Monitoring of the Saylorville and Red Rock Reservoir Bridges for Wind-Induced Vibrations

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EXTENDED ABSTRACT

During a high-wind event in January of 2006, several motorists reported vertical movements of the bridge superstructure over the Saylorville Reservoir. On February 2006, an inspection of the bridge was conducted by representatives from the Iowa Department of Transportation (Iowa DOT) and Iowa State University. During that inspection, no signs of excessive bridge movement could be identified. Areas of specific interest during that inspection included cross-bracing, stiffener-to-web welds, and expansion joints. The Iowa DOT subsequently performed a preliminary literature investigation to determine if any similar event might have occurred in the past, and if so, if any technical information was available. The Iowa DOT determined that implementing a monitoring project on the Saylorville Bridge to better assess the potential for a significant wind-induced event to occur was needed. Furthermore, the monitoring project would alert the Iowa DOT of wind events over a preset threshold. After the monitoring system had been in place and operating on the Saylorville Bridge, the Iowa DOT decided to develop a similar monitoring project on the Red Rock Bridge as well.

The Saylorville Bridge is composed of five main sections separated by expansion joints. Each of these five sections is composed of five spans, consisting of two 168 ft end spans and three 216 ft interior spans; the total length of the structure is 4,920 ft. The superstructure is composed of four steel girders spaced at 9 ft 4 in. and a concrete deck. Rather than monitoring the entire structure, the research team selected one span within one of the five sections to install the monitoring system. The team first decided to use an interior main section, in this case, the first interior main section from the southern end of the bridge. Within this main section, it was again deduced that an interior span was desirable, so the first interior span
from the northern end of this section was selected so as to be closest to the center of the overall bridge as possible. See Figure 1 for the location of the instrumented span.

![Figure 1. Saylorville Bridge plan layout showing instrumented span location](image)

The monitoring system developed for the Saylorville Bridge included strain gages, accelerometers, an anemometer, a data logger, a wireless modem, and a wireless cell phone account. One strain gage was mounted on the bottom flange of each of the four girders of the selected span at mid span. In addition, an accelerometer was installed at mid span and quarter span of one interior girder and mid span of one exterior girder. At the north pier of the selected span, a weatherproof box was mounted on the top of the pier cap to house the datalogger, wireless modem, and battery pack. In addition, a mount was created for the anemometer that attached to the guardrail near the pier. The mount offset the anemometer approximately 5 ft from the guardrail and approximately 20 ft above the roadway (ideal would be 30 ft). Power for the system is obtained from a 10 watt solar panel mounted on the southeastern side of the pier cap. See Figure 2 for photos of the solar panel and weatherproof box.

![Figure 2. Solar panel and datalogger box](image)

Communication with the system is achieved via an unrestricted static IP address on the Verizon Wireless Network using the cellular modem on site. Using a properly set up computer with internet service, the user can log onto the data logger and view data (strain, accelerations, wind speed, direction, battery
power, etc.) in either a graphical or tabular format (see Figure 3 for a typical plot). In addition, preset triggers have been programmed into the system to provide warnings to the appropriate personnel. At the moment, the trigger is set to go off at a wind speed greater than 50 mph from any direction. If the trigger criterion is met, the system sends a text message ‘(Bridge Alarm) Saylorville Bridge System Alert. Trigger Wind Speed is ##.### MPH. Logger time is Date, Time’ to Iowa DOT and Bridge Engineering Center personnel who alert the appropriate personnel to handle the situation. Currently, when a trigger alert is received, Iowa DOT officials respond and close off the bridge to traffic. The trigger interval is set to 20 min, so that as long as triggers are being received, the bridge remains closed. Once 30 min has passed since the last trigger and the officials on site judge that winds have diminished to a safe level, the bridge is reopened.

Prior to this final trigger setting and response criterion, the trigger level was set at a lower level (25 mph) so that the system would be more frequently triggered and could be adequately tested for functionality. Once the reliability of the system had been proven, final adjustments were made to the current settings. To date, there have been two instances of a bridge closure as a result of wind speeds exceeding the 50 mph trigger threshold. The first instance lasted for several hours and produced peak wind speeds of approximately 68 mph; the second instance was shorter but still produced peak wind speeds of approximately 60 mph.

Currently, a similar system is being set up for installation at the Red Rock Reservoir Bridge. The system will include all the same hardware and software and function the same as the system on the Saylorville Bridge.

**Key words:** bridge—long-term structural monitoring—structural health monitoring—wind loading—wind-induced vibration