A REVIEW OF DESIGN CRITERIA FOR VIBRATIONAL RESPONSE OF PEDESTRIAN TIMBER BRIDGES

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ABSTRACT: The paper presents a comparison of performance criteria for vibrational response of timber bridges collected from worldwide design rules. Dynamic parameters like natural frequency, acceleration and damping ratio are factors used for the tabularization of differences in rules. The performance is evaluated on the basis of two selected existing timber footbridges.

KEYWORDS: Serviceability, timber bridges, vibration

1 BACKGROUND

For many years, safety was the most important feature of engineering constructions. The design was mostly focused on ultimate limit state criteria and related design rules. Nowadays, the importance of the serviceability limit state rises and has become almost equally important as the ultimate limit state. The reason for that is mainly the decrease in mass of the structure which is economically beneficial, and new possibilities due to technology advancement. Consequently more attention must be paid to deflection and vibrational issues. Considering light timber constructions like floors or footbridges, humans become a significantly important part of a dynamic system due to own mass contribution, and by representing vibration source and sensor simultaneously [1]. Human perception of vibration is very individual, making serviceability requirements and performance criteria on comfort issues complex and difficult to define in design codes.

2 RELATED WORK

In a work of Hu and Chui [2], a comparison between the subjective rating of 106 field floors and their acceptance predicted by design criteria is made: the one included in Canadian standards and a new one introduced by authors. Variation of comfort definition in the serviceability limit state for timber floors also appear clearly in an example of comparison of design criterions among EU countries. Calculations of vibrational serviceability design criteria based on European standard (EC5) [4] and national annexes presented in [3] from over ten EU countries show considerable lack of harmony.

3 TIMBER BRIDGES

Increasing transport and new development of the transport infrastructure requires increased number and length of bridges. Timber footbridges get increasing user needs due to requirements on universal availability and small slopes due to ease of use for bicycles (Figure 1). Serviceability limit state design criteria are given higher priority than before like in the case of timber floors.

Figure 1: Øyovergangen footbridge designed by Sweco Norge and DBC Bygg AS (total length of construction: 95 m)

Codes for timber bridges differ between countries. The paper presents comparison of timber bridge/footbridge serviceability criterions in various norms worldwide. The guidelines for different countries (inter alia: Canada, USA, Australia) are related to EC. The main parameters taken into consideration are: acceleration, natural frequency and...
dumping ratio. Different approaches of modes calculation are gathered and commented in the paper with emphasis on calculation of accelerations, like between vertical fundamental natural frequency $f_{ver}$ and the coefficient $k_{ver}$ (Figure 2) used to calculate vertical acceleration of the timber bridges in EC5 [5], see Figure 2.

![Figure 2: Relation between vertical fundamental natural frequency $f_{ver}$ and the coefficient $k_{ver}$](image)

Each of the compared norms proposes slightly different guidelines for timber footbridge design. The paper presents comparison of results from re-application of the various design criteria to two existing footbridges located in Norway (Figure 1 and Figure 2). Those two constructions are significantly different in structural lay-out. The results from all the collected codes are compared and analysed.

![Figure 3: Søre Ål footbridge designed by Sweco Norge (total length of construction: 27 m)](image)

### 4 CONCLUSIVE REMARKS

In design process, strict requirements on bridge strength and stability take precedence over serviceability. Furthermore, demands of some countries are less rigorous than others. The synthesis of standards was made in order to enhance the basis for evaluations of the serviceability state with respect to vibrational response. The presented comparison may serve as background information for future development of design codes like EC5.

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### REFERENCES


