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Estimating Characteristic Bridge Traffic Load Effects Using Bayesian Statistics

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ABSTRACT: This paper investigates the use of Bayesian updating to improve estimates of characteristic bridge traffic loading. Over recent years the use Weigh-In-Motion technologies has increased hugely. Large Weigh-In-Motion databases are now available for multiple sites on many road networks. The objective of this work is to use data gathered throughout a road network to improve site-specific estimates of bridge loading at a specific Weigh-In-Motion site on the network. Bayesian updating is a mathematical framework for combining prior knowledge with new sample data. The approach is applied here to bridge loading using a database of 81.6 million truck records, gathered at 19 sites in the US. The database represents the prior knowledge of loading throughout the road network and a new site on the network is simulated. The Bayesian approach is compared with a non-Bayesian approach, which uses only the site-specific data, and the results compared. It is found that the Bayesian approach significantly improves the accuracy of estimates of 75-year loading and, in particular, considerably reduces the standard deviation of the error. With the proposed approach less site-specific WIM data is required to obtain an accurate estimate of loading. This is particularly useful where there is concern over an existing bridge and accurate estimates of loading are required as a matter of urgency.

1. INTRODUCTION

Accurate modeling of bridge traffic loading is critically important in bridge engineering. At the design stage it allows the design of bridges which are fit for purpose, while reducing the waste associated with overdesign. In the assessment of existing structures, estimates of traffic loading are possibly more important. Where there is concern over an existing bridge, this information will determine whether a bridge needs to be repaired or replaced. If a bridge is saved as a result, significant cost savings can be made.

The most accurate method for modelling bridge traffic loading is to use Weigh-In-Motion (WIM) data. WIM systems measure truck weights and axle configurations as they pass along a road at normal highway speeds. Statistical methods are generally used to extrapolate from the relatively short WIM measurement period to the return period used for bridge design/assessment. In Europe, a return period of 1000 years is used for bridge design (EC1 2003) and a design life of 75 years is used in the US (AASHTO 2012).

A common extrapolation approach is to fit a statistical distribution to the measured data and to extrapolate to the required return period. The