



Montana: Bridge Deck Performance

CR5000s help researchers plan for better infrastructure health and design

Amidst a vast expanse of farming and range lands, bridge designers from the Montana Department of Transportation (MDT) recognized a unique opportunity to evaluate highway bridge deck design. Near the small town of Saco, Montana, three bridges were constructed less than one mile apart along the same highway corridor, Montana State Route 243. Consequently, each bridge will experience identical demands from weather, traffic, and winter maintenance. Each bridge has three 15 m spans, incorporating a reinforced concrete deck-on-prestressed stringer design with identical global dimensions and substructure components. The only difference among them is the composition of the reinforced concrete deck. The "Conventional" deck represents the standard deck used in Montana—a conventional concrete with a standard rebar pattern. The "Empirical" deck also uses conventional concrete, but employs approximately one-third the amount of reinforcing steel. The "HPC" deck uses a standard rebar pattern with a high-strength concrete. MDT contracted with The Western Transportation Institute (WTI) at Montana State University to design and install an instrumentation system, acquire data from this system and perform subsequent analysis to evaluate the performance of the three bridge decks.

Instrumentation

During the planning phases of the project, finite element analysis was done on the three deck configurations to identify critical locations in the bridge decks for placing strain gages. Based on this analysis, the instrumentation is primarily concentrated in a single driving lane of one 15 m span of each three-span bridge (approx. 1/6th of the bridge). The strain gages were placed in each bridge deck prior to casting the concrete. The gages were positioned to monitor both longitudinal and transverse strains at three different depths through the thickness of the deck. Three different strain gage technologies were used in each bridge: 35 Vishay foil strain gages bonded to reinforcing steel, 7 Vishay embedment-type strain gages suspended in the concrete and 16 Geokon vibrating wire strain gages suspended in the concrete. Additionally, 16 temperatures are recorded via thermistors internal to the vibrating wire strain gages. To monitor ambient conditions, a weather station was erected at the Saco Public School, located approximately one mile from the bridge sites. Temperature, barometric pressure, wind speed/direction, and relative humidity values are measured at 15 minute intervals and posted to the Internet for public viewing.

Data Acquisition

All strain data is collected and stored using a single CR5000 Measurement and Control System mounted under each bridge. The bonded and embedded gages require Wheatstone Bridge arrangements designed and fabricated by WTI. Corresponding voltages are routed through a single AM16/32 multiplexer. Vibrating wire strains and temperatures are read using a single AWW1 Vibrating Wire Interface coupled with an AM16/32 multiplexer. All gages are read once every hour. Data from each bridge is periodically transmitted to WTI through the Internet via a network of RF400 Spread Spectrum radios based at the Saco School. Weather data is monitored using a CR10X Measurement and Control System and transmitted directly to WTI via the Internet.

Long-Term Evaluation

Case Study Summary

Application

Long-term bridge deck performance and live load testing of experimental bridge deck sites

Location

Saco, Montana, USA

Products Used

CR5000, AM16/32B, NL100

Contributors

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Participating Organisations

Montana Department of Transportation (MDT), Western Transportation Institute

Measured Parameters

CR5000 Deck Performance: strain (bonded foil, vibrating wire) temperature (thermistors) CR10X weather: air temperature, wind speed, wind direction, barometric pressure, relative humidity

Related Website

[Western Transportation Institute](http://www.westerntransportationinstitute.org)

One of the primary objectives of the Saco Bridge Deck Evaluation is the comparative analysis of long-term bridge deck performance. This objective will be accomplished through qualitative and quantitative analyses of bridge deck conditions over a two-year period. Ideally, the project will be extended for several years to more fully evaluate relative deck performance throughout their service lives. Qualitative analyses include crack mapping and surveying operations. Quantitative analyses are mostly focused on how strains in the bridge decks change when exposed to changing weather conditions and vehicle load events. In addition to hourly monitoring of deck conditions, a subset of the strain gages remains continually active to capture "large vehicle events." When calibrated against portable weigh-in-motion (WIM) traffic records, large event data will offer an estimate of the cumulative demands placed on the bridges from traffic loading.

Live Load Testing

A second objective of this project is to compare the load carrying mechanisms of the three bridge decks. This objective is being realized by a series of live load tests. Before being opened to traffic, heavily loaded vehicles were driven slowly along the full length of each bridge along several different longitudinal paths. During each test event, 41 channels of rebar-bonded and concrete-embedment strain gage data were recorded. To accommodate the number of sensors in each bridge and a rapid data acquisition rate, all three CR5000s were simultaneously used during live load testing. Longitudinal positioning of the truck during the test was recorded via a hand-held electronic button, engaged as the test truck traveled every two meters along the deck. In addition to the local deck strains recorded by the internal strain gages, global behaviors were monitored using gages temporarily affixed to the bottom of the stringers, supplied by Bridge Diagnostics, Inc. (BDI). A majority of the tests were conducted using one tandem-axle dump truck. To simulate "worst case" behavior, two vehicles were driven side-by-side along the length of the bridge. High-speed tests were also conducted using a single truck traversing the bridge at 60 mph. A second live load test is scheduled to take place after the bridges have been in service for two years.

Outcome

At present, comparative investigation of bridge deck behavior with this level of detail and control of variables has been limited. This study presents a unique opportunity to develop a better understanding of local reinforced concrete bridge deck behaviors and load paths through the deck and substructure. Researchers and departments of transportation alike will benefit from a heightened understanding of bridge deck performance under vehicle loading and varying, long-term weather conditions. Application of this knowledge will lead to better planning for infrastructure health as well as improved bridge deck design.

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