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Traffic Load Models and Weigh-In-Motion Data

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Summary

During the evaluation of an existing bridge, measurements at the site can be used to update the traffic load model. Measurements can be made with either temporary Weigh-In-Motion (WIM) sensors installed on the road surface or with strain gauges installed on the structure. The aim of updating a traffic load model is to avoid costly interventions on an existing bridge that are often proposed as a result of an assessment using a design traffic load model. This paper presents the measurement of traffic loads and effects at a bridge site in Switzerland. Simultaneous measurements with temporary WIM sensors placed adjacent to a bridge and strain gauges on bridge elements were used to study vehicle characteristics and traffic load effects. The results of this study provide valuable information about the effects of actual traffic on bridges and the use of WIM data for bridge evaluation.

Keywords: Road bridges, traffic loads, weigh-in-motion, strain measurement.

Strain measurements

Static and dynamic load tests were carried out during a bridge closure using two 3-axle test vehicles with a total weight of approximately 25 tonnes each. Continuous dynamic measurements under normal traffic conditions were subsequently made over two periods totalling 18 days. Strain measurements during the static load test enabled the behaviour of the bridge to be assessed. These measurements showed that traffic load effects were lower than assumed during design, thereby illustrating the advantage of carrying out measurements on a structure as opposed to using a default structural model.

By processing the strain data from continuous measurement under normal traffic, it was possible to filter out noise, dynamic effects and temperature effects in order to identify vehicle loading events and to determine the peak static effect of traffic actions during each event. Figure 1 shows a histogram of peak stresses obtained by processing data recorded over a period of three days.

WIM Traffic survey

The vehicle survey was carried out using temporary Weigh-In-Motion sensors installed on the road surface at a distance of approximately 200 metres from the bridge. The portable WIM system consists of inductive loops to detect the presence of a vehicle and to measure its speed and length combined with WIMstrip capacitative sensors that weigh half of each axle. More than 30 000 heavy vehicles were measured using the WIM system over a period of 18 days. However, the system is sensitive to vehicle speed and experiences problems measuring axle groups. For this reason, erroneous measurements were later filtered out and approximately 10,600 heavy vehicles were retained for further analysis. A histogram of heavy vehicle total weight is shown in Figure 2.

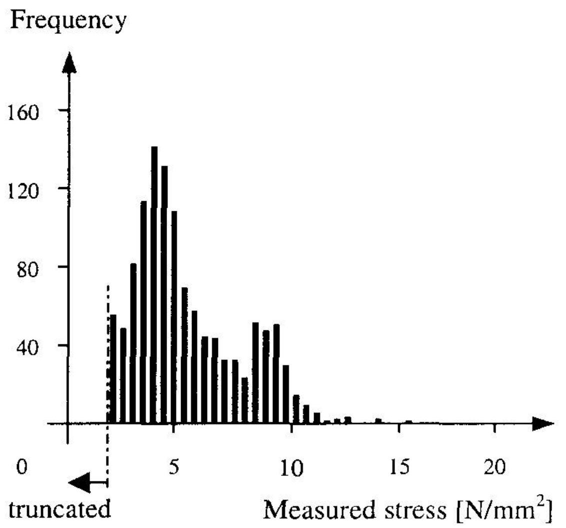

Fig. 1. Histogram of peak stresses measured under normal traffic conditions

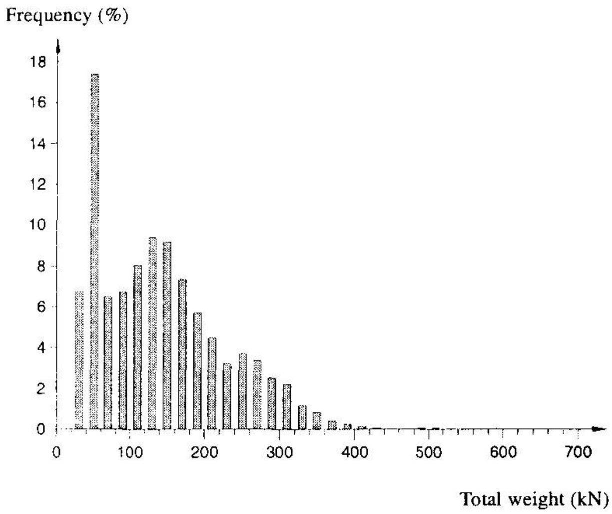

Fig. 2. Histogram of heavy-vehicle total weight

Discussion

The two approaches to updating traffic load models involve different amounts of effort and yield results of different quality. The continuous measurement of strains in a bridge requires expensive equipment and the use of expert technicians as well as complex data post-processing. On the other hand, the use of temporary WIM sensors is relatively straightforward and real-time processing produces vehicle data that is easy to use. In terms of financial investment in equipment and man-time, strain measurement is approximately twice as expensive as the use of temporary WIM sensors. This comparison of cost should in turn be balanced against the value of the data collected. In this respect, this study has shown that strain measurement yields precise data about traffic action effects and bridge behaviour, whereas vehicle data collected using temporary WIM sensors is subject to significant uncertainty. A decision about which approach to adopt must therefore be made by considering the purpose of measurement. If vehicle counting and a general idea of average vehicle loads is required then temporary WIM sensors suffice, otherwise a more costly permanent installation of WIM sensors is necessary for weight data of greater accuracy. If dynamic traffic action effects and bridge behaviour are of interest then strain measurement is preferable.

Conclusions

The measurements carried out as part of the study presented in this paper clearly demonstrate the relative advantages and disadvantages of two approaches to updating design traffic load models for bridge evaluation.

A traffic survey with a temporary WIM system has shown that measurements are subject to significant dispersion. The prediction of extreme traffic loads, in particular, is therefore subject to high uncertainty. Furthermore, traffic action effects calculated using traffic data are dependent on an assumed bridge model, thus introducing further uncertainty.

Strain measurement provides accurate information about the actual traffic action effects on a structure, but is limited to instrumented elements. Direct measurement provides information about load distribution within a structure, the combined effect of vehicles and dynamic effects. However, the volume of strain data recorded should be reduced by processing in real time.