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USING LIGHTWEIGHT MPC WOOD TRUSSES IN BRIDGES

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Abstract

Lightweight Metal Plate Connector (MPC) wood trusses offer advantages for short span rural bridges such as ease of construction, high stiffness and wide availability. It is shown that these trusses may be used in bridge applications provided that proper design for fatigue of the MPC joints, proper corrosion protection and proper details to prevent MPC back-out are incorporated into the design. Recommendations for fatigue design are given. Two MPC truss bridges, one 14.0 m (46 ft) long and the other 11.8 m (39 ft) long built in Maine in 1993 and 1994 are briefly described.

Introduction

Except for a bridge recently constructed in Alabama (Trish, 1994), MPC wood trusses have not been used in vehicular bridge construction. In many parts of the country the largest-capacity wood structural member constructed is the MPC truss. MPC trusses are easy to handle, they are constructed using widely available dimension lumber and they offer high stiffness which is particularly important in timber bridge construction. A number of configurations of timber bridges which use MPC trusses are possible (Dagher et. al., 1992).

This paper summarizes the results of a cooperative research effort initiated in 1991 between the University

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of Maine and the USDA Forest Products Laboratory to develop timber bridge designs using MPC trusses. The research addressed the following concerns:

1. Fatigue: MPC joints are commonly made using thin 20 gage steel sheets. The metal sheets are punched with a dye to form teeth or nails that become an integral part of the plate. The punching causes stress concentrations in the already thin plates and makes them more susceptible to fatigue.

2. Corrosion: MPC plates are commonly galvanized before they are punched. After punching, the unprotected steel is exposed in the critical areas around the teeth. Stainless steel plates are prohibitively expensive.

3. Plate 'back-out': Very much like nails, MPCs may 'back-out' when the wood is subjected to repeated cycles of wetting and drying.

Summary of fatigue testing and design recommendations

Over 160 high-cycle 'fatigue tests and 150 static tests on individual MPC connectors were conducted at UMaine over a period of three years. Typical tests were carried out until 2 million cycles were reached and the residual strength of the MPC joint was determined. Tests were conducted in both tension and shear. Many parameters were varied including the load and plate direction with respect to the wood, type of plate, plate material, plate confinement, number of rows of teeth, speed of fatigue testing and some specimen were moisture cycled at the FPL prior to fatigue testing at UMaine.

Using the test results, fatigue design criteria for MPC joints were developed. The following criteria insure adequate strength of the MPC joints for 2 million load repetitions:

Check 1: Static design for total stress:

(DL+LL+Impact+ etc...) stresses	<	allowable stress of MPC supplied by manufacturer

The joints are designed for total stress using the plate manufacturer's allowable static design values.

Check 2: Fatigue design for LL+Impact only:

(LL+Impact) stresses	<	.60 (allow. static tooth holding)
	<	.35 (allow. static plate tension)
	<	.35 (allow. static shear values)

The joints are designed for fatigue by reducing the manufacturer's static allowable design values. An example of the proposed fatigue design criteria using 20 gage MITEK and ALPINE plates is given by Dagher et. al. (1994).

The proposed fatigue design criteria were developed primarily by testing ALPINE 20-gage MPC joints and some MITEK joints. It is likely that the reduction factors for fatigue will change from one type of plate to another and from one manufacturer to another.

Two Demonstration Bridges

Two demonstration MPC truss bridges funded through the Federal Highway timber bridge demonstration program were constructed in Maine. The first demonstration bridge, located in Byron, is 14.O m (46 ft) long and 9.8 m (32 ft) wide. The second, located in N. Yarmouth, is 11.8 m (39 ft) long and 9.5 m (31 ft) wide. Both bridges were designed for HS25 loading.

Trusses and spacer units were alternated side by side to form the complete width of the bridge. They were stressed in the transverse direction using epoxy-coated DYWIDAG rods. A spacer consists of a 'stripped down' truss with essentially a top and a bottom chord and only enough MPC joints and webs so that the truss can be handled as a single unit. The spacer units prevent metal-on-metal contact of the MPCs in adjacent trusses and prevent distortion of the bridge during stressing. Also, placement of the trusses side by side prevents backing out of the plates due to moisture fluctuations and fatigue loading. The trusses were lifted onto the abutments in pre-assembled modules which were held together by nails and metal straps.

The MPCs were galvanized before punching and they were brush-painted with an epoxy paint after the trusses were manufactured. This protection system is one of five recommended for use on MPC connectors by the Steel Painting Council to yield a 70 year life in a "sheltered marine environment" (Bruno et. al., 1989). Additional protection of both the plates and the wood against water is provided by a membrane which is placed on top of the trusses and paved over with asphalt. The bridges have no separate deck since traffic runs directly over the top chords of the trusses.

The Byron bridge was load tested and opened to traffic in Nov., 1993. The N. Yarmouth bridge was load tested and opened to traffic in June 1994. The load tests verified the very high stiffness of this bridge system. Under two 311 kN (70,000 lbs) dump trucks positioned so as to maximize deflections, the measured deflection in both bridges was less than L/2300. A remote data acquisition system is now operational at both sites.

Conclusions

MPC trusses offer an attractive alternative for rural bridges. Their advantages are wide availability and ease of handling of the trusses, speed of construction and high stiffness. Proper fatigue design as described in this paper and corrosion protection are essential to insure longevity of the system.

The fatigue design criteria described in this paper are based on tests conducted using individual joints. They are currently being verified by conducting fatigue tests on full scale trusses.

Acknowledgments

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References

Bruno, J., Weaver, R., and Bernard, A. (1989) "Evaluation of Coatings for Metal Connector Plates" Steel Structures Painting Council Report 87-08, Pittsburgh, PA.

Dagher, H.J., Caccese, V, and Hsu, Y. (1992) "Feasibility of MCP Connectors in Timber Bridges: Fatigue Study." Report to the Forest Products Laboratory, Civil Engrg. Dept., Univ. of Maine.

Dagher, H.J., Caccese, V, and Hsu, Y. (1994) "Fatigue of Metal Connector Plates" Phase 1 Completion Report to the Forest Products Laboratory and the Federal Highway Administration, Civil Engrg. Dept., Univ. of Maine, 75pp.

Trish, M., Ritter, M., Lewis, S. and Wolfe, R. (1994) "Design and field performance of a Metal-Plate-Connected Wood Truss Bridge", Proceedings, ASCE Structures Congress XII, Atlanta Georgia.