Dynamic Design of Modular Bridge Expansion Joints by the Finite Element Method

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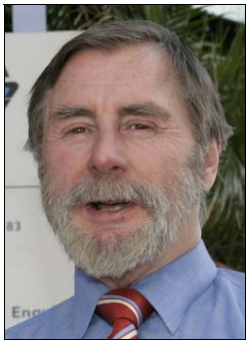

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Summary

Although it is not unusual for modular bridge expansion joints (MBEJ's) to be designed using the Finite Element Method, it appears that designers have been more concerned with quasi-static modelling rather than the development of a fully dynamic model that reproduces all of the characteristics of an operational MBEJ. The paper reports the calibration of a finite element model of both single support bar and multiple support bar design MBEJ's using experimental modal analysis and strain gauge data. Once calibrated, the models accurately reproduce the empirical vibrational modes and dynamic strains of the operational joints. Modelled results display acceptable variation with the measured data. As motor vehicle excitation is transient, a unique procedure was developed that utilised measured strain data to simulate the force-time history of a vehicle pass-by. This is described as a '*virtual dynamic truck pass-by*' and its application to the models permitted the accurate reproduction of all the dynamic characteristics including the dynamic amplification factor. The experimental modal analysis results of the single support bar MBEJ strongly suggested that in some regions, the dynamic response was linear and in other regions, non-linear. A moderately successful attempt was made to reproduce this effect by introducing non-linear stiffness into the model by way of the elastomeric bearings.

Keywords: Bridge decks; Bridges, cable-stayed; Damping; Expansion joints; Finite element method; Modal analysis; Strain measurement.

1. Introduction

Modular bridge expansion joints (MBEJ's) are widely used throughout the world for the provision of controlled pavement continuity during seismic, thermal expansion, contraction and long-term creep and shrinkage movements of bridge superstructures. Modular Bridge Joint Systems (MBJS) are considered to be the most modern design of waterproof bridge expansion joint currently available. The Roads and Traffic Authority of NSW (RTA) has experienced premature fatigue failure of MBEJ's in two bridges. Fatigue cracks were observed in Pheasant's Nest Bridge on the Hume Highway (opened December 1980) and Mooney Mooney Creek Bridge on the F3 Freeway (opened December 1986). The MBEJ's installed into both bridges are multiple support bar designs and are essentially identical having been supplied by the same European manufacturer. In addition, the RTA has a '*hybrid*' single support bar MBEJ in the western abutment of Sydney's Anzac Bridge. Whilst termed '*hybrid*', the Anzac joint consists of two interleaved single support bar structures that behave, in a dynamic sense, as quite independent structures. Although the Anzac MBEJ did not exhibit any evidence of fatigue induced cracking, a routine non-destructive examination of all accessible welds identified a number of manufacturing irregularities that were of concern.

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