Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 156 (2016) 32 – 39

Procedia Engineering

www.elsevier.com/locate/procedia

9th International Conference „Bridges in Danube Basin 2016“, BDB 2016

The Effect of Environment on Timber-Concrete Composite Bridge Deck

Viktória Bajzecerová[a,*], Ján Kanócz[b]

[a] *Faculty of Civil Engineering, Technical University of Košice, Vysokoškolská 4, 042 00 Košice, Slovak Republic*
[b] *Faculty of Arts, Technical University of Košice, Watsonova 4, 042 00 Košice, Slovak Republic*

Abstract

In the field of timber bridges progressive static structural solution is if the timber bearing members of the bridge deck are combined with concrete layer applying a shear connection to receive their composite action. The composite timber-concrete bridge deck comparing to the standard timber bridge deck has a higher rigidity, is more resistant to dynamic effects and has protected wooden part from external mechanical actions. The behavior of timber–concrete bridge deck is significantly influenced by the conditions of surrounding environment. In the presented paper, results of theoretical and experimental investigation of the effect of temperature and humidity changes of environment on the timber-concrete composite bridge deck will be presented. The applied analytical calculation model developed for analysis of long term behavior of timber-concrete elements influenced by the environment temperature and humidity will be introduced. In the experimental program, timber–concrete members with different timber structural parts and various composite connections under short and long term loading were investigated. The environmental conditions, temperature and humidity, during the 5 year long test were continually registered. Comparison of theoretical and experimental results and some practical conclusions for design of timber–concrete bridge deck will be finally presented.

Peer-review under responsibility of the organizing committee of BDB 2016

Keywords: timber-concrete; bridge deck; effect of environment.

* Ing. Viktória Bajzecerová, PhD. Tel.: +421-55-602-4289; fax: +421-55-633-7435.
E-mail address: viktoria.bajzecerova@tuke.sk

Peer-review under responsibility of the organizing committee of BDB 2016
doi:10.1016/j.proeng.2016.08.264

1. Introduction

Timber-concrete composite elements are more and more often used to create bearing structure of the floor decks in modern timber buildings or the bridge decks of the road or pedestrian bridges. That is evident from an overview of the use of timber-concrete composite bridges in different geographical areas and climates presented in [1].

In last decade the main disadvantage of timber bridges comparing to bridges from other materials was their durability. This problem was particularly eliminated by use of timber-concrete composite structural elements. Especially in case of bridge decks brings this solution a big progress. The concrete layer protect the timber part against the negative influence as a water or other mechanical effects. Bounding the concrete together with the timber part of bridge deck a composite static solution is reached, which leads to significant increase of stiffness and load carrying capacity of composite deck. According to several publications [1-3] in last years the use of timber for bridge structures was rapidly increased. This was caused not only by above mentioned composite solution, but also with many benefits of timber as a structural material, for example: renewable, sustainable, easy workable, low energy need etc.

In the design process of these composite structures often their deflection is decisive. According to [4] it is advised to limit the value of deflection to 1/400 -1/500 of the timber bridge span. Except of permanent and traffic loads, changes of temperature and humidity of environment may comprise a significant part of deflection of the bridge.

The article gives a simplified method of calculating the effect of temperature and humidity changes on the timber-concrete composite beams. The theoretical results are compared with the results of long-term experimental tests of three different types of beams with different composite connections. The experiment was conducted in indoor environmental conditions; at the end of the paper, the real effect of external environment in the chosen location is analyzed.

2. Simplified calculation model

The different physical properties of timber and concrete concerning the heat and moisture diffusion processes lead to diverse responses of these materials with the environmental thermo-hygrometric variations. As a result of the different coefficients of expansion there is a different strain of the wood and the concrete part, which cause rise of timber-concrete composite beam´s deflection and also rise of internal stresses. The relative humidity and temperature of environment are constantly changing at the time during the year. The maximum values of temperature are reached at summer time and the minimum values in winter time. The relative humidity is depending on the temperature and atmospheric pressure and their maximum values are in winter time and minimum in summer. These environmental changes are reflected with the periodic changes of deflection of the timber-concrete beam. Increase of relative humidity and decrease of temperature cause rising of the middle span deflection value.

The effect of environmental changes is considered as a short term load, the material creep is therefore negligible. In the formulas instantaneous values of material modulus of elasticity and slip modulus of composite connection can be used.

2.1. Influence of relative humidity changes of environment

The wood reaches equilibrium of moisture condition, if is placed long enough in an environment with constant parameters. In the case of changing environmental conditions, the moisture content of wood adapt to the environment with a lag. The moisture process in the wooden cross-section in relation to the environmental conditions is governed by the law of diffusion. From the practical point of view, to solve complex differential equations of diffusion process is demanding task, therefore the simplified calculation model is applied. In this model the moisture equilibrium in whole cross-section without time delay is considered. The equilibrium of moisture content can be determined by means of sorption isotherms according to various authors ([5], [6]). Concrete moisture expansion can be neglected, because even under extreme conditions for long cycles of absorption and desorption occur in concrete negligibly small deformation.