Traffic Microsimulation for Bridge Loading Assessment and Management

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Summary

Traffic load is a highly variable parameter in the safety assessment of bridges. Its accurate assessment is important to avoid unnecessary and expensive rehabilitation measures for existing structures. Traffic microsimulation offers a comprehensive approach to the modelling of traffic. It is based on individual vehicle behaviour, with parameters that account for differences in vehicle type and driver behaviour. It inherently captures both free-flowing and congested traffic states, offering a more realistic picture of these states and their consequent loading on bridges. Further, microsimulation enables potential traffic management methods to be examined to estimate their effectiveness in mitigating critical loading scenarios. This work summarizes some recent results from the use of traffic microsimulation. Comparison with the Eurocode for bridge loading codes is made and various traffic management strategies are investigated for their effect on loading. The possibility of bridge-to-vehicle communication is explored, as is the use of lane change restrictions zones before the bridge. A bridge load control system is also examined. The results are persuasive: it is shown that microsimulation can be an important tool in more accurate assessment of the actual loading experienced by bridges, as well as providing a means to explore load control through traffic management. Given the ageing bridge stock and increasing financial limitations of the developed world, this work offers bridge owners a means of ensuring safety, whilst reducing costs.

Keywords: Bridges; Traffic; Loads; Microsimulation; Long-span; Congestion.

1. Introduction & Traffic Microsimulation

Many bridges are reaching the end of their design lives as the traffic they support is increasing. Almost 50% of Europe's 1 million bridges [1] were built before 1965 and so are close or at the end of their 50-year design lives whilst freight transport is projected to increase greatly. However, with a replacement cost of 30% of Gross Domestic Product (GDP) [1], replacement is not feasible.

Microsimulation is widely used in traffic engineering and many models have been developed. Its success is because it realistically models the movement of individual vehicles, and takes account of the interactions between vehicles, thus allowing for driver behaviour to be considered. The Intelligent Driver Model (IDM) is a microscopic vehicle-following model developed by Treiber and others [2] and it is proposed here to determine bridge traffic loading for different traffic states.

2. Bridge Assessment: Improving Estimates of Traffic Loading

The different traffic states that are observed in practice and replicated by microsimulation are significant because of the different densities and flow rates of each cause different levels of loading. The relative frequency of occurrence of each traffic state and thus each type of loading must also be considered. The view of traffic as being free-flowing or congested common in past work is thus simplistic, leading to inaccurate estimation of true loading. In this context, traffic microsimulation can help better estimate actual bridge loading for all traffic conditions.

Microsimulation has been used to show that the Eurocode load model may be conservative by up to

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25% in some cases [3]. It has also been used to calibrate a simple congestion model [4], and to assess the governing form of traffic (free-flowing with dynamics or congested) for different bridge lengths and load effects [2]. Traditional traffic loading models have difficulties in these areas.

3. Bridge Management: Controlling Traffic Loading

A great benefit of traffic microsimulation for loading assessment is that the influence of possible traffic control measures can be assessed relative to the status quo. Some recent works examine the influence of controlling gaps between vehicles [6][7], controlling lane changing in the vicinity of the bridge [8][9], and interrupting the traffic stream to avoid dangerous loading scenarios [10]. The maximum reductions in loading found were about 50%, 30% and 12% respectively. However, these management strategies require careful design of the parameters to maximize the benefit.

4. Summary

This paper proposes the use of traffic microsimulation to better estimate real traffic loading for bridge assessment and for managing the load carried by a bridge. Recent results are presented to illustrate the effectiveness of microsimulation in these areas. The results show that more accurate assessment and designed load control strategies can significantly reduce the traffic loadings for which a bridge must be assessed. Bridge owners may consequently yield significant savings.

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