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Bending of Symmetrical and Nonsymmetrical Composite Sandwich Beam with Visco- elastic Core

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1 Introduction

Foam-core sandwich panels and beams are increasingly used for load-bearing components in civil and mechanical engineering. Sandwich panels and beams offer a high stiffness per unit weight, but creep even at room temperature, what is limiting their use in structural applications. In this study, the viscoelastic bending of the sandwich beams will be given. The sandwich beams will be of symmetrical [1] and nonsymmetrical structure. The bearing layers are elastic, the internal core is linear viscoelastic. The model of deflection for a sandwich beam with laminate skins and a polymer core loaded by concentrated load is given. Theoretical results are compared with data from tests on sandwich beams with polymer based composite and rigid foam core.

2 Viscoelastic modeling of sandwich beam

2.1 Symmetrical sandwich beam

For the vertical displacement of the beam loaded by P at the middle applies

$$w\left(\frac{l}{2},t\right) = \frac{\bar{P}\,l^3}{48E.2rs_0^{\,2}} + \frac{\tilde{C}\,\bar{P}\,l}{8G_c\,s_0}$$

where $\bar{P} = \frac{P}{b}\,\Phi(t)$ and $\tilde{C}$ is a time integral operator, P is load and l,b beam length and width respectively, $\Phi(t)$ is a Heaviside function.

Sandwich beam consists of a core of thickness $2s_0$ and the skins with thickness r. Physical constants are Young modules of the skins E and a constant for core G_c.

2.2 Nonsymmetrical sandwich beam

We consider geometric and physical nonsymmetrical structure of the beam.

Sandwich beam consists of a core of thickness $2s$ and the skins, from which the upper has thickness r_h and lower r_d , respectively. Physical constants are Young modules E_h, E_d and shear modulus of core G_c .

For a maximal vertical displacement under concentrated load P we get

$$w\left(\frac{l}{2},t\right) = \frac{1}{k\,\bar{s}}\,\frac{\bar{P}\,l^3}{24} + \frac{\tilde{C}\,P\,l}{4G_c\,\bar{s}}$$

where $\quad \bar{s} = s_h + s_d = 2s_0$, when $\quad s_h = s + \dfrac{r_h}{2} \; s_d = s + \dfrac{r_d}{2}$

$$k = E_h r_h \,(s_h - \delta) + E_d r_d \,(s_d + \delta)\,, \quad \text{where} \quad \delta = \frac{E_h r_h \left(s + \dfrac{r_h}{2}\right) - E_d \; r_d \left(s + \dfrac{r_d}{2}\right)}{E_h r_h + E_d r_d}$$

Further $\quad \overline{P} = \dfrac{P(t)}{b} = \dfrac{P}{b}\,\Phi(t)$, where Φ(t) is a Heaviside function, b is a beam width.

Operator $\tilde{C}$ is of the form $\tilde{C} = 1 + \lambda \;\; C^{*}(\alpha)$. Parameters λ, α are changed according to adopted mechanical model, e.g. for the Poynting-Thomson model (linear solid) and arrangement $G_c - G_x / K_2$ we get the following relationship:

$$\tilde{C}\,\Phi(t) = \Phi(t) + \frac{G_c}{K_2}\int_0^t e^{-\frac{G_x}{K_2}(t-\tau)}\,\Phi(\tau)\,d\tau = 1 + \frac{G_c}{G_x}\left(1 - e^{-\frac{G_x}{K_2}t}\right)$$

Relation $\tilde{C}\,\Phi(t)$ will be substituted into the above equation and we get similarly as in symmetrical case:

$$w\left(\frac{l}{2},t\right) = \frac{\overline{P}\,l^3}{48E.2rs_0^{\;2}} + \frac{\tilde{C}\,\overline{P}\,l}{8G_c\,s_0} = \frac{P\,l}{8b\,s_0}\left(\frac{l^2}{12E\,r\,s_0} + 1 + \frac{G_c}{G_x}\,(1 - e^{-\frac{G_x}{K_2}t})\right)$$

We evaluate the influence of physical constants on the vertical displacement of sandwich beam. The mentioned integral equations depend on ratio $\dfrac{G}{K}$. In a relationship for $\tilde{C}\,\Phi(t)$

$$\tilde{C}\,\Phi(t) = 1 + \; 1 - e^{-\frac{G}{K}t}$$

Where the second part is $\quad 1 - e^{-\frac{G}{K}t}$, i.e. increment to value 1 . We take $\alpha = \dfrac{G}{K}$ stepwise 0,001, 0,003, 0,005, 0,007. The increments $\Delta = 1 - e^{-\frac{G}{K}t}$ pro t = 10, 100, 1000 h are given in Fig.1.

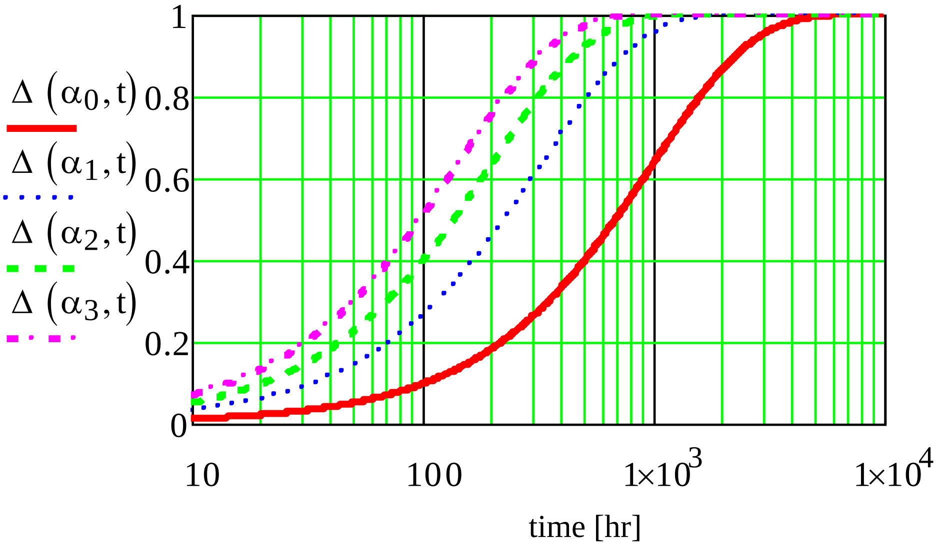

Fig.1 Influence of α= G/K on sandwich beam bending

2.3 Mechanical testing

Mechanical tests have been performed on a symmetrical sandwich beam with bearing layers from composite, reinforced by glass fibres and polyester matrix [2]. Further, the cube testing samples were loaded by constant load in a set-up developed and manufactured in Klokner Institute. Vertical displacements were measured by LVDTs and strains by strain gauges. Testing samples were loaded by 30 and 60 N and unloaded at least for 100 h. The tests show a good agreement with calculated values (Fig.2).

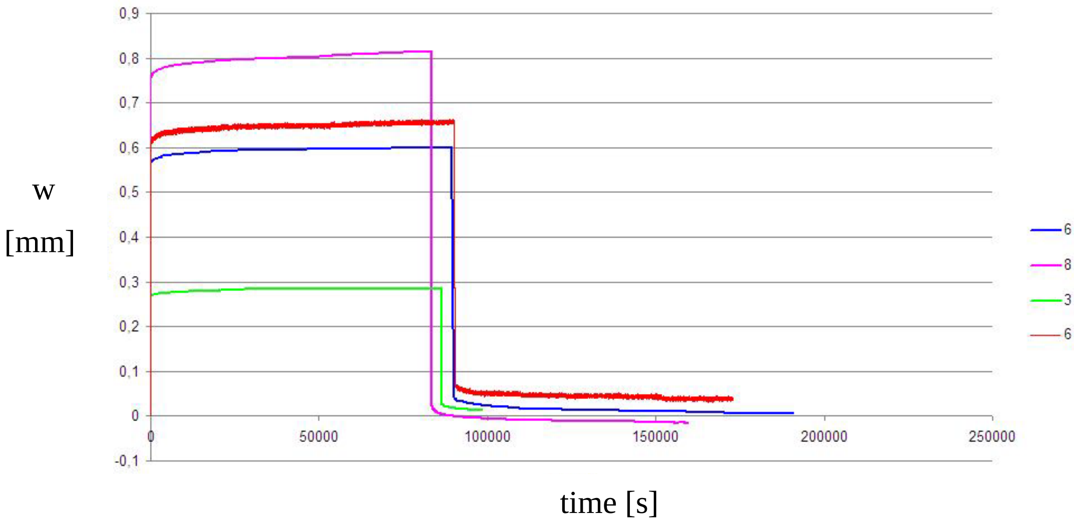

Fig.2 Experimental evaluating of creep for the symmetrical sandwich beam

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