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The influence of sanding process on adhesive bonding of wood

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Abstract

A study was carried out to compare adhesive bonding quality between planed and abrasive planed surfaces of wood. The aim was focused on the issue of reduction of labour cost, equipments and raw material for wood furniture production, referring to experience of some companies which apply sanding process after planning of surfaces to be glued. Beech (*Fagus sylvatica* L.) and fir (*Abies alba* Mill.) were selected to be studied. Samples consisted in boards with length 60 cm and width 10 cm, without deformation or wood structure defects. After planning with the same advance velocity, 1/3 of them were abrasively planed with 60-grit size sandpaper and 1/3 was abrasively planed twice with 60 and 100-grit size sandpapers. After, the boards were adhesive bonded with PVA glue, applying 200 gr/m^2. Related to angles of annual rings between glued boards, was respected EN 205, 30º ÷ 90º. Pressure was applied with hand grip vice. Time of pressure was 24 hours. The adhesive bonded boards were cut up into test pieces 5 cm length and 2 cm wide. The shear strength of test pieces was measured mean mechanical testing machine. Results showed that shear strength of abrasively planed test pieces with 60-grit size sandpaper of both wood species became short of planed ones, while samples abrasively planed with 60 and 100-grit size sandpapers presented approximately the same resistance.

Keywords: gluing, wood, planning, sandpaper, EN 205.

1. Introduction

Currently in Albania there are some companies which carry on their activities realising production of solid wood based panels applying adhesive bonding of wood using PVA or UF (Kaurit) glues. As raw material mostly is used native wood beech (*Fagus sylvatica* L.) as well as other wood species, mainly imported, like European silver fir (*Abies alba* Mill.), walnuts (*Juglans* sp.), maples (*Acer* sp.) and in some cases acacias (*Acacia* sp.). Beech panels are used mainly for production of stairs, chairs, tables even and furniture, while those of other species are destined generally for furniture production.

On viewpoint of the structure it is noted that companies are concentrated in the most important urban areas of the country, in general. This geographical distribution is consequence of raw material location (companies tend to be as near as possible raw material resources) and of infrastructure situation (roads and electricity network). Referring to geographical distribution the capacities of companies are higher in large urban centres. The technology generally is up dated one. According to companies raw material procurement is the main problem which they are facing. There is a quantity and a quality problem. The quality of native beech wood year after year tends to degradation, influencing negatively on development of this sector and forcing companies to import other wood species as raw material such as fir, walnuts, maples etc., mainly from countries of the region. All companies export their products in Italy and in some cases in other EU or regional countries. Normally, they do not operate with full capacity. Regarding to the future of their activity most of them see it positively, if the problem of raw material would not exist [1].

The production of wood based panels is realized through the following technological steps:

- cutting boards into strips;

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- planning strips into four sides mean to four-side planner;
- sanding faces of strips where the glue will be apply;
- applying the glue;
- cold / high frequency electricity pressing;
- calibrating and sanding the panel.

This technology is pretended to be based on their experience and almost all the producers are convinced that this is the best solution to guarantee a high quality product. If we see carefully we note that sanding process is a pin pointing remark which needs to be discussed and analyzed more professionally, because is well known that a smooth, knife-cut wood surface is best for bonding, because the surface is clear, cells are opened and the glue can penetrate enough to secure a good quality of bonding [2].

Studies related to evaluation of gluing performance of wood surface processed by different mechanical processes show different results. By sanding process, in general are obtained lower values of surface roughness, but this doesn't mean a better adhesion between liquid mass of glue or paint and surface of wood [3]. Eucalyptus benthamii wood, used to manufacture edge glued panels with polyvinyl acetate emulsion adhesive (PVAc), shows better shear strength and wood failure percentage for planed surfaces than those sanded ones [4]. By the other hand, black spruce wood glued with isocyanate adhesive gives better performance (shear strength and percent wood failure) for sanded surfaces than those obtained by peripheral straight-edge knife planning [5]. Well known authors have found that universal relationship between bonding performance and surface processing technique could not be identified, making individual studies of bonding performance in dependence on adherent and processing – related surface texture inevitable [6].

In Albania many companies are lacking the accurate technical information with regard to quality as well as relationship between the quality and cost of product. This issue causes them difficulties because of strong competition by companies from other countries. Actually, our product (solid wood panel) is more expensive than product of other Balkan countries, causing so the reduction of EU market's demand for our companies. This is because of low quality of raw material as well as subjective issues. In this frame work the matter is to reduce the cost of production and for this the companies need specific information which actually is impossible to be secured by themselves because of professional and economical reasons.

Analyzing the steps of technology they apply, sanding process seems to be shortcoming ring of chain where the interventions are possible. Taking into account that abrasion of surfaces destined for gluing is a doubtful factor a study is carried out to analyze the necessity of this step. The aim is focused on the issue of reduction of labour cost, equipments and raw material for wood furniture production, referring to experience of some companies which apply sanding process after planning of surfaces destined to be glued. From this viewpoint the study conclude to comparison of gluing resistance between planer surfaces and abrasive surfaces used by our industry. Wood beech (*Fagus sylvatica* L.) and fir (*Abies alba* Mill.) are selected to be studied, because they are the most used wood species for production of solid wood based panels in Albania. The aim of the study is directly related to the problem of quality and competition, so it appears to be important.

2. Material and Methods

The study was based on comparative laboratory method cause – consequence [7]. The method consisted in quantity evaluation of a specific feature caused by a provocative factor and after, in evaluation of the same feature in situation of factor's absence. In our case feature was quality of wood surface and provocative factor was sanding process.

Laboratory tests consisted in preparation of samples and tests of gluing. It was applied the procedure specified to the European standard EN 205 "Determination of tensile shear strength of lap-joints" [8]. The study was carried out at the Faculty of Forestry Sciences of Tirana.

Measurements were concentrated on sandpapers of 60-grit and 100-grit sizes, normally used by our industry. Samples were prepared from 60 cm length and 10 cm width beech and fir boards without deformations or wood structure defects which could influence on gluing resistance. After planning with the same advance velocity, 1/3 of them were abrasively sanded with 60-grit size sandpaper and 1/3 was abrasively sanded twice, first one with 60-grit and second one with 100-grit size sandpapers. The sanding process was carried out by sanding machine with controllable feeding speed and constant pressure of abrasive paper. After this the procedure continued as below:

1. Application of adhesive on boards surfaces.

Boards were selected in order that those destined to be gluing together to had approximate density. The density of wood was measured according to the standard ISO 13061-2 [9]. Their faces had to presented flat and smooth surfaces. Thickness tolerance was not permitted higher than 0.1 mm, making so possible a good pressure during the hardening of glue.

It was used PVA glue. The quantity of glue was referred to industrial application 170÷240 [gr/m^2] and was verified by weighing the boards before and after application of glue.

2. Pressure. It was applied with hand grip vice for 24 hours.

Based on the standard EN 205 boards were selected with angle 30º÷90º between annual rings and bonding surface (Figure 1).

Figure 1. Pressing of glued boards

3. Preparation of samples and tests.

The adhesive bonded boards were cut up into test pieces 5 cm length and 2 cm wide, with grain direction parallel with the longer edge. A canal was sawed to all test pieces as shown in Figure 2.

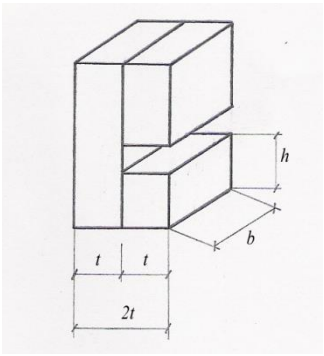

Figure 2. Finished samples
h – height of test's surface
b – width of test's surface
2t – width of test piece

In total were prepared 187 test pieces, respectively 86 from fir and 101 from beech wood. More detailed information with regard to number of test pieces is presented in Table 1.

Table 1. Number of test pieces referred to wood species and surface preparation

Wood species	Number of test pieces		
	planed surface	60-grit size	100-grit size
Beech	33	34	34
Fir	29	27	30

After preparation of samples (test pieces) they were tested mean mechanical test machine (ControLab, FRANCE) applying a force until to their rupture (Figure 3 & 4).

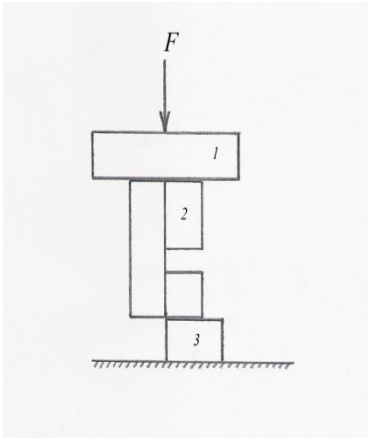

Figure 3. Test's scheme
1 – applier of force
2 – test piece
3 – fixed support

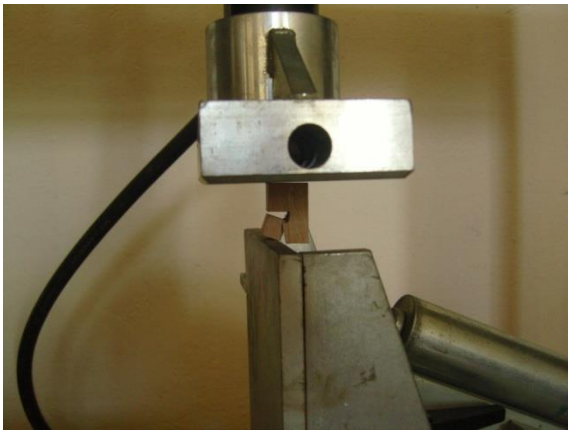

Figure 4. Testing photo

The shear strength of gluing for each test was calculated in *N/mm^2* mean formula *S = F/A*, where F was the force of rupture in *N* and A was gluing surface in *mm^2*.

For data acquisition served the oil pressure trasdutor HBM P8AP and the software LabView. The data were electrical impulses expressed in *Volt*. Their further processing was performed mean Excel software. Conversion of numerical values expressed in *Volt* to numerical values expressed in *N* was performed mean the conversion coefficient 1 Volt = 18920.20593 N.

3. Results and Discussion

In Table 2 are presented summarised results of gluing shear strength referred to studied species and surface preparation.

Table 2. Results of gluing tests referred to wood species and surface preparation

Series of tests		Average shear strength [N/mm^2]	Standard deviation	Wood failure [%]
Planned	fir	2.9	1.5	
60-grit size	fir	2.6	1.2	
100-grit size	fir	3.0	1.3	
Planned	beech	7.4	3.5	
60-grit size	beech	5.7	2.4	
100-grit size	beech	7.0	3.1	

The results of shear strength showed notable differences among the surface preparation methods applied to beech wood. Planed surface gave a value of shear strength 30% higher than 60-grit size sanded surface and only 6% higher than 100-grit size sanded one. With regard to fir this didn't happen so notably. Planed surface of fir gave a value of shear strength 11% higher than 60-grit size sanded surface and 3% lower than 100-grit size sanded one. So, the lowest shear strength for both wood species was obtained with 60-grit size sandpaper, while 60 and 100-grit size sanded surface presented approximately the same resistance with planed one. Other studies were carried out to analyse the impact of surface process on PVA glued joints and arrived to the same conclusion regarding to 60-grit size sanded surface [10]. Gluing strength increased with the increase of grit size paper, while planning gave the maximum strength among the surface processing for wood beech. Glue line of wood fir had the best glue strength. It was noted that to all fir's test pieces the failure of adhesion occurred to wood and none to glue line (Figure 5). This phenomenon is explained taking into account the quality requirements for a good adhesion. The shear consists to rupture of glued materials because of failure of adhesion between glue and wood or only of glue line. In case of a good adhesion wood near glue line will be destroyed. A good adhesion gives a higher resistance than glued wood [11]. The final strength of adhesion depends on resistance of contact surface of wood and on glue. In this framework the strength is determined by the weakest factor between them. When the adhesion is submited to mechanical loads, to maximal value of strength corresponds either failure of wood substrate or failure of glue line. Results showed that adhesion with PVA glue of fir sanded surfaces could not be classified as more qualitative than planned surface. Apart from surface processing, for fir wood a good adhesion occured. On the other side it was impossible to get an accurate numerical value corresponding strength of adhesion, but only the strength value of wood fir, which in our study resulted to the shear strength of wood to longitudinal direction.

Figure 5. Wood failure of fir's test pieces

With regard to beech test pieces the highest wood failure was found to pieces sanded with 60-grit size sandpaper. Although planned surface gave the highest value of shear strength, it gave an intermediate value between two sanded surfaces. Even this, it should be considered as a good wood surface-glue combination, for giving reliable and predictable results.

Beech presented the highest shear strength for all surface processing methods. This was expected knowing that shear strength of gluing increases with wood density increase up to the limits 0.7-0.8 gr/cm^3, referred to 12% moisture content [12].

4. Conclusions

With regard to gluing quality of sanded wood surfaces during production of beech solid wood based panels, we can say that application of sanded process with 60 and 100-grit size sandpapers does not give higher quality comparing to planed surface only. On the contrary planed surface, referring to conifers and broadlives mostly used as raw material in Albania, gives higher gluing strength than 60-grit size sanded surface and not lower than 100-grit size one. Studies have shown that surface roughness improves, to some extent, the adhesive joint performance, because of the larger contact area on the surface of wood [13]. A rougher, but clean surface (without damaget fibers),

can provide enhanced capillary forces and expose more porous structure in the wood [14].

The conclusion of the study has a great applicative importance for our industry, making possible the cost's reduction of solid wood based panels. Nevertheless there are also other steps of actual technology aplied in Albania which must be studied focused on reduction of labour cost, equipments and raw material for production of solid wood based panels.

5. References

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