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# IMPACT OF EDGE AND SURFACE PROCESSES ON THE RESISTANCE OF FURNITURE CORNER JOINT OF PARTICLEBOARDS COVERED WITH MELAMINE RESIN PAPERS

**MustafaALTINOK*, MusaATAR***

*Gazi University Technical Education Faculty, Furniture and Design Education Department, Ankara-Türkiye

**Abstract**

This study was performed to determine the effects of different corner joint processes on the diagonal tension resistance of L-type corner joint of surface of element A and edge of element B of particleboards covered with melamine resin paper. Consequently, intersectional surfaces of Element A were sanded with 100 sand abrasive and edges of Element B were covered with massive wood or PVC. After this process, L-type corner joint samples were produced by using Kleiberit-303, Desmodur-VTKA or Montajkit glues and 3.5x50 mm screws. Diagonal tension test was applied according to ASTM-1037 standards. In conclusion, tension resistance was the highest at the corner joint of sanded Element A and massive edged Element B jointed with D4 adhesive and screws (1.432 N/mm$^2$), and the lowest at the corner joints with unprocessed surfaces, PVC edges and Montajkit adhesive (0.161 N/mm$^2$). Accordingly, sanding of intersectional surface and covering the edges with massive wood or PVC bands increased diagonal tensional performance of L-type corner joints of fiberboards covered with melamine resin paper. So, these processes may provide advantages for furniture corner joints of particle board where high diagonal tension resistance is needed.

**Key words**: Tension Strength, VTKA, kleiberit-303, montajkit glues, L-type corner joint

## 1. Introduction

One of the basic elements of furniture industry, panels (particle board, fibre board, plywood etc.) are coated with Melamine resin, particleboard and laminates in order to improve their aesthetics and resistance properties. Coated panels are used with many of the wood-based materials in the furniture manufacture and design industry. It is stated that their outstanding characteristics that provide endless options in design, colour and texture diversity, their appropriate features such as aesthetic and economic advantages, uniform density and surface smoothness, dimensional stability and higher resistance have satisfied the architects, designers and the people who used them in an increasing level [1].

It is stated that modulus of elasticity, flexure, vertical and horizontal screwing resistance of particleboards covered with melamine resin paper are more than normal particleboards. Particleboards covered with melamine resin paper used widely recently are stated to show diminishing effect on adhesive resistance at resin planes obtained from the highest in Beck adhesive (9.202 N/mm$^2$) and the lowest at contact glue(6.407 N/mm$^2$ ) at face to face bonding of massive wood material and wood-based material [2]. Eckelman suggests the use of composite particleboards having mechanical and high performance features for the high quality furniture design [3]. The specimens having 7.5 cm length between two trunnels have been proved to be the highest tensile and compression strength in trunned corner joints produced from particleboards [4]. In the wooded lath box construction, it has been found out that the effect of particleboard and adhesive type on strength and pressure resistance is more at the VTKA adhesive than PVAc [5].

In case constructed furniture, It is stated that the moment carrying capacity of screwed corner joints is higher than screwed + glued corner joints and screw size and number have positive effect on the joint

*Corresponded Author; altinok@gazi.edu.tr*

performance [6].

It has been expressed that the highest diagonal pressure and strength resistance are obtained in Desmodur-VTKA adhesive + screwed joints in panelled corner joints [7]. As for the corner joints of average dense fibre board, VTKA adhesives are said to have the highest diagonal pressure and strength resistance, but the lowest is on the PVAc adhesive specimens [8].

By using Desmodur-VTKA adhesive, the specimens made of fagus orientalis, scotch pine, white oak have been subjected to withdrawal and shear experiments after acclimatisation, cold and hot pad-batch methods, and boiling and alternation boiling. As a result, Desmodur-VTKA adhesive can be used dry or humid indoor and outdoor [9].

The purpose of this study is to determine the effects of the process in which the corner joint resistance of intersection is sanded and the edge of the other particleboard is coated with massive wood or PVC adhesive in box type furniture made of melamine resin covered particleboards

## 2. Material and Method

### 2.1 Material

#### 2.1.1 Particleboards

According to standards of TS EN 312-3 [10], 18 mm in thickness flat pressed boards produced for general purposes and according to standards of TS 1770 [11], 90 g/m$^2$ in weight and 0.9 mm in thickness panel furniture (pear designed) 50-60 % percent of total weight of which is resin and alpha cellulose paper coated have been preferred as it is widely used in furniture industry. They have been obtained from the establishments in Ankara randomly.

#### 2. 1. 2 Adhesives

In the joining process of the specimens made of particleboards, Desmodur-VTKA, D4 and Montajkit adhesives were used. They have been bought from the sellers in Ankara. Desmodur-VTKA is a kind of single component solvent free, polyurethane-based and moisture cured adhesive that has been introduced to market recently, is preferred mainly for assembly. As stated by the producers of it, it is used for agglutinating wood material, metal polyester, stone, ceramics, PVC and other plastics. In the application process, the guidelines have been applied. According to the guidelines, bonding surface should be clean, dry, dust and oil free. Dry surface should be moisture softly in order to increase hardening speed of the glue.

After it is directly applied to one of the surfaces that has higher soaking capacity, bonding process is conducted at 20 ± 2 °C and 65 ± 5% relative humidity conditions in 30 minutes.

Its viscosity is 5500–7500 mPa s at 25 °C and its density is 1.11 ± 0.02 g/cm3 and cold resistant [12].

According to the standards of; BS EN 204, Polivinilasetat (PVAc-D4) is in D category and it is strengthened with 6 % Turbo-Hardener 303.5 added D4 type adhesive. Its density is ~1.12 g/cm3and viscosity is (200C) 13000±2000 mPas. pH value is ~3. Gel time is 6-10 minutes. Its freezing resistance is -30 0C. The application amount should be 150-180 g/m2. Preservation period should be around 12 months. Application time is 17 minutes under 20 0C, 5 minutes under 50 0C and 2 minutes under 80 0C [13].

Polyurethane-based, grey-coloured Montajkit is a kind of adhesive to bond several materials such as generally wood material, ceramic cement, stone, fibreglass and polyester. With the density of ~1,13 g/cm3 its viscosity is (200C) 250±2 mPas, Its pH value is ~3 and gel time is 6-10 minutes. Its application temperature is 5-40 0C, and moisture is %50-80. It can harden in 15-20 minutes and reach its adhesive resistance in 24 hours. Application amount is 150-200 g/m2 and it can be applied with brush and various application devices.

### 2.2 Method

#### 2.2.1 Preparation of Experiment samples

Melamine coated particleboards were kept under 20 $^0$C (±2) and 65 % (±3) relative humidity until their weight became stable. After this process, 360 A elements (200 x 300 mm) and 360 B elements (182 x 300

mm) were prepared.

B elements were bonded with solid wood parquets (in the rate of 1/3) (120) and PVC sideband (in the rate of 1/3 and 3 mm width) (120) and the rest 1/3 of 120 were used as control.

Half of the A elements (180) left to no process, whereas, the intersectional surfaces of A elements were sanded with 100 sand abrasive. After this process, sanded and half of the sanded surfaces of A and B elements were drilled 2.5 m diameter and 50 mm length for guided screws. (Figure 1).

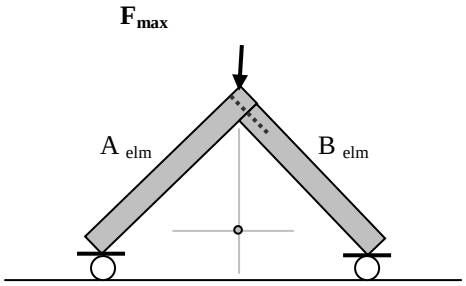


Figure 1. Diagonal Bonding Testing Apparatus

The flakeboard, parquets and PVC bonded outer surfaces (3) Kleiberit-303 (D4), Desmodur (D-VTKA) and Montajkit adhesives and screwed and unscrewed construction (three) sanded and unsanded intersectional surfaces of the 360 B elements (3x3x2x2x10) were processed totally 360. Adhesive was applied150 gr/m$^2$. Unscrewed corner joint samples were pressured by joiner's clamps turning them equally and enough time was allotted. As for the screwed ones, pressure was applied after they were screwed.

**2. 2. 2 Test Method**

It is known that the effective factors in determining the durability of furniture are the kinds of material's corner joint used to make furniture and the strength of the adhesives. Mechanic forces on furniture force some of the horizontal and vertical elements of furniture to unloose but the others to tighten. Therefore, diagonal and bonding method symbolizing tightening and loosing experiment at the corners of furniture was used.

The samples which were applied to diagonal bonding experiment were prepared double axis and half frame. During the experiment, as the points of support were out of the force direction, moment force occurs at the corner joints of samples. (Figure 2). Joint points should be designed in such a way that it can react the forces securely so that it isn't damaged.

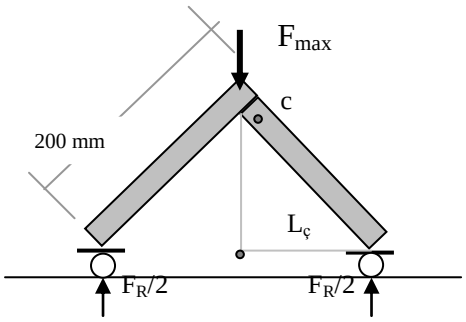


Figure 2. In diagonal bonding samples level arm ($L_ç$) and Turning Point (c)

In the samples, during the damage, the moment force was calculated by multiplying reaction of Fmax (FR/2) and level arm. In the diagonal bonding samples, level arm was determined as 128,693 with the help of right triangle. As for the unscrewed samples, inner moment force (Mint) was calculated according to the formula [1] below. [14].

$$M_{int} = A \times L_m \times \sigma \quad (1)$$

$L_m$ : The vertical distance from the weight point where A and B elements' intersectional surfaces join from c which is turning point from weight center. (mm)
$\sigma_{çem}$ :The secure bonding which adhesive and bonded surface carry. ($N/mm^2$)
A : The surface of glued intersection ($mm^2$).
In screwed diagonal bonding samples, based on the average deviation of force determined according to the unscrewed samples, for each side material and gluing, screw factor ($f_V$) formula and the load that screwed joints bear were calculated as formula 2 and 3.

$$F = n(\pi \; x \; d \; x \; m \; x \; f_v \quad (2)$$

$$f_v = F/ (n \; x \; \pi \; x \; d \; x \; m) \quad (3)$$

F : The average screwed and unscrewed samples' forces
n : Number of screws
$f_v$ : Screw factor,
d : Diameter of screw (mm),
m : The length of screwing to the next screw (mm),

The friction force was minimised by putting wheeled mechanism to the support points. So, the friction forces at the support points were ignored in calculation. The ASTM-D-1037 standards were applied during the experiments. [15].

The durability properties that provide the outer momentum forces at the experiment specimens are the inner momentum force that the binding at the corner joints and the screws create. Theoretically, if the inner momentum force is equal to or higher than outer one, corner joint is durable. On the contrary, if the inner momentum force is lower than the outer one, corner joint is accepted to be a failure. The case of equality creates unstable equilibrium which is the least durability.

**3. Result and Discussion**

In the diagonal bonding experiments, reference to surface process type, material type and the effect of the adhesive types on the diagonal bonding resistance, multi-variant analysis were indicated on Table 1.

Table 1. Multi-variant analysis according to surface process type, material type and the effect of the adhesive types on the diagonal bonding resistance

| **Variant Source** | **Degree Of Freedom** | **Sum of Squares** | **Average of Squares** | **F Value** | **P<0.05** |
|---|---|---|---|---|---|
| Surface Process (A) | 3 | 78.302 | 26.101 | 6426.4667 | 0.0000 |
| Material (B) | 2 | 1.138 | 0.569 | 140.1445 | 0.0000 |
| A+B | 6 | 1.545 | 0.257 | 63.3795 | 0.0000 |
| Adhesive ( C ) | 2 | 1.140 | 0.570 | 140.3467 | 0.0000 |
| A+C | 6 | 0.809 | 0.135 | 33.2101 | 0.0000 |
| B+C | 4 | 2.258 | 0.565 | 138.9849 | 0.0000 |
| A+B+C | 12 | 2.532 | 0.211 | 51.9520 | 0.0000 |
| Error | 324 | 1.316 | 0.004 | - | - |
| Total | 359 | 89.040 | - | - | - |

The effect of surface process type, edge material, adhesive type and the interaction among them on diagonal bonding resistance was found to be important in 95 % reliability. The resistance deviation occurring at the diagonal resistance changes according to the interactions among these elements. Duncan Test was applied to determine between which groups these differences occur (table 2).

Table 2. Average values of surfaceprocess, material and adhesive types ($N/mm^2$)

| **Surface process type +Edge material type+Adhesive type** | **X** | **H.G.** |
|---|---|---|
| Sy+Km+I | 0.186 | PQ |
| Sy +Km+D | 0.198 | PQ |
| Sy +Km+III | 0.179 | Q |
| Sy +Kp+I | 0.000 | R |
| Sy +Kp+II | 0.705 | K |
| Sy +Kp+III | 0.161 | Q |
| Sy +Ky+I | 0.288 | NO |
| Sy +Ky+II | 0.284 | NO |
| Sy +Ky+III | 0.217 | PQ |
| Zy+Km+I | 0.560 | L |
| Zy +Km+II | 0.381 | M |
| Zy +Km+III | 0.241 | OP |
| Zy +Kp+I | 0.000 | R |
| Zy +Kp+II l | 0.765 | J |
| Zy +Kp+III | 0.376 | M |
| Zy +Ky+I | 0.333 | MN |
| Zy +Ky+II | 0.379 | M |
| Zy +Ky+III | 0.376 | M |
| Sy +V+Km+I | 1.193 | EF |
| Sy +V+Km+II | 1.398 | AB |
| Sy +V+Km+IIIl | 1.350 | BC |
| Sy +V+Kp+I | 1.133 | FG |
| Sy +V+Kp+II | 1.278 | D |
| Sy +V+Kp+III | 1.212 | E |
| Sy +V+Ky+I | 1.042 | H |
| Sy +V+Ky+II | 0.921 | I |
| Sy +V+Ky+III | 1.105 | G |
| Zy +V+Km+I | 1.432 | A |
| Zy +V+Km+II | 1.426 | A |
| Zy +V+Km+III | 1.411 | A |
| Zy +V+Kp+I | 1.310 | CD |
| Zy +V +Kp+II | 1.309 | CD |
| Zy +V+Kp+III | 1.322 | CD |
| Zy +V+Ky+I | 1.112 | G |
| Zy +V+Ky+II | 1.163 | EFG |
| Zy +V+Ky+III | 1.152 | EFG |

LSD:0.05562,Km: Edging strip, Kp: PVC edge, Ky: ;Particleboard edge , Zy: Sanded surface, Sy :Melamine coated chipboard., V: Screw, I: D4, II: Desmodur-VTKA, III: Assembly kit

According to the interaction among A element surface type, B element edge material and adhesive types, bonding resistance was found to be the highest (1.432 N/mm2) in the corner joints that were strengthened with screws and most sanded A element and solid edged B elements were bonded with each of the three adhesives. As for the lowest (0.161 N/mm2), they were unprocessed, surfaced edged with PVC and glued with Montajkit adhesive corner joints. The table 3 shows the average values of unscrewed samples and the figure 4 shows that of screwed ones.

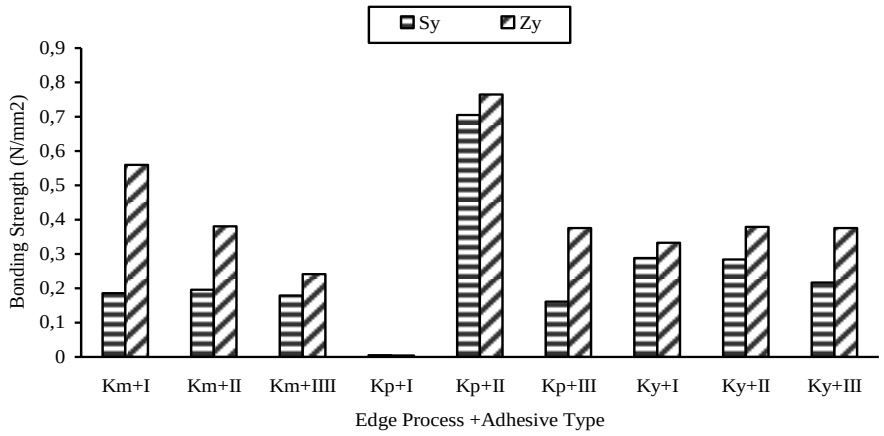


Figure 3. Diagonal bonding resistance at surface process, edge material and adhesive type of unscrewed samples.

Not only did the edge process but also, adhesive type affect the bonding performance of the samples of melamine coated chipboard corner joints as a matter of fact D-VTKA adhesive had high gluing resistance at the PVC coated edge.

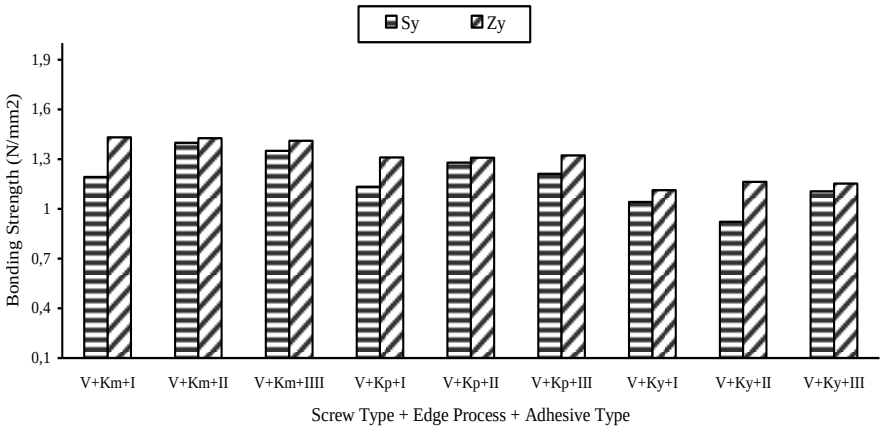


Figure 4. Diagonal bonding resistance at surface process, edge material and adhesive type of screwed samples

In corner joints made of melamine coated boards, surface and edge process, adhesive type are said to have an important effect on the bonding performance of the screw because it was noted that sanded and solid wood material had high bonding resistance with all of the three adhesives. According to this, coating the edges with massive material and sanding the surfaces increased each of the adhesive's resistance.

## 4. Conclusion

In case furniture, it was determined that A elements' sanded melamine coated surface increase the bonding resistance compared to unsanded ones and B elements' massive wood coated and PVC material of intersectional surfaces has more resistance than unprocessed ones. Screwed samples were noted to have more bonding resistance than unscrewed specimens. In diagonal bonding samples, gluing surfaces forces gluing seam vertically and this force occurs in the seam breaking adhesive. As cellulose molecules of craft paper under sanded A elements' overlay, coating can be joined better with Massive wood and PVC material bonded edge surface of B elements, they show higher breaking gluing resistance than melamine coated edge samples.

Diagonal bonding resistance was the highest on massive wood and PVC bonded samples and it was higher than unprocessed edge. Although all of the three materials were polarable, natural wood's having more diagonal bonding resistance than PVC and particleboard might have resulted from its ability to join with

massive in a molecular way. In particle board, low resistance value might have stemmed from porous structure's decrease of adhesion force.

The highest diagonal bonding resistance was obtained from D-VTKA. It may have stemmed from the fact that it has bigger molecular structure than D4 and Montajkit adhesives, its adhesive layer creates bigger cohesion connection in its own structure and it was designed to glue synthetic and metallic surfaces. D4 and Montajkit adhesives should be used to glue spongy and organic materials as they weren't useful for melamine resin coated paper based boards.

In the screw supported surfaces and diagonal bonding samples glued with adhesive, screw support increased diagonal bonding resistance of the sanded and unsanded samples about 2-5 fold and 2-4 fold respectively.

Consequently, in box type furniture manufacture, it can be argued that melamine resin covered and paper covered boards are stable if the joining side (joining intersection) is sanded and the other base edge is encircled with PVC in order for is resistance against diagonal force to be higher. As for bonding these elements, D-VTKA should take place on the top or else, Montajkit and D4 adhesive can be used. It can also be claimed that if adhesive and adhesive free joints are supported with screw, they show higher bonding resistance.

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