DIMENSIONAL STABILITY AND SHAPE STABILITY OF MASSIVE BOARD

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This Publication has to be referred as: Ibrisevic, A[len]; Obucina, M[urco] & Hajdarevic, S[eid] (2020). Dimensional Stability and Shape Stability of Massive Board, Proceedings of the 31st DAAAM International Symposium, pp.0599-0604, B. Katalinic (Ed.), Published by DAAAM International, ISBN 978-3-902734-29-7, ISSN 1726-9679, Vienna, Austria

DOI: 10.2507/31st.daaam.proceedings.082

Abstract

This work analyses dimensional stability and shape stability of massive board, in dependence of the board construction, technological process of production, and type of wood. Massive boards produced by various technological gluing methods, and various constructions are exposed to various room conditions. Motion of measuring points on these boards was measured in time span of 50 days. It was established that the greatest impact on dimensional stability and shape stability of massive board have type of wood and boards' construction, whereas the technological gluing method has smaller impact.

Keywords: board; shape stability; dimensional stability; beech; oak

1. Introduction

Wood is a natural and important material because of its good mechanical and physical features, and a very low price [1] [2]. However, wood is susceptible to dimensional changes, which can be attributed to humidity, which limits its use in certain applications [4]. Because of wood quality reduction, and higher price of it, wood is nowadays most frequently used as a glued element. Products on the basis of glued wood have become more important in the last few years, as they enable efficient and versatile use of renewable wood materials [5]. Most frequently the wood is used for production of various kinds of boards, which can be produced of massive wood, or maybe some other composite material on the basis of wood. Massive wood boards that can be glued by width or length-width, are widely used in the furniture production and architecture. In furniture production these are mostly used for production of tables and corpus furniture.

Wood boards are hygroscopic material as the wood itself, i.e. the humidity level depends on the relative humidity and temperature of the environment [6]. Due to the decrease of humidity level under the impact of environment the wood shrinks [7], and opposite, due to the increase of humidity level the wood swells. During their exploitation massive wood boards are exposed to changes in temperature and humidity, which finally results in changes on wood, and due to this occurrence dimensional stability is disrupted. Dimensional stability impacts on the level of deformation and warping of the final product during its exploitation, and due to that this is a very important feature that needs to be understood [3].

Dimensional stability is one of the most important features of massive wood boards, because due to disruption of dimensional stability we get warped boards (Figure 1). Due to great warping we get the disruption of product construction in which the plate is built, which imminently leads to shortened exploitation period. Several factors impact the dimensional stability and shape stability of massive boards glued by its width. Above all, dimensional stability and shape stability of boards depend on the type of wood used for their production. Also, an important factor that impacts the dimensional stability and deformation of boards is also technological process of their production, as well as the construction of boards itself.

One of the important factors that impacts the shape stability is also lamella layering in boards. Results of wood gluing show that durability of joint depends also on the growth rings and wood cuts in the glued joint [8]. Namely the internal tensions that occur during the change of humidity in wood highly depend on the position of lamellae [8]. Figure 1.a. shows the process of lamella layering which produces bad joint, whereas Figure 1.b. shows the process of lamella layering which produces relatively good joint applicable in practical terms. However, in case that lamellae are layered in a way that the growth ring angle is relatively close then it results in joint with smaller internal tension, as a result of alternate swelling and shrinking. This work through experiment method deals with dependence of dimensional stability in relation to wood type, technological process of gluing and the board construction.

Fig. 1. Type of lamella layering in a board

2. Experimental part

For the purpose of the experiment, boards of beech and oak in dimensions of 1250x900x25 mm are produced. These boards are taken from production and are used for production of stretchable tables for the European furniture market. These boards are made by two different technological procedures of gluing, i.e. by technological method of cold gluing and technological method of gluing in higher temperature. Before the gluing process, 2 hours after cross-section dimensioning, lamellae are prepared, in order not to disrupt the quality of spew line. Humidity in lamellae before gluing was between 6-8% (mean value of wood humidity was 7.1 %, and standard deviation 0.6%).

Gluing was done by PVA-c glue "Multibond EZ-2 HV" produced by "Franklin Adhesives & polymers". During the gluing process, lamellae were laid so that the growth-ring angle was almost the same, in order to decrease the tensioning. After gluing of boards, 7-day conditioning of boards in conditions $T=16 \pm 2^\circ\text{C}$, $V=20 \pm 5\%$ was performed. After conditioning, boards were dimensioned on thickness $D=25$ mm, and formatted on previously defined dimension with grooves made for stiffeners (two stiffeners) and relief grooves (6 grooves 800x3, 2x10 mm).

Fig. 2. Constructive shape of boards

Twelve boards were observed in total, as follows:

1. oak (cold) without stiffener, oak (cold) with stiffener, oak (cold) with stiffener and relief grooves, oak (warm) without stiffener, oak (warm) with stiffener, oak (warm) with stiffener and relief groove.
2. beech (cold) without stiffener, beech (cold) with stiffener, beech (cold) with stiffener and relief grooves, beech (warm) without stiffener, beech (warm) with stiffener, beech (warm) with stiffener and relief groove,

Boards were set on a flat surface in room with temperature $T=20^\circ\text{C}$ and relative humidity $V=30\%$. Measuring was performed by comparator (Figure 3), with observation of motion on every board motion on nine measuring spots (Figure 4).

Fig. 3. Measuring of boards deformation

Fig. 4. Measuring spots

Measuring was performed in a time span of fifty days. During each measuring values of temperature and relative air humidity were recorded.

3. Results and discussion

Results of experimental motion of spots within 50 days are shown on Figure 5. Measuring of motion spots was performed twice a week. During the measuring of motion, measuring of temperature and relative humidity of air were also performed. Mean value of temperature during the measuring interval (50 days) was 18.1 °C with standard deviation 2.8 °C, and mean value of relative humidity was 29.5 % with standard deviation 9.2%. Chart of deformation of all tested boards from massive beech wood is provided on Figure 5, whereas chart of deformation of all tested boards from massive oak wood is provided on Figure 6. Chart is made so that the deviations of measuring spots (1-1-1; 2-2-2; 3-3-3) were measured, and the mean value for spots 1, 2, 3 is calculated with those values entered into the chart.

Figures 5. and 6. show that in the first 10 days there are no significant motion of measuring spots. After this relatively still period there is a significant deformation of boards, and in this period maximum deviations of measuring spots in relation to the initial values occur. Most of the boards have maximum deviations from the initial value 25-30 days after the beginning of measuring. After the boards reach maximum values of deviations, decrease of deformations occurs, and deformations come closer to the initial values. In the last few days of measuring, due to the higher relative air humidity (57%), some boards have larger deviations from their initial values. Namely, due to increase of relative humidity of environment, increase in wood humidity occurs, which causes swelling of wood, and due to that, shape stability deterioration occurs. In non-stiffened boards, maximum motions occur at the end of boards, while the medial part of the board does not have significant motion. Stiffened boards have motion at the ends, but also in the medial part, and with some boards some maximum deformations occur in the medial part of the board (beech cold with stiffener, oak cold with stiffener). Beech boards have the largest deformation with cold-glued board, without stiffener.

Boards with stiffener have far smaller deformation. boards with stiffener and boards with stiffener and additional grooves have almost the same deformation. Oak boards have the largest deformation with warm-glued boards, without stiffener, whereas the smallest deformation was found in cold-glued boards, without any additional stiffener. boards with stiffeners and boards with stiffeners and relief grooves had almost the same deformation, and it varies from board to board. Cold-glued board with relief grooves had smaller deformation than the boards with stiffeners, whereas the warm-glued boards had larger deformation with grooves than the boards with stiffener only.

During the experiment there was only one extreme. Namely the cold-glued oak board without stiffener had a smaller deformation in comparison to boards with stiffener. All other boards showed opposite, i.e. boards without stiffeners had larger deformation. Therefore this extreme was not taken into consideration during the data processing, and this occurrence will be a subject to future research.

Fig. 5. Chart of beech boards deformation

Figure 7 shows a comparative deformation in oak and beech boards. In Figure 7 it is visible that the key significance for shape stability has the type of wood. Namely the beech boards have a smaller shape stability in comparison to boards made of oak, i.e. far larger deformation occurred with beech boards. In Figure 7 it is visible that the maximum deformation was 18.87 mm and it occurred with cold-glued beech board without stiffeners. With beech board, glued in higher temperature the second largest deformation occurred and it was 12.34 mm. Maximum deformation with other boards was between 3.22 and 8.41 mm.

Fig. 6. Chart of oak board deformation

Fig. 7. Maximum values of deformations in oak and beech boards

4. Conclusion

This work experimentally established two-dimensional stability and shape stability of width-glued boards exposed to room conditions, depending on the type of wood, technological process of gluing and board construction. Minimal plate deformation occurred in the first ten days. After that, increased deformation of all boards occurred. Maximum deformation occurred within 25-30 days after first measuring, i.e. after exposing of boards to room conditions of temperature and relative humidity. In this period change in humidity in wood occurs, which results in change of shape stability of boards. Due to the increased air humidity, disruption of balanced humidity in wood occurs, i.e. tension within wood occurs, and due to that, an increased deformation of boards occurs, and this phenomenon is present in boards with stiffeners, and in boards with stiffeners and relief grooves. In boards without stiffeners, due to increase of humidity in the last period of measuring disruption of shape stability does not occur.

From previous charts, it is visible that the type of wood has an imminent impact to shape stability of boards. Namely boards made of oak have far better shape stability in comparison to beech boards. Board construction has also an imminent impact on dimensional stability and shape stability of boards. Namely boards with stiffeners have far better shape stability than the boards without stiffeners. Technological process of production does not have significant impact on shape stability of boards. Namely, this experiment could not provide any conclusions concerning the shape stability of boards and technological process of production, as the results of measuring vary. Because this experiment lasted for long and a large number of various boards was observed, it was not practical to observe more boards of the same kind, because it would require far more space and time.

Additional research is required to take into consideration more boards of the same kind in order to process the data statistically, and establish the real dependence between dimensional stability in relation to the technological process of production and board construction. This topic is to be discussed in future.

5. References

- [1] Wacker JP. (2010). Wood Handbook, Wood as an Engineering Material, Use of wood in buildings and bridges. Forest Products Laboratory, University of Wisconsin, FPL-GTR-190, Madison, USA
- [2] Rowell RM. (2005). Chemical modification of wood. Handbook of wood chemistry and wood composites, Forest Products Laboratory, and Department of Biological Systems Engineering, University of Wisconsin, Madison, USA
- [3] Sargent R. (2019). Evaluating dimensional stability in solid wood: a review of current practice, Journal of Wood Science 65:36, Volume 65., December 2019, ISSN:1435-0211
- [4] Duygu Kocaefe, Xianai Huang, Yasar Kocaefe (2015). Dimensional Stabilization of Wood: Curr Forestry Rep 1:151–161, ISSN: 2198-6436, Springer International Publishing, DOI: 10.1007/s40725-015-0017-5
- [5] Martin S., Mueller C., Neuenschwander J., Sennhauser U. (2009). Air coupled ultrasound inspection of glued solid wood boards, 16 th International Symposium on Nondestructive Testing and Evaluation of Wood, October 12-14, Beijing, China, Beijing Forestry University, <http://hdl.handle.net/20.500.11850/27583>
- [6] Ayırlmis N. (2007). Effect of panel density on dimensional stability of medium and high density fiberboards, Journal of Materials Science, Vol. 42:8551-8557, 2007, DOI: 10.1007/s10853-007-1782-8
- [7] Hajdarević S., Obućina M., Delić M., Ibrisevic A., Cisića M. (2019). Dimensional and shape stability of plywood seat, 30th DAAM international symposium of intelligent manufacturing and automation, 23-26th October 2019, Zadar, Croatia, Volume 30, No.1, ISSN 1726-9679, ISBN 978-3-902734-22-8 Ed. B. Katalinic / Published by DAAAM International, Vienna, Austria, EU, 2019 DOI: 10.2507/30th.daaam.proceedings.042
- [8] Backović M.(1997); Gluing in wood processing technologies, Faculty of Mechanical Engineering, Bosna Public, Sarajevo