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SHORT NOTICE

PARAMETRIC STUDY OF THE FACTORS AFFECTING THE RESISTANCE OF A COMPOSITE TIMBER-CONCRETE CROSS-SECTION

Jaroslav Sandanus
Slovak University of Technology Bratislava, Slovakia
Department of Steel and Timber Structures

ABSTRACT

This paper deals with the effect of geometric, material and rigidity parameters of a composite timber-concrete girder of a floor construction concerning its global behaviour and the basic rigidity and strength characteristics.

KEY WORDS: timber-concrete girder, shear connectors, efficiency and rigidity of the coupling, effective bending rigidity

INTRODUCTION

Coupling as a means of creating sections is known from history. In the past, mostly the same materials were combined (timber-timber, concrete-concrete, etc.). This method was used mostly to create large-scale sections of structural elements (timber) or to decrease the weight of parts of a roof construction. Nowadays we create the sections or elements from various materials or from materials which have various properties. By combining these materials we try to reduce their unfavourable properties and fully use their good ones. This method is used in timber-concrete constructions too. Timber as a structural material has the same properties in compression, tension and bending as concrete in compression. Because the elasticity properties of both materials are similar, we are able to create sufficiently strong and much more rigid constructions with minimum labour input in the process of construction and maintenance.

MATERIAL AND METHODS

A composite timber-concrete girder as a constructional element consists of a timber girder (solid timber or glued laminated timber) and a concrete slab, which is minimally reinforced for the effect of shrinking. The slab is in many cases supported by a shutter (plate shutter or boards of wood-based materials). In the case of a self-bearing slab, the reinforcement is designed for the relevant critical cross-sections. The static scheme is a continuous girder (slab) with several fields. The field span is the distance between the axes of the girders.

The coupling of these two elements (a timber girder and a reinforced concrete slab – Fig. 1) is made using shear connectors of various sorts and types: nails, an inserted and glued reinforcing bar, screws, ... (Sandanus 2001).

According to the shear connector used, it is possible to investigate the efficiency and rigidity of the coupling by means of calculation or experimental testing.

The effective bending rigidity EI_{ef} can be, from the point of view of rigidity, from 50% to nearly 100% of the rigidity of a solid girder.

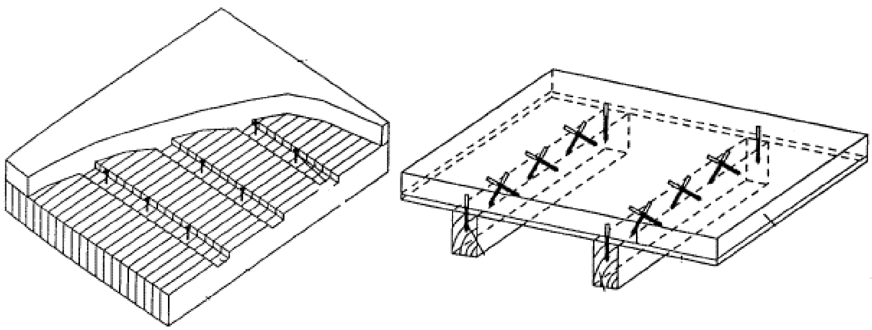

Fig. 1: Timber-concrete composite floors: slab type floor (left) and beam type foor (right)

RESULTS AND DISCUSSION

The most influential parameters that describe the behaviour of a timber-concrete structure are:

a) span of the girders from 3500 mm till 6000 mm,
b) axial distance of the girders from 700 mm till 1100 mm,
c) depth of the timber part of the cross-section,
d) concrete class B 12.5 to B 30
e) flexibility of the shear connectors.

The relations of the basic characteristics of a composite cross-section using the above mentioned parameters were calculated for the same conditions (strength and rigidity).

In the examples the global deflection f_{sht} according to EC5 is considered along with the following stresses: σ_{1b} – stress on top of the concrete slab, σ_{2b} – stress on the bottom of the concrete slab, σ_{3d} – stress on the bottom of the timber girder.

SUMMARY OF THE RESULTS

The results were obtained by calculating a timber-concrete construction by the EC5 procedure (the flexibility of the shear connectors is included) and the methods of German writers, mainly Werner, who have derived a simplified calculation of composite floor constructions (γ-calculation). The coefficient γ describes the flexibility of the coupling according to EC5. Besides the parameters of the cross-section and the material properties, it also depends on the flexibility coefficient C_σ (Voletz 2001).

Mathematical calculations were carried out (elastic analysis) for the specific examples (a girder floor with a 20-30 mm shutter as a formwork). In the examples, only one of the basic parameters of the composite construction was changed, and the effect on the global behaviour of the construction was examined. In the calculation, flexible coupling was considered without rheological changes and with the rheological changes in the material used. On the basis of the results obtained, we can arrive at some conclusions:

a) The change in the span of the timber girder has an expected effect on the rigidity and strength of the composite cross-section as well as the necessary number of the shear connectors. When the span increases, the deflection, stresses in the cross-section and the necessary number of shear connectors increases too. The relationship is non-linear.

b) The change in the concrete class according to the calculation does not have an important effect on the rigidity and strength of the composite cross-section, i.e., all the relations are nearly constant.

c) The change in the height of the timber part of the cross-section has an expected effect on the rigidity and strength, i.e., if the height increases, the deflection, stresses (normal and shear) and the number of shear connectors decreases. In this case the decrease is not so marked.

d) The change in the axial distance of the girders does have not a large effect on the characteristics of the composite cross-section. The effect of this parameter and of rigidity is in all cases linear.

e) The flexible shear connectors have the largest effect on the global effect of the composite girder as well as on the redistribution of internal forces into other parts of the cross-section. The effect of this parameter on the basic rigidity and strength characteristics is shown (Figs.2, 3 and 4).

The values of the flexibility modulus C_σ represent the slip in the contact of the timber and concrete part due to the shear force. Various types of shear connectors were considered (nails, screws, steel bars, SFS screws) in [N/mm] (Sandanus and Thomi 2000).

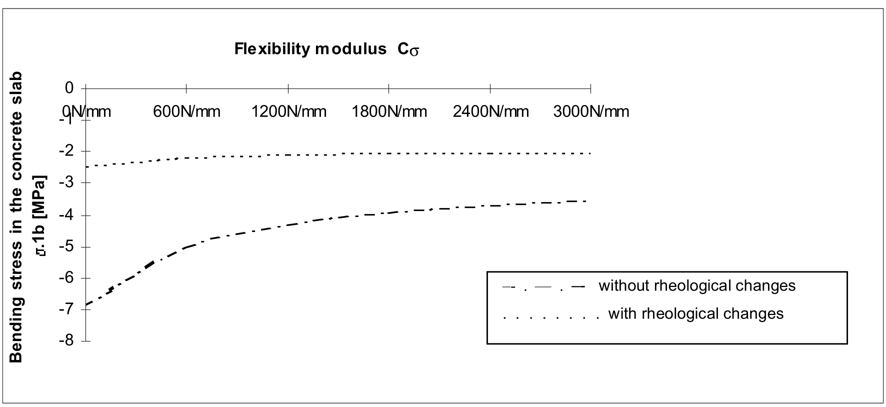

Fig. 2: Relationship of the bending stress in the concrete slab on the top surface and C_σ

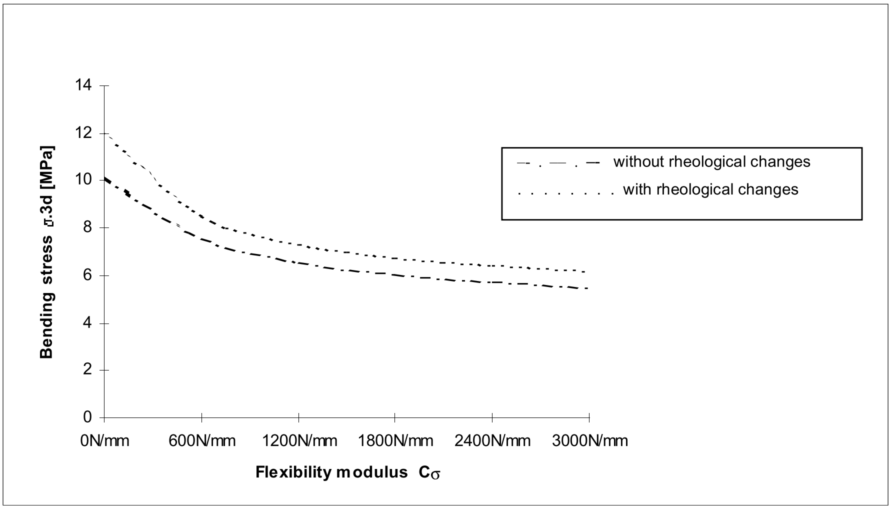

Fig. 3: Relationship of the bending stress in the timber girder on the bottom surface and C_σ

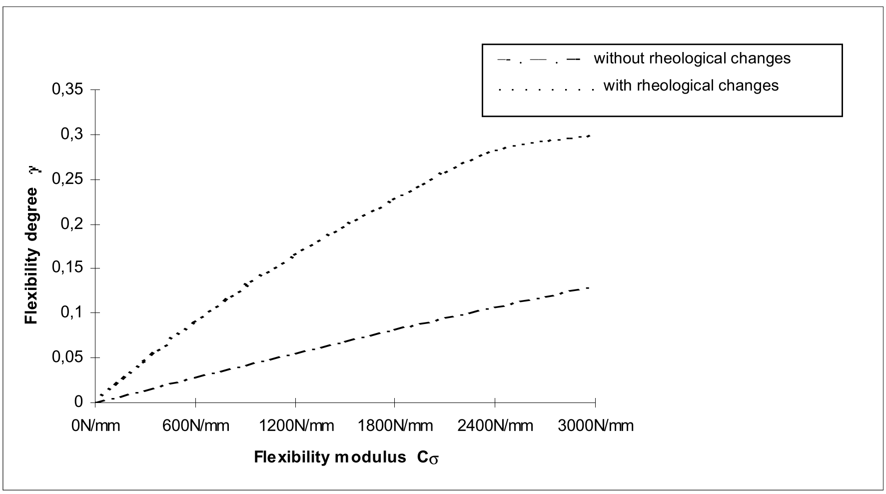

Fig. 4: Relationship of the flexibility degree γ *and* C_σ

Graphic representation of the change in the flexibility of the shear connectors

In the following charts the above - mentioned relations are shown.

CONCLUSION

This parametrical study of a composite timber-concrete floor girder deals with the effect of the parameters of the timber-concrete girder on its ultimate strength.

The timber-concrete composite floor construction is a suitable alternative for the design of these constructions. We can state that it can fully substitute the haevy reinforced concrete floors of civil and administrative buildings from a realisational and economical point of view.

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Assoc . prof. Jaroslav Sandanus, PhD.
Slovak University of Technology
Faculty of Civil Engineering
Department of Steel and Timber Structures
Radlinského 11
81368 Bratislava
Slovakia
E-mail: jaroslav.sandanus@stuba.sk