Technology, 14(2), 47-51, (2011)

TECHNOLOGY

THE EFFECT OF EXPANDED PERLITE ON THERMAL CONDUCTIVITY OF MEDIUM DENSITY FIBERBOARD (MDF) PANEL

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Abstract

The expanded perlite (EPA) is a heat and sound absorption, and lightweight material, which ensures economic advantage in building materials. The objective of this study is to evaluate the effect of EPA on thermal conductivity of medium density fiberboard (MDF) panels. The thermal conductivity of panels was measured by a quick thermal conductivity meter according to ASTM C 1113-99 hot-wire method. The lowest thermal conductivity was measured in K, which is produced at using expanded perlite that is ratio 1% on the only surface layer, as 0.1695 Kcal/mhºC. The highest thermal conductivity value was observed in G, which is manufactured at using expanded perlite that is ratio 20% into the both core and surface layer, as 0.1959 kcal/mhºC. It has been proven that the thermal conductivity value was positively affected by using perlite.

Keywords: Building materials**,** Expanded perlite, Fiberboard, Thermal conductivity, Sound absorption

1. Introduction

Wood based panels are traditionally manufactured adding thermosetting resins into fibers, particles or strand under pressure and temperature (1). One of the most woods based panels is a fiberboard. It is a homogeneous panel which is made from lignocellulosic fibers after they are combined with a synthetic resin or the other suitable bonding system under the heat and pressure (2, 3).

Fiberboards are manufactured primarily to use panels as insulation, and cover materials in buildings and construction in which flat sheets of moderate strength are required. Also, the furniture industry is by far the dominant fiberboard market. They are also used, to a considerable extent, as components in doors, cabinets, cupboards, and millwork (4). Fiberboard generally takes place of solid wood, ply-wood, and particleboard for many applications (5). Many mechanical and physical properties of fiberboard may be improved by adding some materials during manufacturing process. For example, fiberboard panels can be durable to many factors affecting wood panels.

Perlite is produced from pumice stone that is a glassy form of rhyolite or dacitic magma, and it contains 2–5% water (6). After quick heating, perlite transforms into a cellular material of low bulk-density. The formation of expanded perlite permits to expand up to 15–20 times of its initial volume (7).

Expanded perlite is also very suitable as a sound absorbing material. It is generally used in spray form in paints and plastering for the acoustical purpose (8). Approximately, 4.5 billion tones of the total 6.6 billion tones of perlite reserve are located in Turkey. Also, other reserves are located in USA, Greece, Japan, Philippines, Russia, Hungary, Mexico and Italy (9). The economic benefits of lightweight concrete are the low-heat conductivity and unit weight (10, 14). Expanded perlite has been used in constructional elements for a long time, but it has not been industrially used in concrete (15).

Uysal et al. (2008) researched the effect of some fire retardant on thermal conductivity value of poplar wood.

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When they compared un-impregnated to impregnated test samples, the highest value was determined in poplar wood impregnated with boric acid (16). The thermal conductivity values of poplar, cedrus, oriental beech wood, chipboard and fiberboard were found 0.1146 - 0.1253 - 0.1580, 0.1783 and 0.1998 (kcal/mh°C) respectively (17). Yapici et al, reported that the thermal conductivity values of oriented strand board (OSB) panels produced in the different conditions were ranged from 0.129 to 0.170 w/mk (18).

There are many studies on the thermal conductivity values of wood and laminated veneer lumber, but no information exists about the effects of used expanded perlite on the wood based panels. The objective of this study is to investigate the effect of the expanded perlite on the thermal conductivity of MDF panels produced by adding expanded perlite in different ratios.

2. Materials and Methods

The fiberboards were made from commercially manufactured thermo mechanical wood fibers (50% hardwood and 50% softwood) obtained from an MDF mill in Turkey. The fibers were dried up to 3 % moisture content before adhesive was sprayed on them. Adhesive material without wax, which is called as 47 % phenol formaldehyde, was applied in 6% ratio based on the weight of the oven dry fiber. Firstly, expanded perlite was added in all fiber mixture as 1-3-5-7-10-15-20% based on the weight of the oven dry fiber. Secondly, after the fibers were divided into two groups used to the only surface and core layers, expanded perlite was added into the fiber mixture as 1-3-5% based on the weight of the oven dry fibers.

The press operation was applied in 6 minutes under the 40 kp/cm^2 pres pressure. The expected density of panels was 0.65 g/cm^3. Mats (56x56x 1cm) were formed. Totally, 14 MDF panels, which were named from A to M, were produced at this study. All mats were pressed onto automatically controlled at 182±3ºC. After pressing, the boards were conditioned at 65±5% relative humidity and at a temperature of 20±2 ºC until their weight were stable.

Based on related standard, a quick thermal conductivity meter that is power supply; QTM 500 meter; Kyoto Electronics Manufacturing, Tokyo, Japan (19), the hot-wire method was used. The measurement range is 6 W/mK. Measurement precision was 5% of the reading value per the reference plate. Reproducibility was given as 3% of reading value. Measurement temperature was within the range 100 to 1000ºC (external bath or electric furnace for temperature other than room). Measuring time was standard, 100 to 120 s. During the test operation, the temperature of the hot wire rises rapidly and this temperature rise spreads outward in the samples.

3. Results and Discussion

The density and moisture content values of MDFs were determined according to the related to standards (20, 21). The average density and moisture content of panels were obtained as 0.64 g/cm^3 and 7.2 % respectively. The aimed and acquired values related to density, and moisture was found to be within the ranges specified in the standards. The average and standard deviation of the values of thermal conductivity (TC) of produced MDF panels are given in Table 1.

Table 1. Summary of the test results of the specimens

Place of using expanded perlite	Type of MDF panels	Expanded perlite ratio (%)	Thermal Conductivity (kcal/mh ºC)	
			Mean	Std. Dev.
Both core and surface layer	A	0	0.1917	0.008
	B	1	0.1854	0.009
	C	3	0.1830	0.006
	D	5	0.1843	0.010
	E	10	0.1803	0.009
	F	15	0.1780	0.011
	G	20	0.1959	0.009
Only core layer	H	1	0.1866	0.012
	I	3	0.1874	0.011
	J	5	0.1900	0.011
Only surface layer	K	1	0.1695	0.010
	L	3	0.1820	0.008
	M	5	0.1925	0.021

It was shown that the thermal conductivity values determined from panels were changed between 0.1695 and 0.1959 kcal/mhºC. The thermal conductivity value of manufacturing panels without perlite was measured as 0.1917 kcal/mhºC. While the highest thermal conductivity value (0.1959 kcal/mhºC) was determined to be in manufactured MDF panels by using 20%perlite and 80%wood fiber, the lowest thermal conductivity value (0.1695 kcal/mhºC) was measured from type of K with in 1%perlite into the only surface layer fibers. Thermal conductivity value of panel could have been affected by using expanded perlite. Nemli and Kalaycıoğlu reported that thermal conductivity values of particleboards, which were covered by different coating materials, were changed between 0.0916 and 0.1153 kcal/mhºC (22).
Multiple variance analysis was used to determine the differences among the test samples. The results of variance according to the thermal conductivity properties are given in Table 2.

Table 2. Results of variance analysis

Source	Type III Sum of Squares	df	Mean Square	F	Sig. (p<0.05)
A	0.00	2	0.00	2.59	0.08
B	0.00	6	0.00	4.40	0.00
AxB	0.00	4	0.00	3.21	0.02
Error	0.02	117	0.00		
Total	4.48	130			
A: Place of using expanded perlite, B: Expanded perlite ratio					

According to the variance analysis, the effects of the expanded perlite ratio, and interaction between expanded perlite ratio and place of using expanded perlite were found to be statically significant at the 95% significance level, but the effect of only the place of using expanded perlite was found to be statically insignificant at the 0.05 error margin. To comparisons of these means were made by employing a Duncan test to identify which groups were significantly different from other groups, and the results are given in Table 3.

Table 3. Results of Duncan test

Type of panels	Thermal Conductivity (kcal/mh ºC)	
	Mean	HG
K	0.1695	A
F	0.1780	AB
E	0.1803	BC
L	0.1820	BCD
C	0.1820	BCD
D	0.1843	BCDE
B	0.1854	BCDE
H	0.1866	BCDE
I	0.1874	BCDE
J	0.1900	CDE
A	0.1917	CDE
M	0.1925	DE
G	0.1959	E

According to the Duncan test results, the thermal conductivity values ranged between 0.1695 and 0.1959 kcal/mhºC. For instance, thermal conductivity values of the types of D-I panels were found to be much closed to each other (0.1843 to 1874 kcal/mhºC). So, they were assigned to the same homogenous group. The same is true for L and C, as well as it can be said in the J and A-type panels. The change of thermal conductivity of panels according to the ratio and place of using expanded perlite was shown in Figure 1.

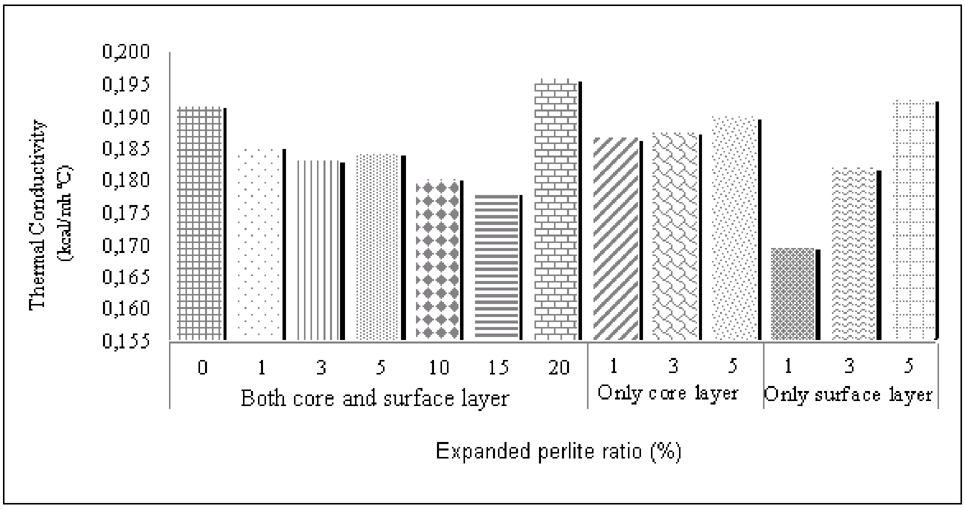

Figure 1. The change of thermal conductivity of panels

4. Conclusions

The thermal conductivity value of wood composite materials is affected by a number of basic factors such as density, moisture content, extractive content, grain direction, structural irregularities, and temperature. Thermal conductivity of wood composites is very important to many applications. Results indicated that using expanded perlite in the produce of panels significantly has the significant effect on the thermal conductivity of MDF panels. While the highest value of thermal conductivity was obtained as 0.1959 (Kcal/mhºC) in the sample of G, the lowest value of was obtained as 0.1695 in the type of K samples. It can say that thermal conductivity values were found between 0.1695 and 0.1959 (kcal/mhºC). At the same time, it was seen that as the increase of using expanded perlite ratio, the decreased of thermal conductivity, but if the ratio of using expanded perlite exceeded 5%, the thermal conductivity values of panels were increased again.

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