MECHANIKA TEORETYCZNA
I STOSOWANA
Journal of Theoretical
and Applied Mechanics
2, 32, 1994

INFLUENCE OF INITIAL STRESS AND VARNISH COATINGS ON VIBRATION DAMPING IN WOODEN BEAMS

TOMASZ GEISLER

BOGDAN SKALMIERSKI

WOJCIECH SOCHACKI

Institute Mechanics and Machine Design
Technical University of Częstochowa

The paper concerns the problem of initial stress and varnish coatings influence on vibration damping in wooden beams. The effect of initial stress on damping properties of the sprucewood- and beechwood-beams has been experimentally investigated. The relationship between logarithmic decrement versus compressive stress and tensile stress distribution along the beam's axis has been determined. Also, the influence of different varnish brands on damping properties of sprucewood-, great maple wood- and pinewood-beams has been established.

1. Introduction

The application of wood a to sound boards making of the musical instruments sets requirements of defining initial stress influence on damping properties. The authors of the present paper aimed at presentation of wood (2 species) damping properties variation subjected to the specified initial stress.

Varnishing some elements of the musical instruments during their production process implies the necessity of establishing the effect of varnish coatings on the damping properties of the lacquered parts. In the section of this paper concerning the analysis of the problem the authors show in what way the varnish influences damping properties of sprucewood-, great maple wood- and pinewood-beams.

2. Investigation of damping properties of the prestressed wooden beams

To introduce the initial stress the beam has been made of two separate parts in which, after assembling and gluing, the area of initial stress is formed. It appears as a result of the end edge misfit affected by the gap formation (see Fig.1).

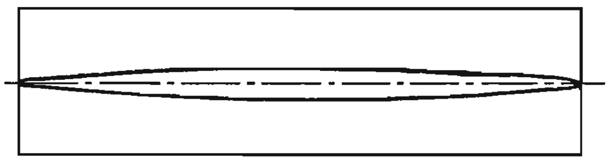

Fig. 1.

In the course of the gluing process both parts have to be clamped together. Thus, both parts have been bent and the state of stress was calculated according to the formulas commonly known in the mechanics of materials. The gap between beams changes along the length symmetrically. This is why in the calculations one can consider only one part of the beam, treating it as a beam fixed at the center (Fig.2).

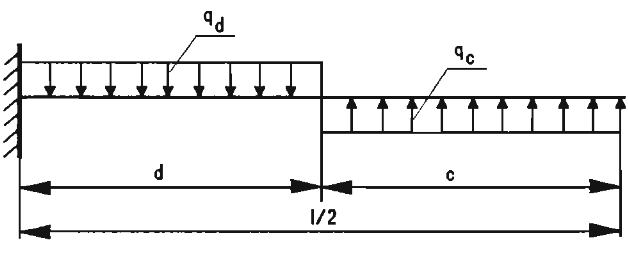

Fig. 2.

The authors assumed that the bending line of wood corresponds to the bending line of the beam.

The fixing moment of the beam is given by the formula

$$M_u = \int_0^{c+d} q(x)x\, dx \tag{2.1}$$

After solving this integral the formula for the fixing moment is obtained

$$M_u = -q_d\Big(\frac{c+d}{2}\Big)d \tag{2.2}$$

Assuming that $q_d d = q_c c$ the reaction value at the point of fixing is equal to zero.

The bending line equation may be written in the form

$$EJy = \frac{M_u}{2}x^2 + \frac{q_d}{24}x^4 - \frac{q_c(x-d)^4}{24}H(x-d) - \frac{q_d(x-d)^4}{24}H(x-d) \tag{2.3}$$

where

$H(x-d)$	–	Heaviside function
q_d, q_c	–	continuous loads
EJ	–	flexural rigidity.

After substituting Eq (2.2) and the relationship between q_c and q_d into Eq (2.3) we obtain the equation

$$EJy = -q_d\frac{(c+d)d}{4}x^2 + \frac{q_d}{24}x^4 - \frac{q_d d}{24c}(x-d)^4 H(x-d) - q_d\frac{(x-d)^4}{24}H(x-d) \tag{2.4}$$

For calculation of the greatest bending we can substitute for $x = c+d$ and Eq (2.4) takes the following from

$$EJf_{max} = -q_d\frac{d+c}{24}[(d+c)^2(5d-c)+c^3] \tag{2.5}$$

This eqation allows one to determine the maximal deflection of the beam, i.e. the value of the greatest wood deflection, for various c and d proportions. In the studies the following cases have been taken into consideration: $d=c$, $d=2c$, $d=c/2$.

Introducing succesively these values into the formula (2.5) enables one to choose the optimal geometrical dimensions of the beam under investigation.

For precise determination of the wood deflection line the relation (2.4) has been assumed, which, after appropriate substitutions and applying the material data and dimensions, gives as a final result the function of deflection magnitude dependent on the x-coordinate. The function has been used for a numerical calculation of the wood deflection line.

2.1. The method of measurement

Studies have been carried out using the Brüel & Kjaer 2515 Vibration Analyser supplied with 4381 piezoelectric accelerometer.

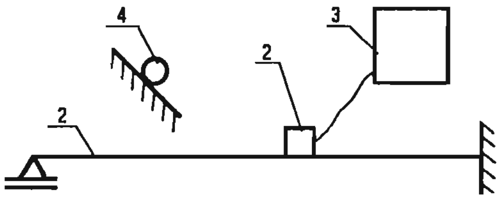

Fig. 3.

The vibration forcings have been realized by the impuls acting of the steel ball on the beam, which, falling down from the specified height strikes the beam. The repeatability of the forcing has been ensured in experiment. Scheme of the test stand is shown in Fig.3. Due to the identical way of beams fixing one has taken that the influence of fixing on damping in beams is also identical. All beams (of one kind of wood) were made from the same batch of wood (the same trunk) and contained the same growth rings. Their humidity was also the same.

Wooden beams (seasoned) of the rectangular cross-section have been examined. They were:

— sprucewood-beam of the size 900mm × 60mm × 15mm

— beechwood-beam of the size 900mm × 60mm × 15mm.

The investigated beams have been prepared (as mentioned above) in the following way: each beam has been cut along into two pieces. Beams of each species were glued together introducing the specified prestressed state, while one of each kind left without any stress. The beams without stresses were glued also. Initial stress (of tensile or compressive type) has been realized by the appropriate cut-outs in the beams, glueing and machining them to the specified dimensions.

Cut-out profiles have been derived from the stress calculation, assuming that the value of stress perpendicular to the fibres will be $1/20R_r$ (max. tensile stress perpendicular to the fibres) for the sprucewood-beam and $1/26R_r$ for the beechwood-beam. Scheme of the introduced stress is illustrated in Fig.4.

Each of the investigated beams has a different ratio of c to d. For the length of the beam being 900mm, c and d have been varying in the following way.

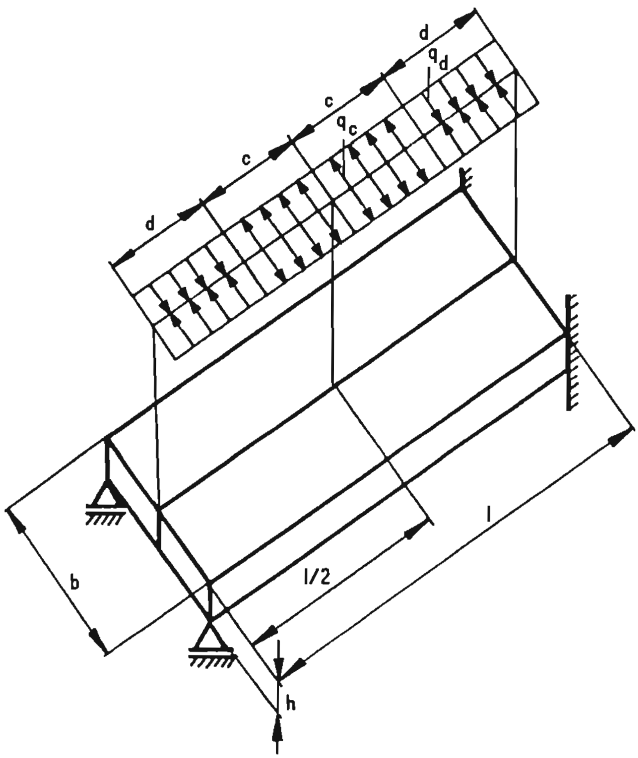

Fig. 4.

Table 1

Item	Type of wood					
	Sprucewood			Beechwood		
	l [mm]	d [mmm]	c [mm]	l [mm]	d [mm]	c [mm]
1	900	-	-	900	-	-
2	900	225	225	900	225	225
3	900	150	300	900	150	300
4	900	300	150	900	300	150

2.2. Results of measurements and calculations

On the grounds of measurements carried out, the logarithmic decrement has been determined for beams of data taken from Table 1. Changes in logarithmic decrement related to the variation of the tensile and compressive load ratio, along the length of the beam, are represented in Table 2 and Fig.5.

Table 2

Item	Type of wood					
	Sprucewood			Beechwood		
	c	d	δ	c	d	δ
1	-	-	0.037	-	-	0.029
2	300	150	0.025	300	150	0.029
3	225	225	0.023	225	225	0.030
4	150	300	0.023	150	300	0.0296

δ – the logarithmic decrement.

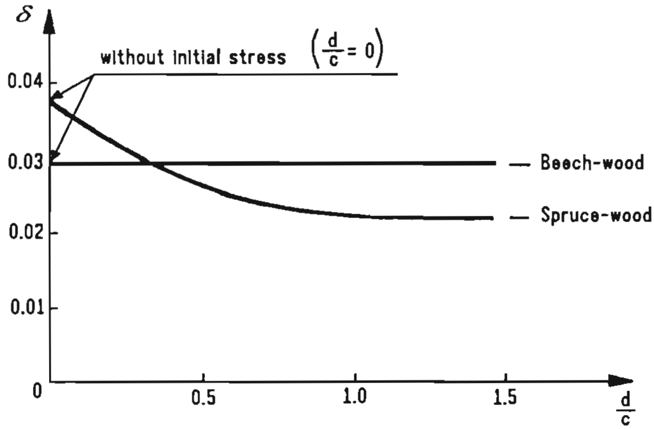

Fig. 5.

3. Investigation of varnish influence on damping in the wooden beams

In this section of the work the authors have considered the problem of influence of different varnish brands on damping properties of the lacquered, wooden beams. The necessity of such studies is implied by the fact that in the musical instruments production process some of the parts have to be varnished, what has the influence on the instrument "quality", since damping properties of the varnished elements change.

The following wooden beams have been investigated:
— the beam of great maple-wood
— the beam of sprucewood
— the beam of pinewood.

For the purpose of the study the following brands of varnish and prime coat have been used:

varnish: Bondex, Dulux, Wiktobejc

prime coats (stains): Bondex, Dulux, Wiktobejc.

Damping properties have been investigated in beams covered with prime coats, prime coats and varnish, and varnishes of different combination, respectively. During the process a beam was covered with the prime coat at first and then with varnish. Results of the investigation have been presented in Table 3.

Table 3

Kind of the wood	Sprucewood				Pinewood		Great maple-wood	
Kind of coating	Decrement							
	δ				δ		δ	
without varnish	0.037	0.052	0.058	0.067	0.083	0.068	0.057	0.06
Bondex + bondex			0.085		0.091	0.077		
Bondex + dulux				0.071				
Dulux + dulux	0.028				0.079	0.066		
Dulux + bondex		0.069						
Transp. varnish							0.070	0.069
Prime coat							0.073	0.073
Prime coat + transp. varnish							0.096	0.096

4. Conclusions

On the grounds of the studies carried out we can state the following:

- With the increase in the area of introduced tensile stress, the logarithmic decrement is becoming lower (sprucewood). Beechwood damping properties are remaining the same
- Varnishes and prime coats increase the logarithmic decrement in each case of the beams in question, except the case of prime coat and varnish combination of Dulux, since in this case the logarytmic decrement of the beam decreased.

Acknowledgements

The investigation was carried within the framework of the grant No. 770289102 sponsored by the State Committee for Scientific Research in 1992-1993.

References

1. KRZYSIK F., 1978, *Nauka o drewnie*, PWN, Warszawa
2. SKALMIERSKI B., 1979, *Mechanika z wytrzymałością materiałów*, Warszawa

Wpływ naprężeń wstępnych i powłok lakierniczych na tłumienie belek drewnianych

Streszczenie

Praca dotyczy zagadnienia wpływu naprężeń wstępnych i powłok lakierniczych na tłumienie belek drewnianych. Zbadano wpływ naprężeń wstępnych na tłumienie belki świerkowej i bukowej. Określono doświadczalnie zależność dekrementu logarytmicznego od rozmieszczenia wzdluż osi belki naprężeń ściskających i rozciągających. Określono ponadto wpływ różnych gatunków lakieru na tłumienie belek świerkowych, jaworowych i sosnowych.

Manuscript received February 23, 1993; accepted for print September 9, 1993