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Damage detection study for a pedestrian cable-stayed bridge using ANSYS

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1. Introduction

Cable stayed bridges are elegant, statically indeterminate non-linear structures with a rather complex structural behaviour which makes them sensitive to vibrations [2, 5]. They have, as a rule, individual traits, and therefore their analysis is always a challenge [2, 3, 5]. Because of rather complex loads and the high utilization of material properties, there is also a rich variety of failure scenarios and possible problems [2-4]. This applies also to management and maintenance plans of these bridges [3]. In connection to development of new testing techniques for bridges at ITAM [1], a theoretical damage detection case study was launched for a cable stayed bridge over the Vltava River at Lužec. The aim of this damage detection case study is to suggest regular vibration measurement and tests that could ease or supplement the prescribed maintenance inspections of this bridge in future. Ambient vibration measurements, forced vibration test and a moving impulse load test are under consideration so far.

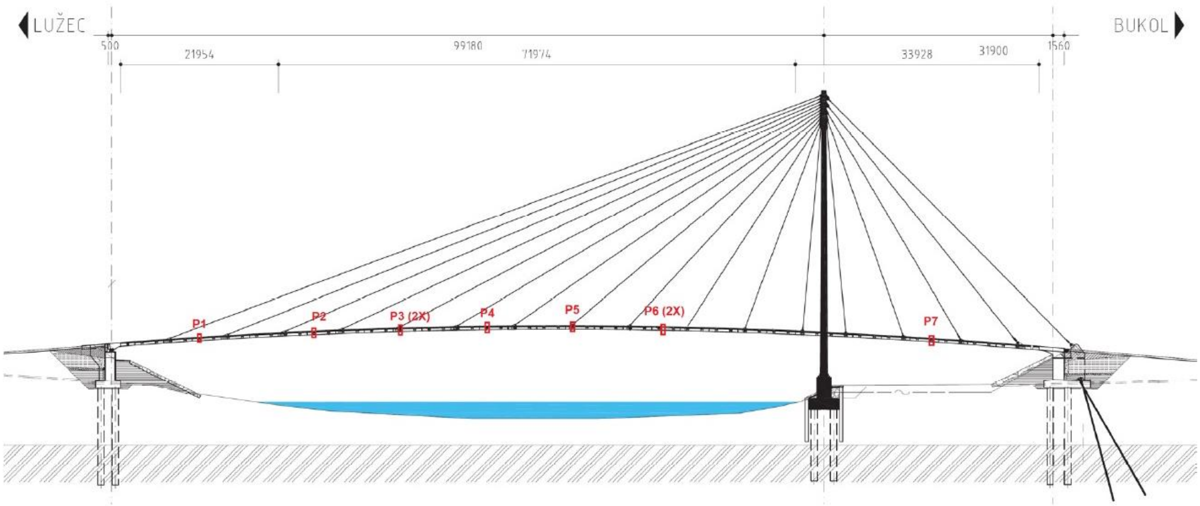

Fig. 1. Schema of the bridge structure

2. Bridge structure and analysis

The bridge (see Fig.1), with its pre-stressed reinforced concrete deck, its 100 m span, and its first natural frequency of about 0.7 Hz, is among the shorter cable-stayed bridges. An analytical model of the structure was assembled using ANSYS Workbench 2021/R2 based on project data supplied by the design office. The main components of the bridge and applied elements are shown in Table 1. The cross section of the bridge deck was assumed to be piecewise with a constant thickness. All finite elements (FE) strictly follow the centre of gravity lines of the structure, which is achieved by eccentric "JOINT" connections. The non-linear static solution is very important because the dynamic analysis is dependent on it as on a starting point. As the final stress in the prestressing cables depends on the deformation, an iterative process had to be applied to achieve the design values. Then, the Prestressed Modal Analysis followed, providing 99 natural mode shapes.

Table 1. Main components and applied FE of the bridge

Component	FE	Material
bridge deck	Shell281	C110/130
prestressing cables of the deck	Beam189	Y1860S7
pylon	Shell281 and Beam189	C30/37 and S355
cables	Cable280	Full locked coil rope (FCL)
prestressing bars	Beam189	Y1860S7
abutment	Shell281	C50/60

3. Damage detection simulations

Global characteristics like natural frequencies and modes alone are usually not sufficient to provide damage-sensitive features applicable to monitoring [2], but there are also some more optimistic examples [2, 6] using damage indices. The bridge deck offers easily accessible measurement points for vibrations, but it is necessary to consider the limitations of an incomplete dynamic model. The first step of the damage detection case study is therefore simulation of various damage scenarios and estimation of measurable effects in the framework of applied dynamic loads and measured outputs.

4. Conclusions

The first part of the damage detection case study confirmed that partial loss of prestress of the deck and loosing of selected cables should have a measurable effect on bridge deck vibrations.

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