APPLICATION OF FIBRE CONCRETE IN COMPOSITE STRUCTURAL SYSTEMS

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Abstract:

Benefits of the combination of material properties of concrete and wood has been utilised mainly in reconstructions and strengthening of existing wood floors since now. In terms of sustainable building the efforts to use wood as a structural material increase and composite wood – concrete structures are used more frequently in newly built houses and even as precast elements. More effective resistance to complicated loading, thermal actions, rheological properties of concrete, concentrated loading in interconnection area and other effects may be achieved by utilisation of fibre concretes.

Keywords: Fibre Reinforced Concrete, Composite Structures, Wood

1 Introduction

Composite structures combine advantageous properties of particular materials for certain straining. They are widely used for different types of structures. Combination of wood and concrete was used in thirties of the last century for the first time and caused hesitations because of fear of biological damage of wood due to increased moisture by mix water separated from concrete.

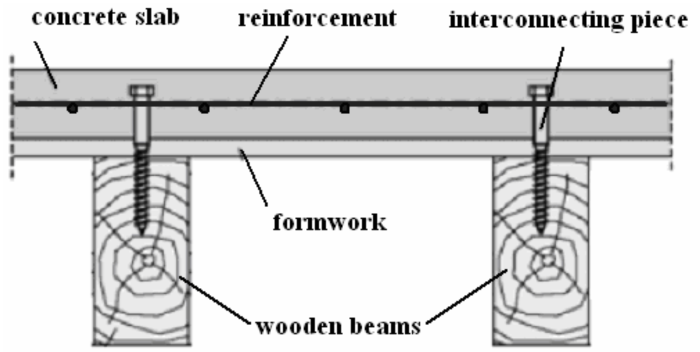

Fig. 1 Sketch of the section of the combined structure

The wood – concrete composite structures are nowadays used mainly for strengthening and reconstructions of existing wooden floor structures but also in newly built houses, even in a form of precast structures. They provide high flexural rigidity and have enhanced noise reduction parameter compared to wooden floors. Contemporary

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research in the field of wood – concrete combined structures focus on problems of optimal interconnection and possibility of application of modern robust fibre concretes.

2 Fibre Reinforced Concrete

The term fibre concrete (FRC) covers composite materials on the basis of cement matrix with randomly distributed fibres from various materials, sizes and shapes. For the design of load-bearing structures, where fibre concrete must provide sufficient reliability in ultimate and serviceability limit states, a fibre concrete, that is able to resist tensile stresses after cracking, must be chosen. That's why that mostly used fibres are steel ones but recently also synthetic macro fibres are used.

It shall be stressed that understanding of the stress-strain diagram of fibre concrete is the most important assumption for design and check of any FC structural member. There is a sketch of the real course of function $s(e)$ approximated by strait lines in certain intervals. Choose of the number of parameters that describe the softening of fibre concrete after the tensile strength is reached depends on the type of analysis and related requirements on accuracy of approximation of the real function $s(e)$.

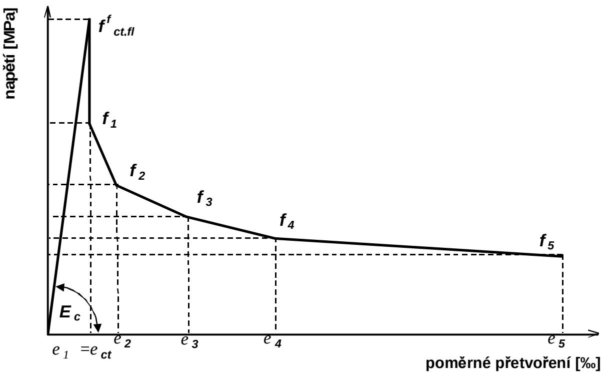

Fig. 2 The stress-strain diagram

3 Application of FRC in Composite Structural Systems

3.1 Composite structure concrete – fibre concrete

Exploitation of fibre concrete properties in composite structural systems can accelerate building because of more simple technology. An example is one of the first practical applications of composite fibre concrete – concrete in housing construction in Wolfsburg, Germany [7]. The fibre concrete grout was used to join the precast filigran panels (see Fig. 3). The application of fibre concrete simplified reinforcing as the upper rebar reinforcement was omitted. The load tests performed in introductory stages proved that resistance is overestimated compared to values determined in calculations. The real values are approximately 2.8 -3.3 times lower.

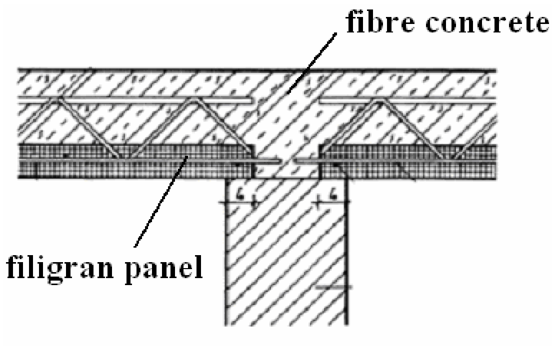

Fig. 3 Fibre concrete grout

3.2 Composite structure wood – fibre concrete

In the figure 4 is a transversal section of bended wood-fibre concrete girder with lay-out of normal stresses according to the interconnection between wood and fibre concrete grout (a – without connection, b – flexible interconnection, c – rigid interconnection). The flexibility of the interconnection is defined by the slip modulus; totally rigid connection is only a theoretical one.

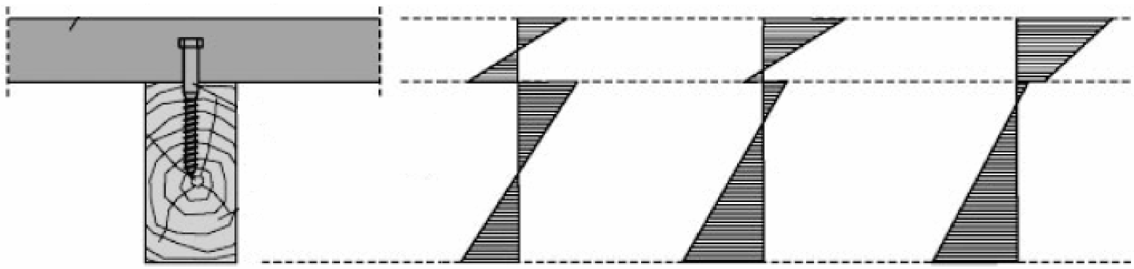

Fig. 4 The lay-out of normal stresses across height in the section without interconnection (a), with flexible connection (b) and rigid connection (c)

The other loading of the concrete part of the composite section is bending along the longitudinal axes of the beam and tensile stresses caused by volume and thermal changes; these stresses may be substantial. Very low and uncertain (from the ultimate state point of view) tensile or flexural strength of concrete results in need of reinforcing of the concrete component by rebar reinforcement. The consequence is oversized depth (at least 7 – 8 cm) because of requirements on cover and lapping. The experiments showed [4] that cracks in the tensile part of the concrete slab are created before the ultimate resistance of the beam is reached. That means that analysis models based on linear-elastic theory do not describe the real behaviour. The rebar reinforcement which is in the central plane of the slab cannot prevent cracking.

Application of fibre concrete and utilisation of its capability to resist tensile stresses leads to possible decrease of the depth of the concrete component of the combined section, eliminates the rebar reinforcement and provide better transfer of complex stresses.

One of the first utilisations of fibre concrete with steel fibres was a successful reconstruction and strengthening of wooden beam floors of a dwelling house in Leipzig [2] with span 6.60m and spacing of beams 80cm. The thickness of the fibre concrete slab was

4.8cm. The load tests, where deflections were measured, proved enhancement of rigidity, resistance and effective distribution of loading to particular wooden beams. Accompanying tests proved enhancement of the interconnection elements resistance.

4 Conclusions

The demands on resistance, serviceability and durability are more and more severe. The necessity to keep the economic attractiveness must lead to optimisation of traditional structural principals and creating of new ones and to utilisation of material properties in maximal level. Fibre concretes are proved to be robust construction material and thanks to their properties they are predetermined for use in structures where high requirements on resistance and serviceability shall be met. Application of fibre concretes may provide economic design, speeding up of building and minimising of errors in execution.

Conditions of successful development of composite structures with fibre concretes are ongoing research of material characteristics and development of material models together with analysis methods that correspond with physical non-linearity of the problem.

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