18th International Conference
ENGINEERING MECHANICS 2012
Svratka, Czech Republic, May 14 – 17, 2012

pp. 142–143
Paper #317

NUMERICAL ANALYSIS OF A BRIDGE PIER SUBJECTED TO TRUCK IMPACT

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Abstract: *The paper presents description and comparison of the procedures prescribed by the European standard EN 1991-1-7 for bridge pier impact load. The methods incorporate static and dynamic analysis and are compared with a outcomes from a detailed FEM model of a truck prepared in the AUTODYN software. The outcomes are evaluated and conclusions are drawn.*

Keywords: ***Impact loading, numerical modelling.***

In some cases of the structural arrangement, the vehicle impact can represent the decisive loading for the design of bridge substructure.

In the present design standards, the Eurocodes, there is a special part dealing with the accidental load caused from impact of road vehicles, trains, vessels etc., EN 1991-1-7. In the most common design cases, the less sophisticated method based on an equivalent static load is used in the design praxis. The other method based on dynamic analysis is ignored because it is more demanding and requires performing of a special dynamic analysis.

The two methods provided within this standard are described and compared among each other. Later, the two methods are compared to the outcomes from a detailed FEM model of a truck prepared in the AUTODYN software.

Tab. 1: Summary of truck impact modelled with the use of the equivalent static force

	Impact direction	Decisive loading	Maximal impact force	Utilization	Dynamic coefficient
Truck impact	longitudinal	shear	1000,00 kN	60%	×
	transverse	shear	500,00 kN	60%	×

Tab. 2: Summary of truck impact modelled with the use of the dynamic analysis

	Impact direction	Decisive loading	Maximal impact force	Utilization	Dynamic coefficient
Truck impact	longitudinal	shear	3038,82 kN	80%	1,3
	transverse	×	×	×	×

Unlike both of the procedures for assessing a bridge pier subjected to vehicle impact incorporated in the EN 1991-1-7 which (based on simplifying assumptions) provide impact loading for the structure, the method based on a detailed FEM model aims to model a real truck hitting a bridge pier in full scale and then obtain the impact load reversely. The truck impact model is prepared in the ANSYS AUTODYN software.

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The truck IVECO Trakker ADN140T50 (*Fig. 1*) was taken as the hitting vehicle. The 3D computational model was prepared in the RHINOCEROS 4.0 software using 2D and 3D finite elements which represent the decisive structural parts of the vehicle.

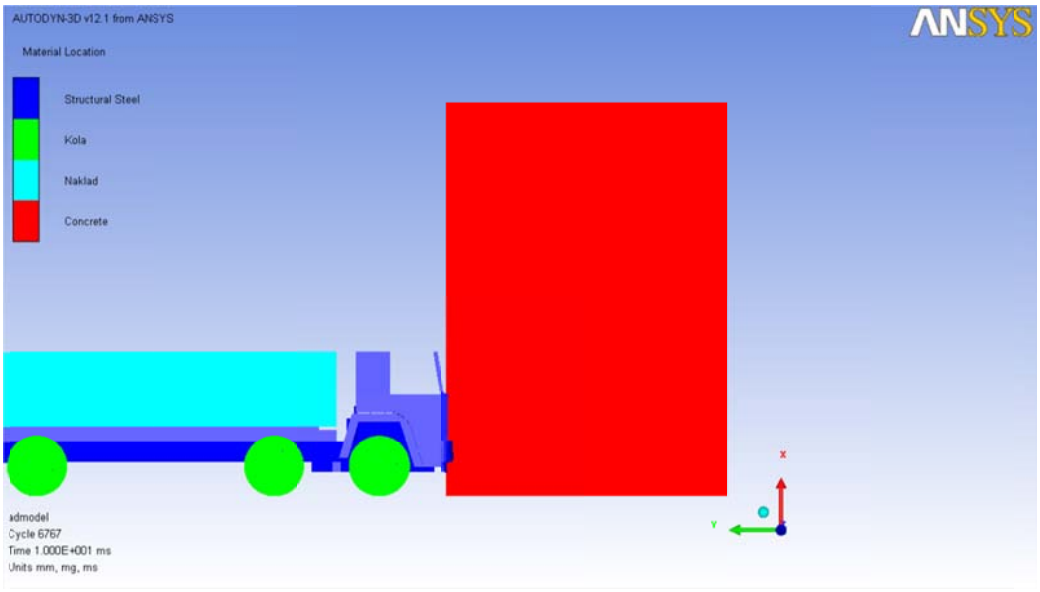

Fig. 1: The 32 tonne truck hitting the bridge pier.

Tab. 3: Summary of truck impact modelled with the use of a real vehicle

	Impact direction	Decisive loading	Maximal impact force	Utilization	Dynamic coefficient
Truck impact	longitudinal	shear	6471,64 kN	170%	1,12
	transverse	×	×	×	×

Three different approaches to vehicle impact were assessed. The first two are incorporated in the EN 1991-1-7 design code: the equivalent static load and the dynamic analysis. The pier of the modelled bridge provided satisfactory resistance to the impact loading. The commonly used method, the equivalent static load provided smaller loading and utilization than the load provided by the dynamic analysis. The equivalent static force was three times smaller than the impact force obtained by the dynamic analysis.

The third tested approach lied in full-scale modelling of the impacting truck. A non-linear computational model of a 32 tonne truck impacting the concrete pier was prepared. From the speed of the vehicle during the impact, the acting impact force during the 334 ms long impact was calculated. This force is two times higher than the impact force obtained by the dynamic analysis and six times higher than the equivalent static force. Thusly the resistance of the bridge pier is not satisfactory when using regular standard approaches for its assessment.

It is questionable whether to use the force calculated from the full-scale modelling of the impacting truck for the assessment of the bridge pier cross-section according to present design standards. The bridge pier experienced some cracking and erosion of crushed concrete elements. By the opinion of the authors, the damaged pier should be loaded by the design load and its residual bearing capacity verified by the means of a non-linear analysis. This analysis will be performed in the ongoing research.

Acknowledgement

This paper was supported the Czech Ministry of Industry and Trade project FR-TI3/531.