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INVESTIGATION OF THE COMBİNED CORNER JOINTS PERFORMANCE ON CASE FURNITURE

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Abstract

In the production of non-structural case type furniture from wood-based panel, it is known that changeable design parameters have significant effects on performance of furniture soundness. These parameters are changeable factors as panel kind, corner joint type, and glue type. This study examined the performance of combined corner joints and furniture soundness, which is changed according to the panel and glue type.

For this purpose, test samples with combined joint were prepared by using wood-based panel, which were melamine-faced particleboard and melamine-faced fiberboard and glue types of polyvinyl acetate, desmodur-vtka, and silicon. After that diagonal compression and tension tests were carried out on the samples.

It was revealed at the end of these tests that, among the combined joint type samples, melamine-faced fiberboard with silicon glue has produced the highest performance of soundness, whereas melamine-faced fiberboard with polymarine glue has resulted in the lowest performance of soundness.

Keywords and phrases: joint type, combined joint, glue type, panel type, melamine-faced fiberboard, melamine-faced particleboard, furniture soundness, performance.

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1. Introduction

Current technology, as it has in all sectors, has advanced in the sector of wood furniture production, too. Wood-based panels, glues, corner joining methods, and additional fastener components are some of the products that have become available thanks to the advancing technology. However, the effects of available corner joining methods and glue types on the strength of case furniture are not known fully for wood-based materials, which vary according to taste and budget. This causes unnecessary loss of time, effort, and stock.

As is the case for various materials used widely in the construction and furniture sectors, the mechanical and design properties of standard-size wood-based materials were investigated by several researchers [14].

Previous researches were revealed that, the strongest type of glued corner joint is the dowel joint and the weakest is the rebated joint type [9].

Strength-analysis of samples made from particleboard has shown that dowel corner joints provide the best results, followed by spline corner joints [8].

It was researched effects of glue type to diagonal tensile strength at the corner joint with tenon-motrise. At the end of tests, it was determined that fiberboard has provided superiorty to particleboard and that the polyvinyl acetate glue (PVAc) has provided the best strength values in L-type corner joints [6].

It was stated that “Moltinject” type joints provide greater strength compared to dowel joints in case furniture using particleboard [10].

It was revealed that, the highest tension strength and compression strength for dowel joints in particleboard is achieved when the distance between two dowels is 7.5cm [16].

It was determined that in case furniture constructions using particleboard; rebated, rebated with wire hook, and wedged rebated joints -among the corner joint samples prepared with PVAc glue- were, respectively, produced the highest strength values during the tests for bending strength [5].

It was find out to increase compression and tension strength depend on dowel size at the dowel corner joints using particleboard [15].

In case furniture from particleboard and fiberboard were compared with each other their diagonal compression strengths of dowel-corner joints, which different glue types were used for bonding. End of the diagonal compression test according ASTM D 143-83, it was informed that fiberboard samples and polyvinyl acetate glue have produced higher strength values than particleboard samples and other glue type [7].

It was applied compression and tensile test to particleboard and fiberboard samples. Fiberboard samples with corner joint have produced higher strength values on every two tests than particleboard samples with corner joint [12].

The aim of this study was to contribute to minimize or completely eliminate the waste of effort, capital, and time in the industry, by determining the possible strength differences, that may come out as a result of the interaction of the combined corner joint type with different panel and glue type.

2. Material and Method

2.1. Melamine faced particleboard (YL-Lam)

These are wood-based panels produced by coating particleboard with phenol and melamine. Panel dimensions are 183×366cm and 210×280cm, and in thicknesses of 8, 12, 16, 18, 22mm (TS 1770).

2.2. Melamine faced fiberboard (MDF-Lam)

These are wood-based panels produced by coating fiberboard with phenol and melamine. Panel dimensions are 183×366cm and 210×280cm, and in thicknesses of 6, 8, 10, 12, 16, 19, 22, 25mm as per TS 64 [13].

2.3. Glue

Polyvinyl acetate (PVAc), desmodur-vtka (polymarine), and purocal (silicon-polyurethane based) glues, *which are mostly preferred in the case furniture production sector* were used as adhesive in the scope of this study. *PVAc glue* has many advantages such as being non-abrasive to cutting tools, odour-free, non-flammable, easy-to-apply cold, and setting quickly. It also has disadvantages such as the reduction in its mechanical resistance due to softening with temperature after application and the failure to provide the required adhesion above 70°C. Depending on the type and surface properties of the material to be joined, application of 150-200g/m^2 of glue on one of the surfaces are sufficient for good adhesion.

The values specified for the adhesives are: density of 1.1g/cm^3, viscosity of 160-200cps, pH value of 5, pressing duration of 20 minutes in cold application at 20°C and 2 minutes at 80°C, and it is recommended to rest the adhesive in the pressing environment until, it cools down (TS 3897).

Polymarine glue is a special adhesive used in binding various wood materials treated for protection from the outdoor elements, or from seawater. Due to the hazardous chemicals it contains, it can cause loss of sensation in case of contact with eyes or skin. The manufacturer recommendations were observed during the application of the polymeric glue. The surfaces to be glued should be free from grease and dust, clean, dry, and also smooth. Once glue is applied on one of the surfaces, the pieces should be joined within 30 minutes and pressed for at least 2 hours. It is recommended that gloves are worn during application and the gluing operation not be performed below 5°C [4].

Purocal glue is *silicon*-polyurethane based glue. It has just started to be used in furniture production sector. It is used to bond many different construction materials such as fiber sheet, formica, concrete, metal, plastic, and especially, the wood-based materials of 30% moisture content. It is a kind of glue, that is transparent; non-dripping; rapidly interpenetrating into the bonding holes; resistant to water and chemicals; and providing the opportunity for working in $-30°C$ - $100°C$ range. Manufacturer recommendations were observed during the application of the polymeric glue. The surface that the glue will be applied should be clean and free from oil. Soffits should be humidified to increase the speed of the glue to interpenetrate into the bonding holes and to adhere. When applied on any surface, it should be clamped by using bench clamp for 30 minute and left for drying. Application temperature is +5°C - +35°C. It should be kept in cold and dry places [11].

3. Method

3.1. Preparation of samples

The samples were prepared by processing YL-Lam and MDF-Lam panel in size 18mm × 183 × 366cm. The parts of sample were categorised into groups A and B and joined as shown in Figure 1. Their properties, amounts, and dimensions are presented in Table 1.

Table 1. Properties, amounts, and dimensions of the test samples

Panel type	Loading direction and number		Sample size (mm)		Joint component size (mm)		Glue type
	Compression (<)	Tension(^)	Length	Width	Dowel L	Spline L	
YL -Lam	10	10	320	200	$33 \times 10 \varnothing$	$120 \times 18 \times 7$	PVAc
	10	10	320	200	$33 \times 10 \varnothing$	$120 \times 18 \times 7$	Polymarine
	10	10	320	200	$33 \times 10 \varnothing$	$120 \times 18 \times 7$	Silicon
MDF-Lam	10	10	320	200	$33 \times 10 \varnothing$	$120 \times 18 \times 7$	PVAc
	10	10	320	200	$33 \times 10 \varnothing$	$120 \times 18 \times 7$	Polymarine
	10	10	320	200	$33 \times 10 \varnothing$	$120 \times 18 \times 7$	Silicon

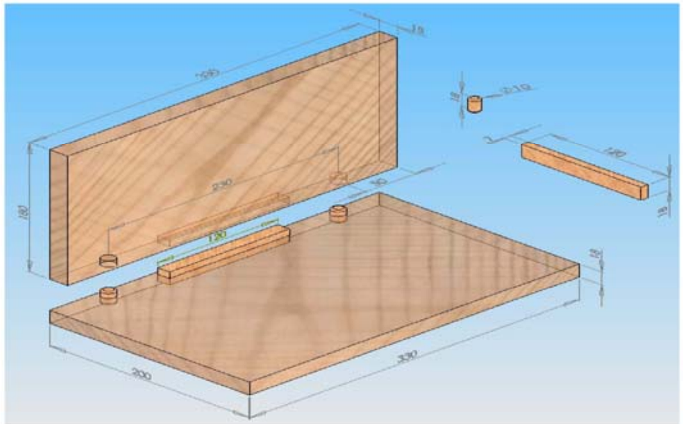

Figure 1. Combined corner joint types of the test samples.

Preparation of combined (dowel+spline) joint type samples: Markings for dowel and spline were made on the face and edges of the Element A and Element B of sample components. Holes of 10mm diameter and 17±1mm depth and grooves of 120 × 7mm dimensions and 9±1mm depth were opened on the face of Element A and edges of the Element B (Figure 1). PVAc glue was applied to the holes in the Element A and 33 × 10±1mm dimension dowels and 20 × 18 × 7mm dimension spline were put in the slots. PVAc glue was applied to the edges of the Element B, the component joints were pressed together by using a clamp and left to harden. By pressing, it was turned the clamp arm same number for all samples.

3.2. Experimental method

Selection of wood-based panel and corner joint type and the strength of the glue are important factors for case furniture constructions [1]. The experiments were carried out by using a universal test device in the Laboratory of Construction Department of Technology Faculty, Süleyman Demirel University. Diagonal compression and tension experiments were carried out on the samples (Figure 2).

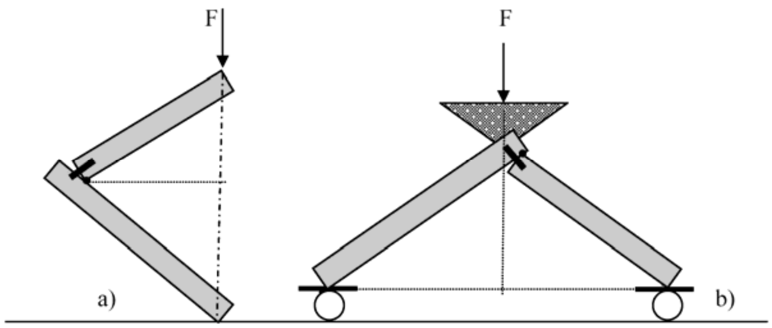

Figure 2. Diagonal compression and tension tests [(a) compression, (b) tension].

The device gauge was set to a force of 1000kp and, the force was gradually increased during the experiment. The tests were carried out according to the procedure of ASTM 1037 standards; the load of specimen throughout the test by a uniform motion of the movable head of the testing machine at a rate of 3-5mm perm in was applied. The maximum compression strength and tension strength were determined as the applied force to each experimental sample at the time of failure. The result for each of the samples was displayed by the computer to which the test device was connected.

3.3. Data evaluation

Homogeneity of the data was achieved by excluding the outlying results that disturb the normal distribution obtained from the experiments [2, 3]. Where the results of the multivariate analysis of variance (MANOVA) indicated a significant difference between groups, the Duncan test was used to compare the factors within the group. The success rankings of these factors were determined by classifying their average values into homogeneous groups.

4. Results

Averages and standard deviations of the diagonal compression and tension strength values related to panel kind and glue type are given in Table 2.

Table 2. Averages and standard deviations of the tensile and compression strength values according to panel kind and glue type

Panel type	Glue type	Compression strength (N/mm^2)		Tensile strength (N/mm^2)	
		Averages	s	Averages	s
YL-Lam	PVAc	8.11	1.02	27.26	3.90
	Polymarine	8.66	1.06	22.98	1.03
	Silicon	7.55	1.17	28.58	3.69
MDF-Lam	PVAc	7.69	1.09	33.20	2.74
	Polymarine	7.18	0.77	22.65	3.09
	Silicon	7.06	0.61	39.90	4.55

Examining Table 2, it can be understood that the diagonal compression strengths of YL-Lam samples are higher and the diagonal tension strengths of the same are lower than those of MDF-Lam samples. Results of multi-variance analysis conducted to learn, whether these differences are statistically meaningful are listed in Table 3.

Table 3. Multivariate analysis of variance (MANOVA) results for compression and tensile strengths

Variable	Test values	Sum of squares	S.D	Average of squares	F value	P< 0.005
Panel type (A)	Compression	9.52	1.00	9.52	10.09	0.00*
	Tension	477.71	1.00	477.71	42.34	0.00*
Glue type (B)	Compression	4.88	2.00	2.44	2.59	0.08
	Tension	1343.95	2.00	671.98	59.55	0.00*
A × B	Compression	3.51	2.00	1.76	1.86	0.17
	Tension	339.97	2.00	169.98	15.06	0.00*
Error	Compression	50.93	54.00	0.94		
	Tension	609.30	54.00	11.28		
Total	Compression	3633.95	60.00			
	Tension	53562.07	60.00			

*Statistically significant at a significance level of 5%.

According to the results of the variance analysis, the difference between group A and group B in terms of compression and tension strength according to type of material, is statistically significant at a significance level of 5% for both compression and tension strength, and there is no significant difference between compression strengths according to glue type, whereas the difference identified in tension strength according to glue type is again significant at a significance level of 5%. In terms of pair interactions, whilst the difference in compression strengths between groups is not found to be significant, it is found that the difference between groups in terms of tension strength was statistically significant at a level of 5%.

The Duncan test was used to determine the minor differences between all the variables within groups having relationship. The results are shown in Tables 4, 5, and 6.

Table 4. Duncan comparison test results for panel type in compression and tension experiments (N/mm^2)

Panel type	Compression strength (N/mm^2)	H-group	Tensile strength (N/mm^2)	H-group
YL-Lam	8.11	A	26.27	B
MDF-Lam	7.31	B	31.92	A

It was find out that diagonal compression strength of YL-Lam (8.11N/mm^2) and diagonal tension strength of MDF-Lam (31.92N/mm^2) are the highest strengths. It has been also revealed that, they differentiate from each other at a significant level.

Table 5. Duncan comparison test results for glue type in tension experiments (N/mm^2)

Glue type	Tensile strength (N/mm^2)	H-group
PVAc	30.23	B
Polymarine	22.82	C
Silicon	34.24	A

According to the variance analysis results for glue type in compression and tension experiments (Table 3), the experiment, where glue type causes a statistically significant difference relates to the tension strength. Therefore, the Duncan test results, *which compare the smallest significant differences between variables within groups* are examined only in terms of tension strength values. As a result, it was recorded that 34.24N/mm^2 average adhesion strength of the silicon samples is higher than those of other experiment samples (see Table 5).

Table 6. Duncan comparison test results for glue+panel type in tension experiments (N/mm^2)

Panel kind and glue type	Tensile strength (N/mm^2)	H-group
YL-Lam + PVAc glue	27.26	C
YL-Lam + Polymarine glue	22.98	D
YL-Lam + Silicon glue	28.58	C
MDF-Lam + PVAc glue	33.20	B
MDF-Lam + Polymarine glue	22.65	D
MDF-Lam + Silicon glue	39.90	A

According to the results of the variance analysis of compression strength and tension strength values resulting from the interaction, glue+panel type in compression and tension experiments (Table 6), it was found that statistically significant differences are only reached in tension strength. Therefore, the Duncan test for pair comparisons is only examined in terms of tension strength values. It was determined the highest average tension strength (33.90N/mm^2) in MDF-Lam+silicon samples, and the lowest average tension strength (22.65N/mm^2) in MDF-Lam+polymarine samples. This is shown in the Figure 3 graphically.

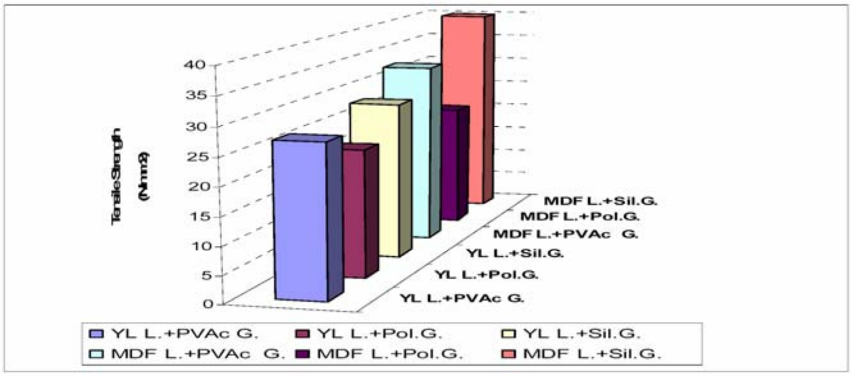

Figure 3. Tensile strength values.

5. Conclusion and Recommendation

In this study, it was determined that diagonal comparison and tension values were changed in the case construction corner joints of the YL-Lam and MDF-Lam, according to combined joint type and glue type.

As a result of the experimental studies, it was determined that MDF-Lam has higher diagonal tension and lower compression strength than YL-Lam. This can be explained with the fact that MDF-Lam has higher inter adhesion strength (0.55N/mm^2) than YL-Lam (0.33N/mm^2) and a void-free wide bonding surface (TS EN 312 ve EN 622-5). These results are in agreement with those reported by [7, 12].

The order of the test samples according to adhesion strength and test stress is as follows: Silicon by diagonal tension stress (34.24N/mm^2), PVAc by diagonal tension stress (30.23N/mm^2), and polymarine by diagonal tension stress (22.82N/mm^2). It can be explained by the fact that, when compared to other glues, silicon glue has the capacity to interpenetrate quickly into the spaces in the material and to create a larger bonding surface.

The order of test samples according to material type and glue type is as follows: MDF-Lam+silicon (39.90N/mm^2) and YL-Lam+silicon (28.58 N/mm^2) in the diagonal tension strength. It can be explained by the fact that, MDF-Lam has higher inter adhesion strength (0.55N/mm^2) than YL-Lam(0.33N/mm^2) and a void-free wide bonding surface and create more bonding surface and that specific weight of MDF-Lam is higher than that of others.

It is recommended to use MDF-Lam and silicon glue in the combined corner joint that require high durability in the case furniture production. It is recommended to use silicon glue in case YL-Lam is preferred due to economic reasons.

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