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RESEARCH PROJECT TITLE

Wind Monitoring of the Saylorville and Red Rock Reservoir Bridges with Remote, Cellular-Based Notifications

SPONSORS

Iowa Department of Transportation
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The Bridge Engineering Center (BEC) is part of the Institute for Transportation (InTrans) at Iowa State University. The mission of the BEC is to conduct research on bridge technologies to help bridge designers/owners design, build, and maintain long-lasting bridges.

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Wind Monitoring of the Saylorville and Red Rock Reservoir Bridges with Remote, Cellular-Based Notifications

tech transfer summary

This monitoring system records, stores, and posts live wind speed data in a graphic format to the internet.

Background

Following high winds on January 24, 2006, at least five people claimed to have seen or felt the superstructure of the Saylorville Reservoir Bridge in central Iowa moving both vertically and laterally. Since that time, the Iowa Department of Transportation (DOT) contracted with the Bridge Engineering Center at Iowa State University to design and install a monitoring system capable of providing notification of the occurrence of subsequent high winds.

Although measures were put into place following the 2006 event at the Saylorville Reservoir Bridge, knowledge of the performance of this bridge during high wind events was incomplete. Therefore, the Saylorville Reservoir Bridge was outfitted with an information management system to investigate the structural performance of the structure and the potential for safety risks.

In subsequent years, given the similarities between the Saylorville and Red Rock Reservoir bridges, a similar system was added to the Red Rock Reservoir Bridge southeast of Des Moines. The monitoring system developed and installed on these two bridges was designed to monitor the wind speed and direction at the bridge and, via a cellular modem, send a text message to Iowa DOT staff when wind speeds meet a predetermined threshold.

The original intent was that, once the text message is received, the bridge entrances would be closed until wind speeds diminish to safe levels.



Anemometer mount at the Saylorville Reservoir Bridge



Cellular antenna and solar panel mounted on A-frame



Datalogger enclosure mounted on A-frame

Once the system was functioning and providing the Iowa DOT with accurate, reliable alerts that allowed for the safe and timely closing of the structure during high wind events, there was a desire to provide the wind data information to Iowa DOT personnel as well as to the public.

Scope and Objectives

The system developed provides a mechanism to not only generate wind-related safety alerts, but also store and process the recorded data and then publish that information, live, to a website for viewing.

The objectives of the system development and implementation are as follows:

- Notify Iowa DOT personnel when the wind speed reaches a predetermined threshold such that the bridge can be closed for the safety of the public
- Correlate structural response with wind-induced response
- Gather historical wind data at these structures for future assessments

System Components

The desired functionality of the system was to capture wind-related information (wind speed and direction) and store, process, and disseminate that information quickly and accurately via the internet. To accomplish this, the following pieces of hardware were selected for the data acquisition system:

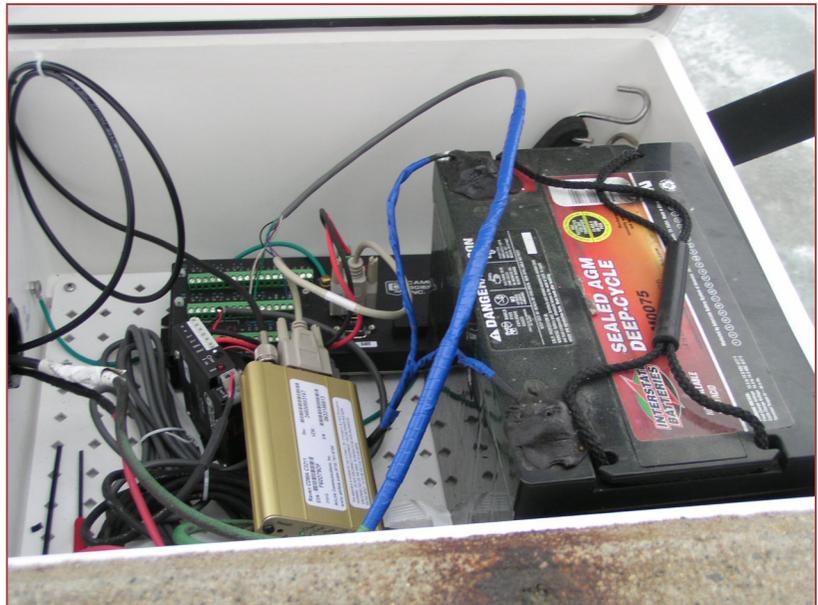
- Anemometer
- Campbell Scientific CR1000 datalogger
- Cellular modem
- Deep-cycle battery
- Solar panel
- A-frame mount
- Steel pole
- Antenna
- Offsite webserver

To facilitate the collection of accurate wind data and minimize effects from passing vehicles, the anemometer was mounted on a 20 ft, 2 in. diameter steel pole mounted to the bridge guardrail via a prefabricated A-frame bracket.

The A-frame mount, in addition to providing support for the pole, set the pole a safe distance away from the guardrail to provide room for oversized loads and snowplows in the winter months.

The A-frame was also utilized for mounting the cellular antenna, solar panel, and hardware enclosure. Initially, these pieces of equipment were installed on top of the pier underneath the bridge; however, to allow for ease of maintenance, they were moved to the A-frame next to the guardrail.

The A-frames at Saylorville and Red Rock vary slightly in geometry, but the general concept and layout of equipment is similar. The enclosure provides security and weather protection for the datalogger, cellular modem, and deep-cycle battery.



Monitoring equipment inside enclosure at the Saylorville Reservoir Bridge

Key Findings

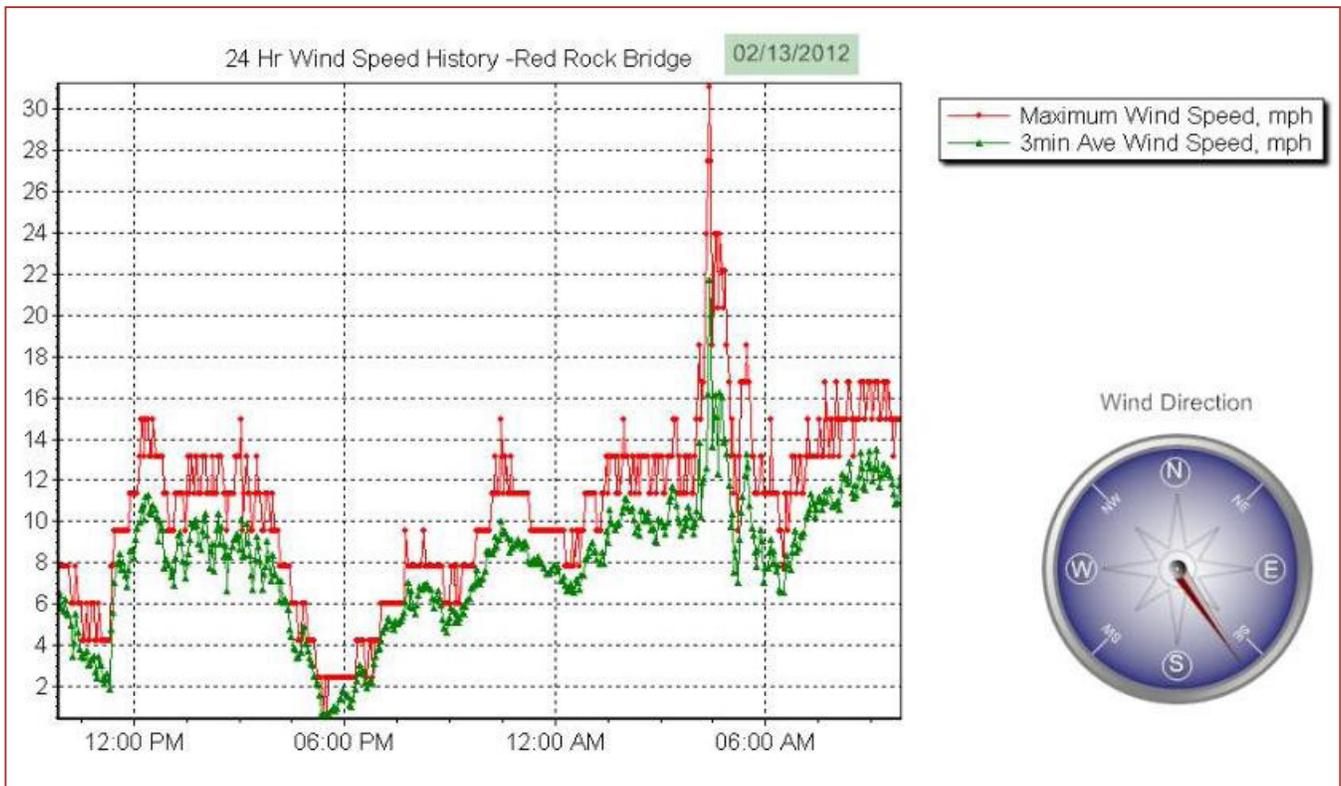
In general, the most typical wind direction at both locations is the northwest (NW) or southeast (SE) directions, with the Saylorville location being slightly more toward the north and south directions than the Red Rock location. In both cases, these typical winds correspond to a direction nearly perpendicular to the bridge length and parallel to the river/reservoir channel.

Based on data collected over the one-year duration of the project, the wind data suggest that both locations (Saylorville and Red Rock) experience similar trends in wind direction, 3 minute average wind speed, and 3 minute maximum wind speed.

Comparison of the plots from Saylorville and Red Rock show striking similarities in distribution of average wind speed, with the Red Rock Reservoir Bridge experiencing about a 30 to 34 percent increase in the frequency of wind speeds averaging between 5 and 10 mph and 10 and 15 mph, while all other categories are relatively similar in frequency. In addition, the highest percentages of average wind speed are between the 5 and 20 mph ranges for both locations.

Similar results were found when plotting the 3 minute maximum wind speed percentages for both locations. The highest 3 minute maximum wind speed category for both locations was the 65 to 70 mph category, with the Saylorville Bridge having two occurrences and the Red Rock Bridge having one occurrence during the one-year duration of this project.

Based on the research team's experience with these two systems in the years prior to the upgrade (which allowed for more advanced data analysis), one to two occurrences of those peak wind speeds (65 to 70 mph) at these bridges appears to be typical.



Typical 24 hr wind speed history plot from Saylorville/Red Rock website

Implementation Readiness and Benefits

In summary, the Iowa DOT wind monitoring systems at the Saylorville Reservoir Bridge and Red Rock Reservoir Bridge are capable of recording, storing, and posting live wind data from the locations to the internet.

Prior to modifications, the system only provided real-time alerts to Iowa DOT and pertinent law enforcement personnel related to wind speed thresholds measured on the bridges (and these capabilities still exist).

The alerts allow the Iowa DOT and law enforcement to divert traffic quickly when wind conditions make bridge passage unsafe.

With the recent modifications, the Iowa DOT and law enforcement personnel are able to make decisions based on real-time weather information so that more accurate decisions about bridge closure and duration of closure may be made.

Furthermore, the system that was developed can be implemented on other bridges with the data presented in a similar form and format.