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INVESTIGATIONS OF ORTHOTROPIC DECKS

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Abstract: *The partial investigations of orthotropic decks carried out in the Institute of Theoretical and Applied Mechanics, v.v.i., in Prague for a project of the European Union „BRIFAG" is described. The performance of orthotropic decks is studied under dynamic loads including the crack propagation, estimation of fatigue life of the bridge elements, etc. It was found that the most vulnerable detail appeared at the spatial connection of the deck with cross and longitudinal beams. The results are concentrated in a figure of stress ranges as a function of the number of stress cycles.*

Keywords: ***Orthotropic decks, fatigue, stress, Wöhler line.***

1. Introduction

The European Union approved the research of fatigue behaviour of orthotropic decks that are applied to highway as well as railway bridges and formed an international team whose main task is to study the fatigue of orthotropic decks on both the highway and railway bridges. The impact on economy and research is the most important.

Each of the participant team has its own research programme and, here, only the results achieved in ITAM (and not all) are shortly mentioned. The team can be seen in the Fig. 1 during its meeting in the laboratory of ITAM in Prague, (Lukić et al., 2009), (Akhlaghi et al., 2009).

ITAM tested the elements of orthotropic decks on fatigue in the testing machine up to the cracks. The evaluation of tests presented the relationship of stress ranges on the number of absorbed stress cycles (Wöhler line). It is supposed that the stress ranges are the main factor of fatigue cracks in structures. This function enables also to estimate the fatigue life of the investigated structural element.

The orthotropic decks represent a popular structural element since the Second World War and it is counted now several thousands in structural engineering (civil, industrial, ship and space structures) all over the world. Their advantages are: light weight, low height and low first natural frequencies. On the other hand, as they are fully welded, they suffer from the secondary stresses that cause cracks and the initiation of fatigue cracks. Therefore, the orthotropic decks should be carefully studied and tested.

2. Specimens

The investigated model (see Fig. 1) represents a part (a cutout) of a railway bridge in the approximate scale 1 : 1. The strait ribs are preferred on railway bridges because they provide several advantages: no closed spaces, no corrosion, simple welding, easy maintenance and painting.

A series of 16 specimens was tested under the harmonic load in the laboratory of ITAM. The applied forces with various minimum $F_{\min}$ and the maximum $F_{\max}$ forces as well as the number of stress cycles up to the fracture were recorded.

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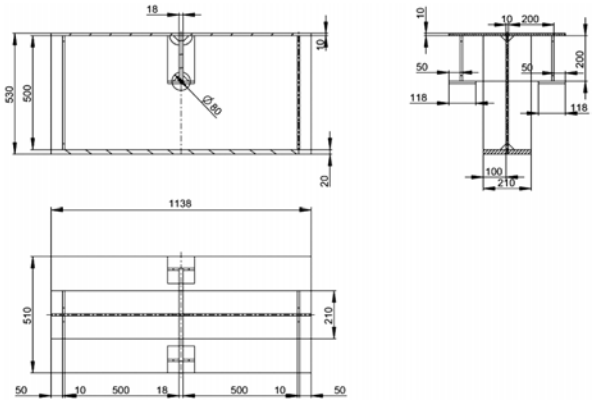

Fig. 1: The tested model of the orthotropic deck.

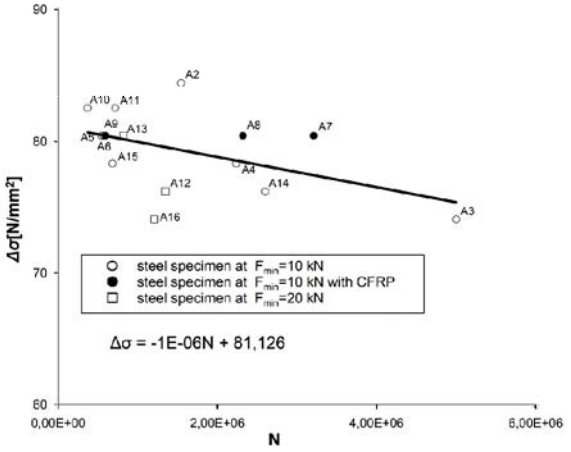

Fig. 2: Stress ranges as a function of absorbed cycles.

It has approved that the stress range is the most important parameter affecting the fatigue of structures. The stress range is defined as the difference of the local maximum and minimum of stresses in the investigated point:

$$\Delta\sigma = \sigma_{\max} - \sigma_{\min} \tag{1}$$

It enables also to estimate the fatigue life of the investigated structural element.

The key results were concentrated in the Fig. 2 and evaluated by the last square method. It presented the mean value

$$\Delta\sigma = -10^{-6} N + 81{,}126 \tag{2}$$

where is $\Delta\sigma$ in N/mm^2 and N is the number of absorbed stress cycles

3. Conclusions

The international project "BRIFAG" has presented the fatigue data of orthotropic decks on both the railway and highway bridges. The fatigue cracks appear in the places (in most cases) where the stress concentration arise and form the initiation of fatigue cracks. It happens usually in spatial crossing the deck with cross and longitudinal beams.

The function on N enables to estimate the fatigue life of structural elements. It is the most important result of investigations, Frýba, & Urushadze (2011), Urushadze et al., (2011).

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