MPC-400
Time Duration 2012-2013

Project Title:
Evaluation of Ice Loads on Bridge Piers in South Dakota-Yrs 2 & 3 (Continued Project)

University:
South Dakota State University

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Research Needs:
Ice load on bridge structure is one of the major components for Extreme Event load combinations specified in the AASHTO Code. In seismic inactive regions such as South Dakota, ice load can be the predominant lateral load that governs the design of bridge substructures. Accurate estimation on the magnitude of ice forces that act on bridge piers and abutments in northern climates is a major concern in the design of new bridges and in the evaluation of existing bridges. While empirical equations were provided by AASHTO to calculate the design ice load based mainly on effective ice strength and thickness, these formulas were developed assuming thick ice formation which is quite different from the “ice cakes” that form on South Dakota rivers. Thus even with very accurate ice strength and thickness values, ice load calculated based on AASHTO formulas may still be inaccurate. This inaccuracy will lead to inappropriate pier designs that may cost the public in the long run.

Field measurement of ice load is the most direct and accurate approach to obtain local pier-ice interaction data and has seen its applications in several cold region bridges (e.g. Brown et al. 2010). The proposed work focuses on directly measuring ice load at critical sites in South Dakota and comparing the actual load statistics with codified load values. Combined with existing studies on ice conditions formerly conducted within the state (USGS report released in 2002), the

information gathered in this study will provide the bridge designers with more accurate and confident ice load values for new bridge design as well as existing bridge evaluation.

Research Objectives:
The objectives of the proposed study include: 1) Develop an efficient and easy-to –implement ice load monitoring system for bridge sub-structures in cold regions; 2) Accurately monitor extreme ice loads exerted on bridge piers at selected site in South Dakota; and 3) Provide recommendation for the application of AASHTO ice load section in South Dakota based on measured ice loads.

Research Methods:
The actual ice load at two selected South Dakota bridge sites will be continuously monitored through two winters using a custom designed device and solar powered data-logger. The collected ice impact data will be analyzed statistically, together with the public weather data during the monitoring period. The data collected in this project will be combined with existing data on ice strength and thickness to develop recommendations for realistic design ice load values for SD rivers.

Expected Outcomes:
A reliable and easy-to-implement field monitoring system for extreme ice loads on bridge substructure will facilitate bridge health monitoring under ice load conditions for cold regions such as North and South Dakota. The data collected in this study will hold its own value as the first hand field ice-pier interaction data set in South Dakota. Calibration of design ice load parameters based on realistic data gathered in this study will enhance safety and reliability of current bridge design practices in South Dakota.

At the end of the study, a comprehensive report will be published to document the research procedures and results, and to provide recommendations for calibrated ice load design parameters to be used for South Dakota. Prototype ice load monitoring system will be able to remain in field and continue collecting data in the future depending on the need and future funding from South Dakota Dot. Graduate students and Dot personals will be trained on the use of the data collecting system through involvement in the research.

Relevance to Strategic Goals:
1. Improved Infrastructure Design
2. Infrastructure Longevity
3. Economic Analysis of Investments and Impacts

Educational Benefits:
Not Applicable

Work Plan:
The proposed study will include following Tasks:

Task 1: Literature review and site selection. Existing hydrology records related to ice load conditions in South Dakota will be gathered in order to identify critical instrumentation

sites that can potentially provide the most comprehensive information about design ice load within the state. A thorough review of existing analytical and experimental studies on ice load investigation will be conducted in order to identify the most effective and cost-saving technology that is applicable to the selected site.

Task 2: Development of prototype ice-load monitoring system. A prototype ice-load monitoring system will be designed to automatically acquire ice load data over time. Data collection will be triggered by ice loading events of predefined magnitude. The system will be weather proof and only require minimum maintenance.

Task 3: Manufacturing, testing, and installation of monitoring system at selected sites. Monitoring system designed in Task 2 will be built and tested first in laboratory conditions. Then it will be installed at the bridge site with the assistance and permission from South Dakota Dot.

Task 4: Data collection and system maintenance. Graduate and undergraduate students will travel to bridge site to perform necessary system check and maintenance. Data will be collected remotely through wireless devices in order to avoid interruption of data collection due to severe weather conditions.

Task 5: Statistical and analytical analysis on ice load data. The data collected will be used to evaluate statistical characteristics of the ice load condition at instrumented site. Analytical models for pier and ice interaction will also be constructed and calibrated with the collected data.

Task 6: Evaluation for the applicability of AASHTO ice load formula to South Dakota river conditions. Conduct calibration and develop equivalent design parameters based on AASHTO ice load formula that will provide appropriate level of load values consistent with the field measurements. These equivalent parameters may not carry explicit physical meaning but can be used by designers directly to determine realistic ice load values in the design of South Dakota bridges.

Task 7: Final report. A comprehensive report will be prepared which summaries the literature review, research methodology, findings, conclusions and recommendations.

Project Cost:

Total Project Costs: $83,666

MPC Funds Requested: $31,801

Matching Funds: $115,467 Source of Matching Funds: SDDOT and SDSU

TRB Keywords: Ice load, Bridge design, Extreme load, Monitoring, Code calibration.

References:

Brown, T.G et al., 2010, Extreme Ice Load Events on the Confederation Bridge, Cold Regions Science and Technology, 60, pg: 1-14.

AASHTO, 2010, AASHTO LRFD Bridge Design Specifications, Fifth Edition, Washington DC.

U.S. Geological Survey, 2002, Estimation of Ice Thickness and Strength for Determination of Lateral Ice Loads on Bridge Substructures in South Dakota, Technical Report SD98-04-F, September 2002.