OHIO DEPARTMENT OF TRANSPORTATION
OFFICE OF STRUCTURAL ENGINEERING
RESEARCH IMPLEMENTATION PLAN

Title: Dynamic Load Environment of Bridge Mounted Sign Support Structure

State Job Number: 134153
PID Number: 77021
Research Agency: Case Western Reserve University
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Study Start Date: 11/1/2003
Study Completion Date: 6/1/2005
Study Duration: 19 months
Study Cost: $10,000
Study Funding Type: 80 Federal / 20 State from ODOT SPR (2)

STATEMENT OF NEED:
Welded aluminum highway sign support trusses must withstand in-service dynamic loads, which largely constitute the fatigue environment. Sources of these dynamic loads include the natural wind and seismic environment, the artificial wind environment created by passing vehicle-induced motions of the supporting bridge. A bridge mounted sign support structure located in ODOT District 12, on the I-77/I-480 interchange just south of Cleveland, suffered a fatigue failure of an upper chord member adjacent to a support tower.

RESEARCH OBJECTIVES:
The objective of this study is to initiate an investigation into the dynamic load environment of this failed sign support structure. This research will quantify the dynamic characteristics of the in-situ structure both analytically and experimentally, and it will investigate the Potential dynamic interaction between this sign structure and the supporting bridge structure. The traffic-induced dynamic motions of the bridge at the location of the sign support towers will be measured in-situ, so as to quantify the resulting dynamic loading imposed on the sign support structure.

RESEARCH TASKS:
- Prepare a detailed dynamic finite element model of the failed sign structures to ascertain expected dynamic characteristics.
- Measure in-situ the natural frequencies, and damping ratios of the structures.
- Prepare a detailed finite element model of the supporting bridge to investigate the potential interactions between the sign structure and the bridge, as well as the expected in-situ differential motions of the sign supports.
- Measure in-situ motions of the bridge structure at the location of the sign support towers to obtain input excitations of dynamic finite element simulations of the sign structure.
- Conduct finite element simulation of the sign support structure in its expected dynamic environment to predict the expected fatigue lifetime.
- Compare this prediction to the actual lifetime.

RESEARCH DELIVERABLES:

- The final report will describe all research activities, findings, and conclusions.

RESEARCH RECOMMENDATIONS:

Both modal analysis and time history analysis for moving vehicle loads were performed. The analysis results indicated that the failure was a classical fatigue rupture, induced primarily by the dynamic effect of moving truck traffic on the bridge. Even though inferred stress levels were well below the CAFL for the AASHTO category ET detail in question (.44 ksi), the extremely high number of low amplitude traffic-induced stress cycles (in the hundreds of millions), combined with the absence of an endurance limit for welded aluminum, resulted in the observed failure. The predicted lifetime of the replacement sign support structure is approximately that exhibited by the original structure, namely thirty to forty years, and regular inspection is advisable. The lifetime of the truss can be increased by enhancing the truss capacity or its location on the bridge, or by utilizing a steel truss rather than an aluminum truss:

- To accommodate the range of axial forces in the diagonal members of the truss, a larger aluminum cross section could be used to decrease the induced stresses. A decreased stress range would greatly increase the lifetime of the truss members; increasing the cross section by 30%, for example, would increase the expected lifetime of the weld detail to 83 years.

- The lifetime of the truss can also be increased by relocating it to the piers, where there will be negligible induced support vibration due to traffic load.

- The sign could also be relocated to the part of the bridge with a more symmetrical cross section that has less torsional motion, as the torsional bridge mode was closest in natural frequency to the natural vibration modes of the truss.

- The sign support truss could be fabricated from steel, which does tend to exhibit an endurance limit, below which fatigue life is presumably unlimited.

PROJECT PANEL COMMENTS:

None

IMPLEMENTATION STEPS & TIME FRAME:

- Educate and promote the annual inspection of bridge mounted signs to look for fatigued members. Line No. 63 of BR-86 Form shall be filled out thoroughly when bridge mounted signs situations exist. This step will be on going and to be mentioned during bridge inspection training seminars.

- A new policy will be added to the BDM for proper location of new bridge mounted signs. This step is anticipated to be complete by June, 2006.

EXPECTED BENEFITS:

- Safety will be enhanced by detecting fatigued members before failure.
- Sign reconstruction will be better planned.
- Avoiding highway shutdowns in failure events.

EXPECTED RISKS, OBSTACLES, & STRATEGIES TO OVERCOME THEM:
None expected.

OTHER ODOT OFFICES AFFECTED BY THE CHANGE:
- Production.
- Construction.
- Districts.

PROGRESS REPORTING & TIME FRAME:
There will be a quarterly report sent to the R&D Office showing all implemented steps with their respective completion in percent. An annual summary report will be provided by the program office for three years after implementation is complete to measure implementation costs and benefits for research performance purposes. Progress reporting is anticipated to start in March, 2006.

TECHNOLOGY TRANSFER METHODS TO BE USED:
- The final report of this research will be available online at the ODOT website.
- The Bridge Design Manual (BDM) will be updated to include the new requirements.
- The bridge inspection training seminars will facilitate to spread the word out.

IMPLEMENTATION COST & SOURCE OF FUNDING:
It will be a very minimal cost to implement. There will be an additional time to thoroughly inspect the structural members of the bridge mounted signs. Once fatigued members were discovered, district constructions funds will pay for the replacement.

Approved By: (attached additional sheets if necessary)

Office Administrator:

Signature: Tim Keller Office: OSE Date: 11/21/2005

Division Deputy Director:

Signature: Tony Vogel Division: DHO Date: 11/21/2005