Influence of furniture exploitation on the bending strength of final mountable-dismountable corner joints

Marija Krstev, Ivana Antovska, Elena Jevtoska and Gjorgi Gruevski

Faculty of Design and Technologies of Furniture and Interior – Skopje, Ss.Cyril and Methodius University in Skopje, Macedonia

E-mail: ilievskal1@yahoo.com

Abstract. The aim of the researches presented in the paper is to show how the exploitation of furniture affect the strength of its connectors, more precisely the bending strength of the final corner dismountable joints for designed furniture – office desk. For studying this influence, 2 office desks were made (from chosen material OSB panels), joined by dismountable connectors, and also from the same material and the same type of connectors, reference test fixtures were made and their bending strength was the value of comparison. Office desks were tested according to European Standard for determining the stability of the structure (EN 527-3:2003 E) and that was simulated exploration of furniture. After that, the final corner compositions were cut off, and its bending strength was compared with the reference test fixtures strength. The research results showed that the exploiting of dismountable furniture has not a significant impact on their compositions strength.

1. Introduction

The quality of furniture and its durability, primarily depends on the material from which it is developed, the type of couplings that are used to merge its constituent elements, the method of processing during the production, as well as the way in which it is used from the buyer.

The furniture has to be solid and firm enough, to withstand its own weight and also the weight of the load it carries. During furniture exploitation, the most common issue that occurs is the bending strength. Bending strength is also one of the most studied kind of strength which affects the construction of cabinet furniture. In this paper, chosen material are oriented strand boards (OSB) with 18 mm thickness, produced by Kronospan Bulgaria EOOD (OSB/2 EN300: High load-bearing boards for indoor use). The advantage of this material is its ability to withstand the load in the direction of the orientation of wooden strands, and the basic negative characteristic is the expressed inhomogeneity due to the size of the chip. The used couplings are mountable-dismountable, eccentric clutch Minifix 15 with clamp and binding element produced by Hafele (Figure 1), which allows us to dismantle the furniture to its constituents.
Through this research, we need to give the basic direction and recommendation to users, whether the cabinet furniture, which is big and heavy, should dismantle it before relocating or transporting to another location, and respond to the question of whether such dismantling and re-installation, will change joints strength, specifically, the strength of bending. In that direction it is necessary to solve the following tasks:

- Determination the stability of the finished product - office desk, according to the European Standard for Office Furniture EN 527-1: 2000, EN 527-2: 2000 (E), EN 527-3: 2003 (E), made of oriented strand boards, assembled with dismountable connectors, which actually simulates the exploitation of furniture;
- Determination the moment of bending of the final corner joints cut off from office desks that passed the stability test according to the European Standard;
- Determination the moment of bending of the final corner joints, made from oriented strand boards, taken as reference test joints.

2. Methods of the experimental work

In order to conduct the survey, two office desks were made from the selected material, with dimensions 1200/738/550 mm, assembled with dismountable couplings.

The office desks, such as finished products, subjected to the test method cycles according to the European Standard for Office Furniture, which simulated the exploitation of furniture (Figure 2 and Figure 3) and we enabled the angular compositions that will later cut off from these desks be already burdened with certain stretching. The examination is performed in the furniture testing laboratory at the Faculty of Design and Technologies of Furniture and Interior - Skopje, on the multifunctional test field from the German manufacturer Weinmann.

Figure 1. Minifix 15 with clamp and binding element.

Figure 2. Testing stability under load with force in a horizontal direction.

Figure 3. Application of vertical short-term loads during the testing process.
Strains in the corner compositions of furniture, occur as a result of the exploitation, or internal forces during relocating or transporting the furniture in mounted condition. The analysis showed that occurs bending strains, which cause the deformations of the furniture. Under the action of these forces, some of the corner compositions are loaded with bending forces by opening the shoulders, and some with their closure. Given that, the test method is moving in two directions: with load with bending forces at opening (test objects of Group I) and when closing (test objects of Group II) the shoulders of the composition (Figure 4).

![Figure 4. Test scheme for testing corner joints](image)

a) - when load opens the shoulders of the test samples
b) - when load closes the shoulders of the test samples.

The type, shape and dimensions of objects for testing are displayed on the image (Figure 5). In this paper, two types of test objects are tested: the one is reference, specially made for the purpose and others are cut off from the office desks we used when examining the durability according to the European Standard. In this way, we have two values to compare: bending strength in angular compositions of new furniture, unused, and already exploited desks, dismantled, and re-mounted in order to further use. The testing of samples is carried out after five days of conditioning at temperature \( t = 15 - 30 ^\circ C \) and humidity 45 to 70% and then measure the dimensions.

![Figure 5. Front and cross-sectional view of final corner joint coupled with eccentric clutch.](image)
Figure 6. Examination of corner joints when bending loaded by opening the sides of the sample object.

Figure 7. Corner joints when bending loaded by closing the sides of the sample object.

The necessary apparatus for carrying out the test of the test fixtures includes a universal test machine, which ensures the accuracy of the test of 1% of the force of breaking, moving trolley and a device for measurement of linear dimensions with an accuracy of 0.1 mm. The examination is carried out according to the Figure 4. The test objects are burdened with a smooth force until breaking. The breaking time is 60 ± 30 seconds from the start of load.

2.1. Results and discussion
The processing of data from the conducted research is made according to the usual methods of variation statistics.

The medium arithmetic values are calculated \[x_{sr}\], the standard deviation \[s\], the coefficient of variation \[V\] and their errors \[f_{x_{sr}}, f_s, f_V\]. The test subjects had been divided into two groups with three models, with following marks description:
- **Group I** - Examination with bending forces when opening shoulders:
  Model A – test objects merged with eccentric clutch Type A (minifix 15 with clamp and binding element): A / 1 - reference test objects; A / 2 – test objects at 2500 cycles; A / 3 – test objects targeting 5000 cycles.

| Model | \(X_{sr}\) [Nm] | \(f_{X_{sr}}\) [Nm] | S [Nm] | \(f_{S}\) [Nm] | V [%] | \(f_{V}\) [%] | P [%] | n [Number] |
|-------|----------------|-------------------|--------|----------------|-------|--------------|-------|-----------|
| A/1   | 6.41           | 0.61              | 1.49   | 0.43           | 23.24 | 7.06         | 9.49  | 6         |
| A/2   | 6.17           | 1.02              | 2.05   | 0.72           | 33.17 | 12.95        | 16.59 | 4         |
| A/3   | 6.33           | 0.69              | 1.38   | 0.49           | 21.85 | 8.09         | 10.93 | 4         |

The results of the examination of the test objects of Group 1 show small, insignificant variations of the values of the bending, which shows that the swinging of the desks according to the European
Standard does not have a significant impact on the strength of the exploited corner composition compared to the reference.

![Figure 8. Results from the examination Group I / Model A (Examination with bending forces when opening shoulders).](image)

- **Group II** - Examination with bending forces when closing shoulders:
  Model A – test objects merged with eccentric clutch Type A (minifix 15 with clamp and binding element): A / 1 - reference test objects; A / 2 – test objects at 2500 cycles; A / 3 – test objects targeting 5000 cycles.

### Table 2. Results from the examination Group II objects.

| Model | Xsr [Nm] | fXsr [Nm] | S [Nm] | fS [Nm] | V [%] | fV [%] | F [%] | n [Number] |
|-------|----------|-----------|--------|---------|-------|--------|-------|-----------|
| A/1   | 6.21     | 0.77      | 1.89   | 0.55    | 30.45 | 9.57   | 12.43 | 6         |
| A/2   | 3.47     | 0.35      | 0.7    | 0.25    | 20.16 | 7.41   | 10.08 | 4         |
| A/3   | 6.02     | 1.5       | 3      | 1.06    | 49.85 | 21.57  | 24.93 | 4         |

As can be noted from the data in Table 2, the swinging of the desks according to the European Standard has no significant impact on the moment of bending strength in the corner compositions, regardless of the model.

![Figure 9. Results from the examination Group II / Model A (Examination with bending forces when closing shoulders).](image)

### 3. Conclusion

The results of the examination of the bending strength of the dismountable final corner compositions made of OSB panels, when loading with bending forces and analysis of the data obtained before and after simulated exploitation, provide the following conclusions:
1. Simulated exploitation does not have a significant impact on the strength of bending on corner composition, which means that the furniture that has the ability to dismantle, can be used in the full of its strength, again.

2. The previous conclusion is formed on the basis of the technical characteristics of the coupling element that provides an elastic, not a rigid connection and who succeeds to receive and withstand the strain in furniture.

3. Impact on the results obtained is the interconnection of the eccentric clutch with the type of material (OSB plate). The different values and deviations in a minimum and maximum for the specific moment of bending are the result of the incompatibility of the OSB plate as a material for making furniture due to its non-proficiency and volatility in quality and the purpose of the eccentric joints for material with a finer and equated structure.

4. Another factor that has an impact on the diversity of bending strengths, represents the human factor present when mounting and screwing clutches.

5. The practical application of the results of this paper is in the recommendation to keep an eye on the selection of materials and shackles and to be used appropriately for the purpose for the piece of furniture to fully respond to the function and purpose for which it is provided.

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