibration data collected in two New Hampshire vertical lift bridges: the newly constructed Memorial Bridge (opened in 2013) and the historical Sarah Mildred Long Bridge (opened in 1938). Both bridges offered very unique opportunities for SHM: monitoring the Memorial Bridge in its very early, non-deteriorated stage and comparing vibration data collected before and after repairs at the Sarah Mildred Long Bridge that was impacted by a 473-foot cargo tanker in April 2013. Finite element models (FEMs) of the two bridges were created to compare the field data. By studying the frequency responses of the vibration data and the FEM, the authors were able to identify and explain noticeable changes between the healthy and damaged states of the Sarah Mildred Bridge and to verify select design assumptions of the Memorial Bridge.

Sarah Mildred Long Bridge

On April 1, 2013, a 473-foot cargo ship struck the Sarah Mildred Long Bridge, a 2804-foot double deck truss bridge, in Portsmouth, New Hampshire (Figure 1). The Sarah Mildred Long Bridge was constructed on 1940 and is considered structurally deficient by both the New Hampshire Departments of Transportation (NHDOT). Figure 2 illustrates the damage and...
sensor locations. The structural damage caused by the impact was confined to a vertical member and a diagonal member that were replaced and a lower chord that was heat straightened. Given that wireless sensors are very easy to deploy and remove, the NHDOT allowed access to the bridge and measurement of ambient vibrations during and after the repairs. Assessment of the collected vibration data, Figure 3, shows clearly that the impact of damage changed the dynamics behavior of the truss elements, causing the damaged bridge’s frequency response to shift right and upward. The field data was also used to calibrate a FEM to determine the structural properties that are changed due to the impact and repairs.

**The Memorial Bridge**

Bridges deliver such a fundamental service to society that they are taken for granted. Typically, bridges only stir the public’s interest when they must unexpectedly be replaced at great cost, or, worse, when they fail. Memorial Bridge carries US Route 1 across the Piscataqua River connecting Portsmouth, NH with Kittery, ME. The Memorial Bridge is the first ‘gussetless’ truss bridge in the world, see Figure 4, and NHDOT engineers are using a metalized coating for the steel members The structural monitoring will capture the behavior of these “gussetless” connections from traffic excitation and the impact of the lifting and lowering of the movable span. During Summer 2015,
accelerometers and strain sensors were temporarily deployed at three locations, as shown in Figure 5, to determine the optimal sensors location, adhesive method and wireless communication capabilities. Figure 6 shows the strain and vibration data collection in June 2015. This limited data from the temporary deployment was also used to as an initial attempt to calibrate a FEM for structural condition assessment.

![June 10th Strain Data during Lift Event at 11:30 am](image)

**Figure 6 Vibration Data from Location 2 on June 10, 2015**

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**References**


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