Soft-WIM: Vehicle Identification from Bridge Measurement

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Summary

This paper presents an approach for the identification of operational loads given measured static responses of a bridge structure and its corresponding analytical model. In an optimization process single vehicles and corresponding attributes are identified from data recorded during the presence of one or multiple vehicles on the bridge. The vehicle attributes gross weight, velocity, axle loads and axle spacings are determined. The problem is solved by means of two encapsulated evolutionary optimization routines. The objective function is represented by the calculation of the difference between measured and computed strains. For measurement, only two sensors which are installed in one cross section without any installations on top of the bridge are required.

The application to real measurements as well as obtained results will be shown. The results demonstrate that structural health monitoring in conjunction with adequate mechanisms can successfully support the acquisition of additional, valuable information.

Keywords: Concrete bridges; monitoring; long-term measurements; load identification; weigh-in-motion; genetic programming.

1. Introduction

Compared to rail, inland waterways and air, Europe's road network is of prime economic significance for transport. The main part of passenger and freight transport is realised on roads and motorways. In 2004 4960 billion passenger-kilometres (pkm) were accomplished by passenger cars, busses and coaches in the EU-25. 958 billion pkm were carried by railway, tram, metro, waterborne and air. 84 % of the total passenger transport was performed on roads and motorways. The freight transport constituted 1724 billion tonne-kilometres (tkm) on the EU-25 roads in 2005. In comparison to the freight transport on rail and inland waterways, the roads carried almost 78 % of all freight [1]. Forecasts on the transport development in Europe indicate an intensification of this situation: The EU-15 traffic forecasts for 2010 show an increase in passenger transport of almost 23 % and in freight transport of about 30 % in comparison to 2000 [2]. In addition to a general increase in transport on European roads, overloaded vehicles are observed frequently and the number of heavy haulage permits rises from year to year.

The efficiency of a road network is dependent on its civil structures. A continuous increase in road transport implies higher demands to existing structures. Structures which have not been designed accordingly deteriorate due to an intensified traffic situation. To guarantee security and durability, the structures' condition is regularly rated by inspectors. The ratings are partly based on visual inspections and thus subjective [3]. Objective statements about a structure can be obtained from structural health monitoring [4]. Within appropriate computer analyses measurements that are performed on a monitored structure are evaluated. In future, automated monitoring systems that continuously examine a structure's behaviour and condition gain an increasingly important role [5].

The clear and objective assessment of civil structures requires knowledge about the actual traffic situation in terms of acting traffic loads, their distributions and frequencies. Weigh-in-motion (WIM) systems were developed to acquire traffic data [6]. Vehicle loads and vehicle types are determined without the interruption of the traffic flow. Basically, two systems can be distinguished [7]: Systems in or on the pavement and systems on bridges. The bridge systems use existing bridges as

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