INTEGRAL EQUATIONS OF VOLTERRA IN ANALYSIS OF STEEL – REINFORCED GLUE-LAMINATED TIMBER BEAMS, REGARDING RHEOLOGY

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The paper presents analysis of the stress changes due to creep in statically determinate reinforced wood beams. Each beam consists of glue-laminated timber □-section, acting compositely with steel rods, or steel-plate; U-profile, symmetrical or unsymmetrical attached to the upper or lower surface of the beams. The mathematical formulation of this problem involves the equation of equilibrium, compatibility and constitutive relationship, i.e. an elastic law for the steel part and an integral-type creep law for the wooden part. For determining the redistribution of stresses in beam section between wood beam and steel part with respect to time 't', Volterra integral equations of the second kind have been derived, on the basis of the theory of the viscoelastic body of Boltzmann ů Volterra. Analytical method, which makes use of Laplace transformation and numerical method, which makes use of quadrature formulae for solving these equations, are proposed. The computer programs are realized in environment of a high-performance language for technical computing MATLAB®. Some relevant examples with the model proposed are investigated and discussed. In this mathematical model, different creep function are assumed and compared by describing of the time depended behavior of the wood. Finally, this analysis shows the way how to be integrated the advantages of the highly perfect model of visco-elastic body, describing the creep of wood, and availability of powerful software products. The proposed methods give us the possibilities for realistic estimates of the behaviour of the reinforced glue-laminated wood beams, subjected to sustained service.

Key words: *wooden beam, stress, rheological, redistribution, Laplace transformation, Volterra integral*

1. Introduction and background

The deformation of a material over time at constant load is commonly known as rheological properties of the material or creep. Wood is a viscoelastic material [20, 21] and therefore, creep must be accounted for in the design of a wood structure when sustained loads are present. As early as a turn of the 20^{th} century, creep was acknowledged in the design of wood structures. At the 1903 Annual Convention of the American Society of Civil Engineers, Hatt et al. [6] stated in a presentation that it was generally known 'that the deflections under ordinary quickly applied load in a test are only one-half of those, resulting from the continued application of the same load'. The authors, however, recommended further study to better determine a quantitative relation between short-term and long-term behaviour.

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