Engineering Structures 33 (2011) 3755–3761

Contents lists available at SciVerse ScienceDirect

Engineering Structures

journal homepage: www.elsevier.com/locate/engstruct

Damage due to heavy traffic on three RC road bridges

Martin Pircher [a,*], Bernhard Lechner [b,1], Oliver Mariani [b,1], Andreas Kammersberger [c,2]

[a] *ABES Consulting International GmbH, Bergmanngasse 7, 8010 Graz, Austria*

[b] *Kompetenzzentrum - Das Virtuelle Fahrzeug Forschungsgesellschaft mbH, Inffeldgasse 21a, 8010 Graz, Österreich, Austria*

[c] *Amt der Steiermärkischen Landesregierung, Landhausgasse 7, 8010 Graz, Austria*

ARTICLE INFO

Article history:
Received 23 September 2010
Received in revised form
6 July 2011
Accepted 1 August 2011
Available online 1 September 2011

Keywords:
Heavy vehicle loading
Bridge monitoring
Accumulated damage
Reliability
Failure probability
Bridge damage model

ABSTRACT

An investigation of the damage caused by road traffic on three reinforced concrete bridges was performed. This study was performed with a focus on the determination of the damage induced by heavy vehicles in relation to the damage caused by average everyday traffic. A damage model based on fatigue of reinforcement bars was employed. The stress cycles in the reinforcement bars were determined using measurements of the crack widths under traffic loading. Stress cycles were analyzed using the Rainflow Method and Miner's Rule was employed to gain a measurement for the damage. Monitoring systems were installed on each of the three bridges and operated for several weeks continuously to collect input data for the damage model. Computer software was developed to process the monitoring data in the sense of the damage model. The described methodology was developed and used for the first time in the described project.

Heavy traffic was shown to cause a disproportionate high portion of the overall damage on all three bridges. The obtained results indicated that the damage caused by singular events, such as the passage of a heavy vehicle, in relation to the damaging effects of every-day traffic differed significantly between the considered bridges. For one of the bridges the greatest damage from singular traffic events was computed for passages of special transport vehicles. The same bridge was also found to display the highest damage by a single passage in relation to average everyday traffic. Passages of short and heavy trucks with four and five axles were identified as the most detrimental traffic events on the other two bridges.

1. Introduction

Valid bridge designs according to most modern design codes should ensure that the probability of failure remains under a given critical limit throughout the design life time. The reliability of a structure is the inverse of the probability of failure and can be computed by comparing the loading with the resistance of a structure [1,2]. Any structure is exposed to environmental influences, service loading and permanent loads which can all be seen to cause small portions of damage accumulating over time. In general terms, this accumulated damage can be interpreted as reducing the structural resistance, and therefore the structural reliability of a structure. On the other hand, code-specific loading also changes, and in the case of traffic loading on bridges these loads have increased significantly over time in most design codes. Additionally, traffic volume and therefore the number of loading events on bridges also tend to increase accelerating the rate at which damage accumulates.

Fig. 1 illustrates the described changes of loading S and resistance R over time. Discrete values for S and R are usually not available and therefore they are assumed to be distributed according to some probability functions. The area under the intersecting parts of these two probability functions is a measurement for the probability of failure. The initial position of these curves at time $t = 0$ illustrates the situation immediately after completion of a structure, and the dotted lines in Fig. 1 show the situation at some later point in time during the design life. In the present paper, the term *damage* is used in the sense of a reduction in structural resistance. Accumulated damage as a result of many loading events throughout the life time of a structure causes a steady decrease of resistance. It can be assumed, that the probability of failure remains below the defined critical level throughout the life time of a structure as long as these damage loading events remain within the regulations of the applied design code indicated by the dotted line labeled 'Design loading' in Fig. 2.

However, singular overloading events beyond the service load levels prescribed in the design code, such as illustrated

* Corresponding author. Tel.: +43 0 316 670619 0; fax: +43 0 316 670619 99.
E-mail address: martin@abes-australia.com (M. Pircher).

1 Tel.: +43 316 873 9001; fax: +43 316 873 9002.

2 Tel.: +43 0 316 877 2466.

0141-0296/$ – see front matter
doi:10.1016/j.engstruct.2011.08.012