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Analysis the effects bending load of veneers for purposes of planar moulding

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Abstract: *Analysis the effects bending load of veneers for purposes of planar moulding.* The aim of this article is determine the effects of mechanical stress veneers loaded by buckling and horizontal bending (three-point and four-point). There are described and evaluated methodologies that are suitable for the formability veneers determination in the plane. We used samples of three trees: beech (*Fagus sylvatica*), birch (*Betula pendula*) and ash (*Fraxinus excelsior*). Based on the analysis of shape changes and breach is evaluated a plane formability of veneers.

Keywords: veneer, plane stress, bending, buckling

INTRODUCTION:

Modern furniture constructions are often produced as stereotomic. These structures are formed into various curves and curved planar and spatial surfaces. This furniture most often produced from plastic, but we have focused on natural materials - wood. For wood, as anisotropic material, it is important to examine the changes in shape and damage in its planar and spatial forming. Inasmuch as, that some stereotomic construction are formed by surfaces, in our study, we focused on surface elements - veneers.

The problem of forming veneers is interesting both technologically and economically. According to Möller (2002), using curved surfaces is expected saving of material in terms of its thickness. The authors Wagenführ, Buchelt, Pfriem (2005) investigated the effect of veneer thickness and size of the bending load on the size of the bending radius and deformations, compared with deformations in three-dimensional forming. One of the objectives of this research, as well as our research is to determine the minimum radius of curvature, which is suitable for veneers sheathing.

In order to understand the spatial deformation veneers, is necessary to examine the behaviour of veneers in a plane load. The aim of this work is to propose a methodology to evaluate the basic types of bending load. Identify and compare changes in shape of thin wood materials (veneer). Formability expressed by the coefficient of bendability.

MATERIALS AND METHODS:

Since the testing of mechanical properties of veneer (thin flat materials) methodologies does not exist, therefore these methods are based on tests to determine the mechanical properties of wood and plastic (as thin materials). First we conducted preliminary measurements on which they were established suitable samples dimensions and boundary conditions - the type and size supported size of forces.

For the experimental tests in two directions - longitudinal and transverse have been used native birch, beech and ash veneer with a thickness of 0.55 mm with radial and tangential plane. Dimensions of test pieces were adapted to the test methodology and were designed so that the results are comparable. Method of support sample for each test was based on actual technological conditions for forming veneers during pressing, i.e., it was a free supported.

Bending load:

In the case of bending, we used the methodology of testing of thin plastics, based on this methodology; we have designed also dimensions of test pieces. The tests were conducted in three-point and four-point bending as shown in figure 1.

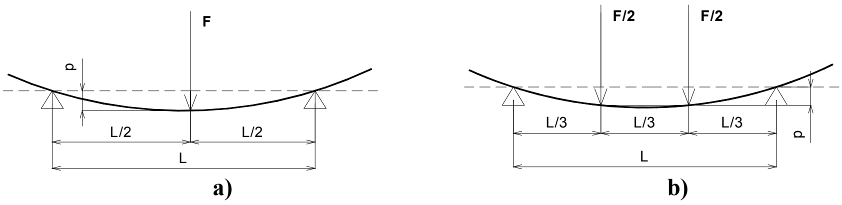


Fig. 1 Static scheme for bending load; a) three-point bending, b) four-point bending

Dimensions of test specimens: for diameter of supports 4 mm, its distance 20 mm, test specimens: width 20 mm, length 50 mm; for diameter of supports 8mm, its distance 40 mm, test specimens: width 20 mm, length 150 mm. Specimens were loaded parallel and perpendicular to the fibers in the radial and the tangential plane, as shown in Fig. 2

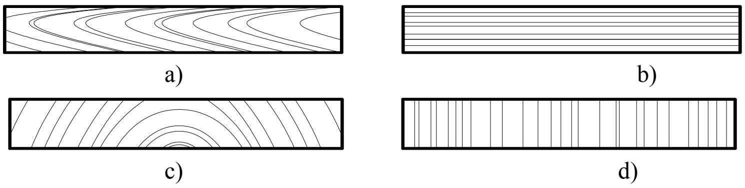


Fig. 2 Direction of loading and bending of test samples
a) parallel to the fibers in the tangential plane, b) parallel to the fibers in a radial plane;
c) perpendicular to the fibers in the tangential plane, d) perpendicular to the radial plane of the fibers

Buckling load:

After the preliminary tests, we have set final methodology: free support, straining parallel to the fibers. Based on preliminary results is free supporting of more appropriate and less distortion test method. For fixed support were test specimens breached in the point of constraint, already at low size of load. Figure 3 shows a loading scheme. The test was carried out only on samples longitudinal direction of the fibers in the tangential and radial plane. The test on samples with a transverse direction of the fibers has not been realized.

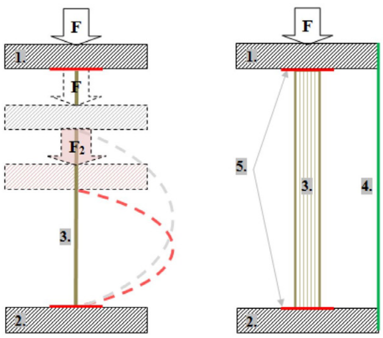


Fig. 3 Static scheme for bucklingg load

RESULT:

We chose coefficient bendability k_o as a criterion for evaluating plane formability veneers, which expresses the quality of the material to change shape due to the applied bending moment

$$k_o = \frac{h}{r_{\min}\ [\,]}$$

where:

h - thickness of the veneer (mm)

r_{min} - minimum bending radius (mm).

Bending load:

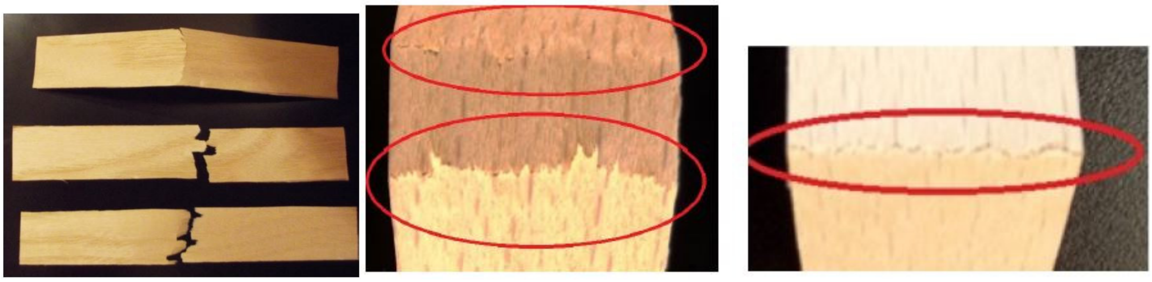
The aim, in the case bending tests, was to verify the suitability of three-point or four-point bending, for evaluation formability veneers and suggest a support sizes depending on the size of the test specimen. Preliminary tests showed that size of supports (rounded supported) and their distance is significant. Values a coefficient bendability and minimum radii for bending load are presented in table 1.

Tab. 1: Coefficients bendability k_o veneers for bending load.

Type of load		Wood species	Plane of veneer	Thickness, length of the sample (mm)	The eflection (mm)	Min. radius of curvature r_{min} (mm)	Coefficient of bendability k_o
three-point bending	parallel to the fibers	Birch	tangential	0,55; 50	2,52	20,16	0,0273
			radial	0,55; 50	2,44	20,81	0,0264
		Beech	tangential	0,55; 50	4,26	11,98	0,0459
			radial	0,55; 50	3,15	16,15	0,0340
		Ash	tangential	0,55; 50	3,74	13,63	0,0404
			radial	0,55; 50	3,13	16,26	0,0338
	perpendicular to the fibers	Birch	tangential	0,55; 50	5,67	9,03	0,0609
			radial	0,55; 50	5,35	9,56	0,0575
		Beech	tangential	0,55; 50	6,7	7,66	0,0718
			radial	0,55; 50	5,6	9,14	0,0602
		Ash	tangential	0,55; 50	3,77	13,52	0,0407
			radial	0,55; 50	2,98	17,07	0,0322
four-point bending	parallel to the fibers	Birch	tangential	0,55; 50	4,24	12,04	0,0457
			radial	0,55; 50	3,46	14,72	0,0374
		Beech	tangential	0,55; 50	5,66	9,04	0,0608
			radial	0,55; 50	4,59	11,13	0,0494
		Ash	tangential	0,55; 50	4,59	11,13	0,0494
			radial	0,55; 50	3,99	12,78	0,0430
	perpendicular to the fibers	Birch	tangential	0,55; 50	5,68	9,01	0,0610
			radial	0,55; 50	6,33	8,10	0,0679
		Beech	tangential	0,55; 50	7,14	7,19	0,0765
			radial	0,55; 50	6,17	8,31	0,0662
		Ash	tangential	0,55; 50	3,86	13,21	0,0416
			radial	0,55; 50	2,57	19,77	0,0278

The measured values show that for the plane forming is best direction parallel to fibers in a radial plane. Four-point bending has values of deflection more than three-point bending; four-point bending is considered "pure bending".

The best formability (the smallest r_{min} and the largest k_o) at the load bend is observed in beech sample in *tangential plane parallel to the fibers* and *perpendicular to the fibers*, less formability is characterized birch and ash. Failure modes of veneer sheets at loaded bend moment are shown in fig. 4.



a) b) c)

Fig. 4 Ways to breach of veneer sheets for the bending load test
a) ash veneer, b) beech veneer (radial plane) damage in four-point bending, c) beech veneer (radial plane) damage from three-point bending

Buckling load:

The evaluation of buckling tests was conducted at basis of deflection and radius of curvature which characterizes the formability of wood. A way of measuring deflection is shown in Fig. 5.

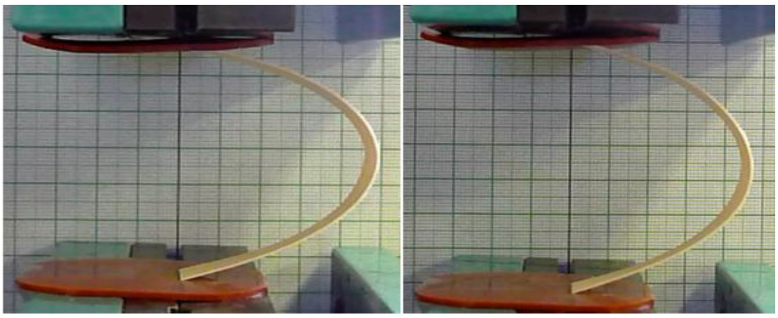


Fig. 5 The measurement deflection at buckling load for
radial and tangential veneer sample - load parallel to the fiber

If we focus on the test specimens with a length l = 100mm from the viewpoint of maximum deflection, the maximum deflection of 52.7 mm were test specimens from the beech veneers with radial plane. They were followed by beech tangential veneer, ash radial veneer, ash tangential veneer. Birch veneer radial deflection reached smallest 44.6 mm. From the viewpoint of minimum radius of curvature - the smallest minimum radius of curvature had sample from tangential beech veneers, on average 3.1 mm. The largest radius of curvature of 17.6 mm is characterized for birch radial veneer.

Another group were test specimens with a length l = 50 mm. The maximum deflection reached samples obtained from ash radial veneer, followed by ash tangential veneer, beech tangential veneer, beech radial veneer, birch tangential and radial veneer. In the case of minimum radius of curvature, the smallest value of 6 mm achieves test samples from the radial ash veneer, followed by samples with plane: ash tangential, beech radial, beech tangential, birch tangential and birch radial veneers. Values a coefficient bendability k_o and minimum radii r_{min} for bending load are presented in table 2.

Tab. 2: Coefficients bendability k_o veneers for buckling load.

Type of load		Wood species	Plane of veneer	Thickness, length of the sample (mm)	The eflection (mm)	Min. radius of curvature r_{min} (mm)	Coefficient of bendability k_o
buckling load	parallel to the fibers	Birch	tangential	0,55; 100	48,3	10,1	0,054
			radial	0,55; 100	44,6	17,6	0,031
		Beech	tangential	0,55; 100	52	3,1	0,177
			radial	0,55; 100	52,7	4,2	0,131
		Ash	tangential	0,55; 100	50,7	6,4	0,086
			radial	0,55; 100	51,6	4	0,138
		Birch	tangential	0,55; 50	21,8	18,1	0,030
			radial	0,55; 50	20,3	20,6	0,027
		Beech	tangential	0,55; 50	24,7	14	0,039
			radial	0,55; 50	24,6	13,3	0,041
		Ash	tangential	0,55; 50	26,8	11,9	0,046
			radial	0,55; 50	29,3	6	0,092

Based on the established results as a more suitable size for the this type of methodology appear to test specimens whose length was 100 mm. Tested samples with a length of 100 mm, achieve a smaller radius of curvature compared with samples whose length was 50 mm. It follows, which is dimension of the sample longer, its ability to moulding better.

CONCLUSIONS:

1. Based on the tests, we found that both methods are suitable for the assessment of formability veneers. In our case, we can only compare the results of each test parallel to the fiber. For the test on buckling perpendicular to the fibers is necessary to optimize the dimensions of the test samples in order to give the test measured output values.
2. The largest values of formability are achieved in wood parallel to the fibers in the tangential plane. Preliminary results which apply to conditions of our experiments show that best characteristics for the forming at the load bend parallel and perpendicular to the fiber has beech veneer ($k_o||$=0,061, $k_o\perp$=0,076). Also, for buckling load values achieved a maximum value of ($k_o||$=0,177). Based on the literature was confirmed assumption that the beech wood species are most suitable to forming. Birch seems like less suitable wood for the moulding, bendability coefficient values have the smallest value (for the bending: $k_o||$=0,026, $k_o\perp$=0,076, for the buckling: $k_o||$=0,027).
3. Mode of failure depends on the type of wood i.e. whether it is a ring-porous or diffuse-porous wood. In our case is ash veneer (ring-porous wood) least suitable for moulding. Shape of failure is characterized by significant protrusions affected by growth rings. Based on the analysis of damage is beech and birch veneer suitable for the plane molding. Protrusions which characterize the mode of failure are less pronounced as for ash. Based on the shape of breach we can predict forming ability of veneer sheets. It would be interesting to follow as changing the shape of breach after the modification of veneer sheets and whether will improve its properties for the moulding.

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Streszczenie: *Analiza efektu obciążeń zginających fornirów w celu oceny formowalności..* Celem artykułu jest ocean efektów obciążenia zginaniem trzy I czteropunktowym oraz wyboczeniem na naprężenia w fornirach. Opisano i o oceniono metodykę oceny podatności fornirów na formowanie. Użyto trzech gatunków drewna, buka, brzozy oraz jesionu, na podstawie wyników badań oceniono ich formowalność.

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