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Hygroscopicity and movement of medium density fibre board

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A B S T R A C T

Dimensional stability of Medium Density Fiberboard (MDF) is a critical factor in usage of products. Many problems in the use of wood based products are caused by changes in moisture content due to hygroscopic nature of material. Hence a study on hygroscopicity and movement of commercially manufactured medium density fibre board was carried out. The hygroscopic behaviour was determined by measuring the Equilibrium Moisture Content (EMC) at two extreme conditions i.e., 96% to 35% relative humidity and the movement values were measured for 6mm and 17mm thickness samples. From this study it was observed that the Equilibrium moisture content (EMC) for MDF is lower and comparable with reference to hygroscopicity of Group C Indian timbers. The movement values for the medium density fibre boards exposed between 96%RH and 35% RH were found to be 0.28% in width, 4% in thickness.

Introduction:

MDF is an excellent substitute for solid wood in many interior and exterior applications such as furniture, cabinets, molding window and door frames, wall panelling, siding and roof sheathing. MDF is a wood based composite having a density of 500-900 kg/m^3 formed by breaking down of wood into fibres, in a defibrator, combining it with wax & resin. Panels by were formed by applying high temperature and pressure in a hot press. MDF is one of the most rapidly growing composite panel products in the market because of its smooth and solid edges which can be easily machined and finished. The uniform surface provides an excellent substrate for painting or applying decorative overlays. The physical and mechanical properties of MDF are mainly dependent upon the properties of the raw materials (wood, resin, and other additives) as well as manufacturing parameters [1]. Wood fiber properties such as fiber structure and strength, anatomical and chemical properties, and fiber composition (percentages of whole and broken fibers and fines) are considered to be basic characteristics influencing fibreboard properties due to occupying a large portion of the total panel volume [2].The reduction of EMC could happen because of the hemicelluloses, the most heat sensitive polymers of the wood components[3,4]. High temperatures used in manufacturing fibre boards decrease the hygroscopicity of the wood fibres[5]. In wood and wood composites, the moisture observed at high relative humidity exposure is never entirely released when redrying to lower relative humidity levels [6,7].

As solid wood and other wood based panels, Medium density fiber board is also a hygroscopic material. Linear expansion or contraction in occurring response to increased or decreased moisture content of the materials is one of the most important properties of medium density fiber board. The important movement'sarised from increased or decreased moisture content of the panel can cause high internal stresses due to the restraint offered by fartering such as nails in construction. These stresses may be large enough to cause buckled panels, pushed out nails and separation of panel form the structure. Though fibre-boards might appear to be similar to plywood in principle, although the wood components are reoriented. Hygroscopicity, expansion and contraction values of medium density fibre board thus become important design parameters. Hence the hygroscopicity and movement of commercially manufactured medium density fiber board was studied. This study on the hygroscopicity of MDF would help the manufacturers to assess the quality of the product at different supply zones and also the dimensional stability of the product can be arrived during actual use. The hygroscopicity of the samples were also compared with Indian timbers.

Material and methodology:

6mm and 17mm commercially manufactured medium density fibre board, having a density of 720-730 kg/m^{3}were used for the study.

Determination of equilibrium moisture content, width/thickness shrinkage and width/thickness shrinkage coefficient:

The specimens of 100mm length, 50mm width of 6mm and 17mm thickness were exposed to 96%RH and 35% RH at 35 ^{0}C. Weights of the specimens were taken and the exposure was continued under a constant temperature and humidity till the observed mass remains constant for 24 hours (weight difference < 0.1%). The length, width and thickness of the each samples were measured using digital callipers' with an accuracy of ±0.001 mm after samples attained constant weight corresponding <0.1%.The specimens took 10 days to get constant weight at each relative humidity. Finally the samples were exposed at 101^0 C for oven dry. Linear, width and thickness variations of fibre boards, between two equilibrium moisture contents, are calculated as a percentage of the initial specimen length, width and thickness. The hygroscopic strain is determined at 95 ± 1°C as the percentage change of the initial length, width and thickness recorded at equilibrium. The decrease was monitored from 96% to 35% relative humidity in desorption .The moisture content (*M*) of each test species prior and after high humidity exposure is calculated using equation-1. Shrinkage is calculated using equation 2,3 and shrinkage coefficient using equation 4,5,6 for 6mm and 17mm thick sample from 96%-35% RH at 35^{0}C respectively .

$$M = m-m_{od} /m_{od} \quad (1)$$

Where m is the mass of the test species prior/after humidity exposure and m_{od} is the oven-dry mass of the test specimen after humidity exposure.

WC=(W96_initial–W35_final)×100/W96_initial (2)

TS=(TS96_initial–TS35_final)×100/Ts96_initial (3)

Where, WC = Width contraction after RH change from 96% to 35%, based on the width measured at 96% Rh (%).TS= Thickness contraction after RH change from 96% to 35%, based on the Thickness measured at 96% RH (%).

Width and thickness shrinkage coefficient was calculated as follows

$$WSC = WC /\Delta M \quad (4)$$

$$TSC = TS/\Delta M \quad (5)$$

$$\Delta M = M96-M35 \quad (6)$$

Where, ΔM = moisture content difference, M96=moisture content at 96 % RH, M35= moisture content at 96 % RH

Determination of fibre saturation point:

A graph was plotted with moisture content on x-axis and volume shrinkage at the corresponding EMC on Y-axis. A curve is drawn which intercepts the maximum points. A tangent line is drawn till it extends to x-axis. The point at which tangent line coincides the moisture content is the fibre saturation point

Determination of Movement values:

Movement values between 96% RH and 35% RH were calculated using the maximum and minimum moisture content the samples exposed. The shrinkage moisture content relationship is approximately below Fibre saturation point, the movement under given climate conditions is calculated using total shrinkage percentage

Movement % = S [M –m/f]

Where M- Maximum moisture content of the sample exposed, m- Minimum moisture content of the sample exposed, f- Fibre saturation point

Results & discussions:

EMC, Shrinkage and Shrinkage coefficient of the samples at 96%RH and 35% RH at 35c is shown in the table-1. From Table 1 it is observed that the average moisture content of the sample of 6mm samples was 20.62% after high humidity exposure and the samples of 17mm thickness showed moisture content of 19.2%.

Table: 1. Equilibrium Moisture content, Shrinkage and Shrinkage coefficient of the samples at 96%RH and 35% RH at 35^{0}c

Sample	Moisture content at 96% RH (%)	Moisture Content at 35% RH (%)	Width (%)	Thickness (%)	Thickness shrinkage Coefficient	Width shrinkage Coefficient
6mm*	20.62	9.06	0.35	8.54	0.70	0.030
17mm#	19.20	8.61	0.30	7.25	0.60	0.020

*average of 11 samples, # average of 10 samples

The difference in equilibrium moisture content of the samples at 96% RH and 35% RH of 6mm & 17mm samples lie between 11.5 and 10.5% respectively. This indicates that medium Density Fibre board is less hygroscopic than some of Indian timbers .Hence comparable with reference to hygroscopicity to Group C Indian timbers like *Abiespindrow (fir), Acrocarpusfraxinifolius (mundane), Adina Cordfolia (haldu), Anogeissuslatifolia (axle wood),* *mangiferaindica (mango), machilusmacrantha (machilus), Lagerstroemia hypolenca (Andaman pyinma), Diptero Carpus alatus (gurjan), Cedrelatoona (toon), Shorearobusta (sar), Terminaliaarjuna (arjuna), Xyliaxylocarpa (iru), Micheliachampaca (champak), prunuspadus (bird cherry), QuercusSemicarpifolia (kharsuoak), Schimawallichi (chilauni*)[8].T

his reduction in EMC is due to the resin,wax present in the panels and also the pressing conditions of the material at high temperature which has influenced on the hygroscopic properties of the medium density fibre board. On comparing the shrinkage coefficient between 6mm and 17mm samples in table-1, width shrinkage percentage was 33% and thickness shrinkage percentage 15 % less in 17mm samples.Thickness shrinkage coefficient is less in 17mm samples compared to 6mm sample. The higher shrinkage in thickness than in width is due to the more surface sorption of water because of the more surface area.This infers that dimension stability differs w.r.t thickness of the sample.17mm sample has shown less shrinkage than 6 mm samples which indicates higher thickness samples are more stable than the lower thickness sample. This is due to the process conditions maintained for manufacturing of MDF at different thickness.

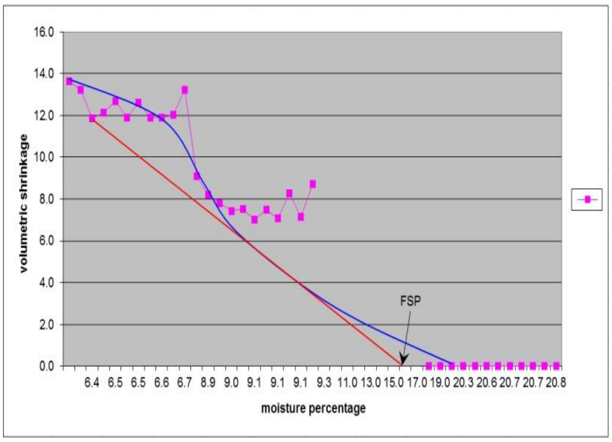

Figure-1 FSP of 6mm sample

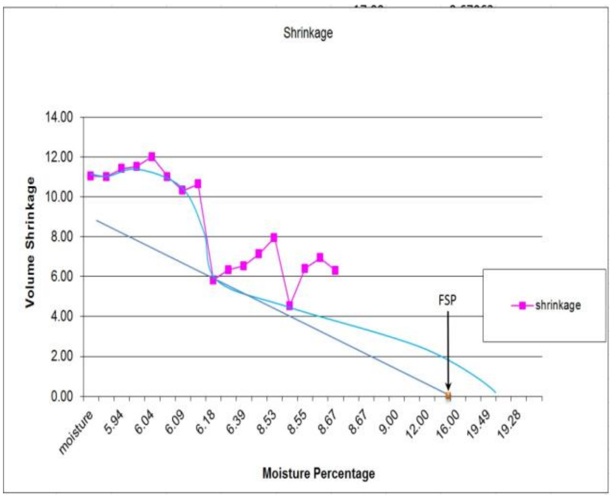

Figure-2 FSP of 17mm thick board

Table: 2. Movement values between 96% and 35% RH at 35^{0}c

Sl. No.	Density kg/m3	Width %	Thickness %	Volume %
6mm*	**728**	**0.292**	**4.82**	**5.99**
17mm#	**727**	**0.296**	**3.91**	**4.56**

*average of 10 samples, # average of 09 samples

The point at which tangent line coincides the moisture content is the fibre saturation point(Fig-1& 2).From the fig 1,2 it has been found that the FSP is16.2% for 6mm sample and 15.8% for 17mm sample. Table 2 shows the movement values between 96% and 35% RH at 35^{0}C for 6 and 17mm thick samples. The movement values between 96% and 35% RH in the volume of the 6mm samples were on an average of 5.9.Whereas the movement values between 96% and 35% RH in the width and thickness of the 6mmsamples was on average of 0.292and 4.82 respectively. The movement values between 96% and 35% RH in the width, thickness and volume of the 17mm samples were on average of 0.296, 3.91 and 4.56 respectively. A movement value with reference to width is almost same for any thickness, whereas the movement values with respect to thickness of 17mm was considerably less than 6mm samples. Hence a 400mm MDF of 17mm thickness will move by about 1.1mm in width and 0.66mm in thickness in moving from 96% to 35% relative humidity. This is equivalent to 8% increase in moisture content.

Conclusions

The equilibrium moisture content (EMC) for MDF is lower than for solid wood. Medium Density Fibre board is less hygroscopic than some of Indian timbers and comparable with reference to hygroscopicity to Group C Indian timbers. However it is suitable for installation in buildings where the moisture content does not exceed 16% for any length of time and does not exceed 20% at any time.The movement values for the medium density fibre boards exposed between 96%RH and 35% RH were found to be 0.28% in width, 4% in thickness. A 400mm MDF of 17mm thickness will move by about 1.1mm in width and 0.66mm in thickness in moving from 96% to 35% relative humidity.

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