

# Characteristics of Medium Density Fiberboards for Furniture Production and Interior Application

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## Abstract

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**BACKGROUND:** The paper analyzes the properties of medium density fiberboards (MDF) intended for furniture production and interior application. Because MDF panels are one of the mostly used wood-based panels in furniture production sector in the Republic of Macedonia it is important to know and understand their basic physical and mechanical properties.

**AIM:** For better understanding of MDF panels and their proper end use by the furniture constructors and designers, physical and mechanical properties of MDF panels present in the market are tested.

**MATERIALS AND METHODS:** Commercially produced MDF panels taken from one company from wood-based panel market were tested. Evaluation of the quality of the panels was made on the basis of the obtained results for the physical and mechanical properties of the panels. Properties of MDF were tested according to the national MKS standards and European norms.

**RESULTS:** Tested MDF panels present on our market are characterized by good physical and mechanical properties that meet the requirements of the standards for MDF for use in dry conditions including furniture production and interior applications.

**CONCLUSIONS:** It is recommended to avoid application of these MDF panels in high humidity conditions for a longer exploitation period. For this kind of applications, such as bathroom areas, the furniture constructors and interior designers should consider use of MDF.H type of panel for application in high humidity conditions, which will provide good dimensional stability of the products during whole exploitation period.

## Introduction

Medium density fiberboards (MDF) or dry process fiberboards represent engineered wood-based panels made from wood fibers bonded together with an adhesive on the base of a synthetic resin. A typical production process involves reducing wood down to small chips, which are then thermally softened and mechanically refined into fibers, which are then mixed with a synthetic resin binder. The resinated fibers are dried and then formed into a mattress ready for pressing. The mattress is pressed in a hot press to the desired thickness (Wood Panel Industries Federation). The average density of standard form of MDF ranges between 450 to 800 kg/m<sup>3</sup> (Wood Panel Industries Federation) [1].

MDF are one of the most rapidly growing products in the world wood-based panel market [2, 3].

MDF are available in a wide range of thickness, can be easily machined and finished to a high standard, so have been accepted in a wide range of applications both in furniture and construction, where in both cases they replace solid wood and other wood-based panels (plywood and particleboards) in particular applications. It is also used for interior door skins, moldings, and interior trim components [4]. MDF are applicable in production of window boards, wall paneling, architraves, and decorative facades and as core material for floorings. Its uniform and smooth surface provides an excellent base for applying decorative overlays, veneers and painting [2]. When MDF panels are used as substrate for overlays, their surface roughness is an important factor in determining the quality of the final product [5].

It is supposed that MDF panels are the best substitute for solid wood, but MDF properties differ from those of solid wood [6]. MDF panels have

homogenous structure and higher isotropy of the properties compared to solid wood, which has different mechanical properties in different directions of the wood.

Beside standard MDF panels, value added variants with enhanced mechanical performance and improved performance in the presence of moisture and fire are also produced (Wood Panel Industries Federation) [1]. These value added variants extend the MDF furniture application in many products such as shopfitting and display, interior fitments, exterior application (signage and shop fronts).

MDF panels produced in Europe are specified according to the requirements defined in the EN 622-1 [7] and EN 622-5 [8]. EN 622-5 defines the requirements of MDF that are classified according to their intended end use. According to that classification, the requirements for the following types of MDF are specified in the standard:

- general purpose boards for use in dry conditions (type MDF);
- general purpose boards for use in humid conditions (type MDF.H);
- load-bearing boards for use in dry conditions (type MDF.LA);
- load-bearing boards for use in humid conditions (type MDF.HLS);
- light MDF boards for use in dry conditions (type L-MDF);
- light MDF boards for use in humid conditions (type L-MDF.H);
- ultra-light MDF boards for use in dry conditions (type UL1-MDF);
- ultra-light MDF boards for use in dry conditions (type UL2-MDF);
- boards for use in rigid underlay in roofs and walls (type MDF.RWH)

For better understanding of MDF panels and their proper end use by the furniture constructors and designers, physical and mechanical properties of MDF panels present in the market are tested.

## Materials and Methods

For the realization of the research, medium density fiberboards were taken by random choice from the storehouse of the company „Soloprom“, Skopje and transferred to the Laboratory for wood-composite materials at the Faculty of Forestry in Skopje. The MDF panels were product of the company „MDF

Hallein GmbH & Co KG“, Austria. The product dimensions of the panel were 2070 × 2650 × 19 mm.

Test specimens for determination of the physical and mechanical properties according to the national and European norms were cut from the panels. The following properties were tested: density (MKS D.A8.085), moisture content (MKS D.A8.083), thickness swelling and water absorption (MKS D.A8.084), modulus of rupture (MOR-bending strength) and modulus of elasticity in bending-MOE (MKS EN 310), internal bond-IB (MKS EN 319) [9] and hardness according to Janka [10].

Thickness swelling and water absorption are tested after 24 hours immersion in water, which is a standard treatment and after prolongation of the treatment up to 48 hours in order to see the behavior of the MDF panels during exposure of high humidity conditions and prolonged water impact.

The bending strength and modulus of elasticity in bending were tested in five directions, i.e., parallel and perpendicular to the length of the panel and at the angles of 22.5°, 45° and 67.5° to the panel's length. Tests in different directions of the MDF panels will provide data for the strength of the MDF panels in different direction related to the homogeneity of the structure of MDF.

The obtained data were statistically analyzed. One way ANOVA was used to determinate the significance of the effect of the direction of the force in bending on the MDF bending strength and modulus of elasticity in bending. Shapiro-Wilk test for normality of the obtained data was applied and Levene's test for homogeneity of variances was applied. Tukey's test was applied to evaluate the statistical significance between mean values of the properties in different panel direction.

Statistical software SPSS Statistic was used for statistical analysis of the obtained data.

## Results

The obtained results for the physical and mechanical properties of MDF panels (Table 1) showed that the tested MDF panels meet the requirements for general purpose boards for use in dry condition including furniture manufacture and interior fitments.

The value for thickness swelling after 24 hours immersion in water is below 12 % which guarantee the dimensional stability of MDF when it is used as a material for interior application and furniture production. Thickness swelling after prolongation of

water immersion treatment up to 48 hours is above 12 % which shows that these MDF panels should not be used in high humidity areas for a longer period, although incidental exposure to water will not decrease the panel stability and its properties.

**Table 1: Statistical data for physical and mechanical properties of MDF panel**

Property	N	Mean	SD*	SE**	95% Confidence Interval for Mean		Min	Max
					Lower Bound	Upper Bound		
					Density (kg/m <sup>3</sup> )	12		
Moisture content (%)	12	7.75	0.09	0.03	7.70	7.81	7.61	7.92
Thickness swelling after 24 h (%)	12	9.07	1.56	0.45	8.07	10.06	6.91	11.46
Thickness swelling after 48 h (%)	12	13.84	1.37	0.39	12.97	14.71	12.18	15.94
Water absorption after 24 h (%)	12	20.47	3.45	1.00	18.28	22.67	15.33	23.10
Water absorption after 48 h (%)	12	31.83	2.92	0.84	29.97	33.68	27.14	34.43
IB (N/mm <sup>2</sup> )	12	0.61	0.07	0.02	0.57	0.65	0.51	0.76
Janka hardness (N/mm <sup>2</sup> )	12	47.68	2.13	0.43	46.78	48.58	41.20	50.52

\*, SD, standard deviation; \*\*, SE, standard error.

The statistical data for the bending strength and modulus of elasticity in bending of tested MDF are shown in Table 2 and 3.

**Table 2: Statistical data for MOR in different directions of the panel**

Force direction	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max
					Lower Bound	Upper Bound		
					Parallel	12		
Perpendicular	12	35.54	1.19	0.34	34.78	36.30	33.24	36.87
Angle 22,5°	12	34.13	1.31	0.38	33.30	34.96	31.44	35.84
Angle 45°	12	35.14	1.59	0.46	34.13	36.15	32.38	37.49
Angle 67,5°	12	35.68	1.58	0.46	34.68	36.68	33.34	38.31

There are no statistically significant differences at 0.05 probability level.

The analysis of variance of the obtained data for bending strength (ANOVA: F (4; 25) = 1.782; p = 0.146) showed that there are no statistically significant differences in the mean values of this property in different directions of the panel at 0.05 probability level. This shows that MDF panel has homogeneous structure that provides uniform bending strength across the panel in all directions. This homogeneity allows cutting MDF panels in desired direction of the panel without worrying about the direction of the span of the loaded panel, which is important for better utilization in furniture production, interior applications and construction.

**Table 3: Statistical data for MOE in different directions of the panel**

Force direction	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max
					Lower Bound	Upper Bound		
					Parallel	12		
Perpendicular	12	3347.18 <sup>b,a</sup>	169.59	48.96	3239.43	3454.93	3008.64	3540.98
Angle 22,5°	12	3225.50 <sup>a</sup>	183.33	52.92	3109.01	3341.98	2930.87	3580.98
Angle 45°	12	3098.72 <sup>c,a</sup>	99.34	28.68	3035.60	3161.83	2874.28	3210.51
Angle 67,5°	12	3238.06 <sup>a</sup>	157.42	45.44	3138.04	3338.08	2968.69	3509.48

The mean values with the same letters are not significantly different at 0.05 probability level.

The analysis of variance of the obtained data for modulus of elasticity in bending (ANOVA: F (4; 55) = 4.4; p = 0.004) showed that there is a statistically significant differences in the mean value of this property in different panel directions. The post-hoc Tukey's test showed that MOE parallel to the panel's length statistically differs from the MOE at the angle of 45° to the panel's length. Besides this differences, the value of MOE in two major directions of the MDF panel are similar and there are no statistically significant differences between them, which also speaks for the high isotropy of the properties of the MDF panel.

The homogeneity of the MDF panel also can be seen from the polar diagram of bending strength shown on Figure 1. Approaching of the diagram to the form of circle speaks for higher isotropy of the MDF bending properties.

The obtained values of bending strength and modulus of elasticity in bending of tested MDF panels in all tested directions exceed the minimal values for general purpose MDF (20 N/mm<sup>2</sup> for the bending strength and 2200 N/mm<sup>2</sup> for the modulus of elasticity in bending) and load-bearing MDF for structural application defined in the standard EN 622-5 [8].

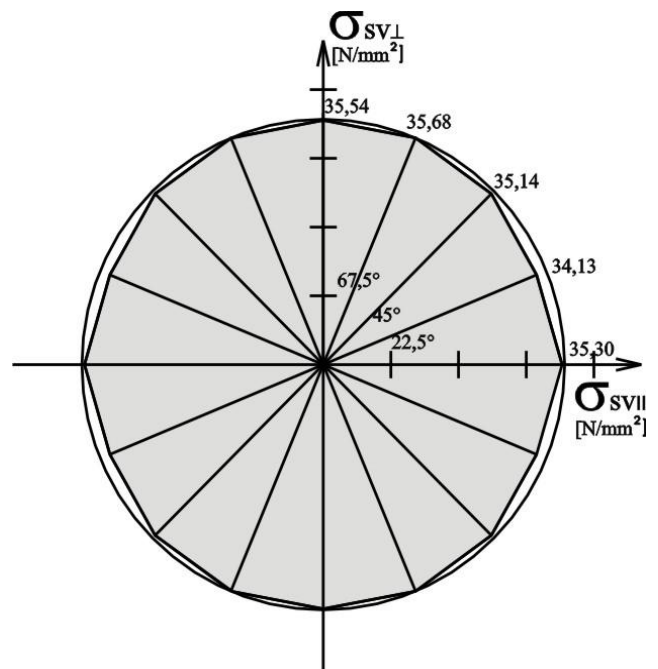


Figure 1: Polar diagram of bending strength of MDF panel

According the values of thickness swelling after 24 hours immersion in water, internal bond, bending strength and modulus of elasticity of bending, tested MDF panels beside furniture production and interior design, also can be used as load-bearing panels in dry conditions (as type MDF.LA).



Figure 2: Failure mode of the test specimens for determination of bending strength and modulus of elasticity in bending of tested MDF panels

Failure mode of the test specimens during determination of bending strength and modulus of elasticity in bending of tested MDF panels is shown on Figure 2, while the failure mode of the test specimens for determination of internal bond is shown on Figure 3.



Figure 3: Failure mode of the test specimens for determination of internal bond of tested MDF panels

## Discussion

Beside particleboards, MDF are one of the mostly used wood-based panels in furniture production sector in the Republic of Macedonia. These panels are imported from other countries. For proper use of MDF panels it is essential for furniture designers and users to be familiar with the properties of these panels. Also in past years in our country there is an increased interest for construction of wooden buildings where the wood-based panels are one of the basic materials for structural and non-structural use. In such buildings different types of MDF can be used as load-bearing members or as general purpose board depend on the place of incorporation in the building. Very often, buyers and users of wood-based panels are not familiar with different types of MDF panels, their categorization and characteristics that are intended for different application. That is way it is important to take an overview of the characteristics of these panels that are present in the market in our country, which will contribute in better understanding of the proper use of MDF according to their physical and mechanical properties.

For adequate use of MDF boards in different application areas their physical and mechanical properties must meet the standard requirements. For

evaluation of the MDF quality and characterization of their performance, physical and mechanical properties are used. Mechanical properties are the most frequently used to evaluate MDF and other wood-based panels for structural and nonstructural applications, where the strength properties usually reported, include modulus of rupture (MOR, bending strength), compression strength parallel to surface, tension strength perpendicular to surface (internal bond strength), tension strength parallel to surface, shear strength, fastener holding capacity and hardness [11]. Elastic properties include modulus of elasticity (MOE) in bending, tension, and compression.

General purpose MDF for use in dry conditions is one of the most used MDF type for interior fitments including furniture, where typically load-bearing panels are not need it. For application in high humidity areas as bathroom and kitchen cabinets, where the MDF product can reach high moisture levels from the surrounding area, MDF for use in humid condition should be used (MDF.H). In application in construction, as well as in construction of wooden buildings, depend on the place where the panels are incorporated, load-bearing MDF panels are used either for dry or humid conditions.

Thickness swelling is one of the basic properties that determine whether the panel will be used in dry or humid conditions. That is way it is very important for furniture constructors and designers to be aware of the climate conditions in which the furniture or other interior fitments will be incorporated. The basic mistake is made when the MDF for use dry condition is used in high humidity areas such as bathrooms where the panels are exposed on high moisture levels and water impact for a longer period. When MDF is exposed to water contact, wood fibers swell and residual stress that is created during the MDF pressing process is released, which causes increasing of MDF thickness [12]. This thickness swelling also reduces the strength characteristics of MDF [13].

It is very important to use the proper type of MDF for these applications, such as type MDF.H which will guarantee the stability of the products made by these panels during its exploitation period.

The values of the water absorption of MDF correspond with those one of the thickness swelling. Thickness swelling of the panels is related to the water absorption, so the higher water absorption contributes in higher swelling in thickness.

The obtained value of internal bond shows that the structure of MDF has good adhesion which guarantees good dimensional stability of the panel and high mechanical characteristics.

Testing of MDF hardness is not mandatory, but gives the information about MDF durability. It is

more important property for high density fiberboards that are used as core materials for floorings. The obtained value for Janka hardness shows that the tested MDF is durable for application in furniture production and other interior elements.

Requirements for MDF for use in furniture production are related to the basic panel properties, i.e. thickness swelling, internal bond, bending strength and modulus of elasticity in bending. MDF panels for this application must meet the required values for the certain property defined by the standard.

The quality of the furniture made from panels, such as MDF will depend on the designed construction and joining strength, which depends on MDF characteristics, coating material and thickness of panel details [14].

In conclusion, medium density fiberboards are one of the most rapidly used wood-based panels for furniture production and interior application due to its good physical and mechanical characteristics, easy machining and smooth surface. The homogeneity of its structure provides same properties in length and width direction of the panel. The smooth and compact surface is ideal base for application of decorative foils, veneers and painting, which allows manufacture of panels with different esthetic effects for interior design applications. Proper application of MDF panels demands understanding of the basic physical and mechanical properties of the panels, especially of those one present on the market.

Tested MDF panels present on our market are characterized by good physical and mechanical properties that meet the requirements of the standards for MDF for use in dry conditions including furniture production and interior applications. It is recommended to avoid application of these MDF panels in high humidity conditions for a longer exploitation period. For this kind of applications, such as bathroom areas, the furniture constructors and interior designers should consider use of MDF.H type of panel for application in high humidity conditions, which will provide good dimensional stability of the products during whole exploitation period.

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