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ENGINEERING PROPERTIES OF COMPOSITES CONTAINING POLYURETHANE, WHEAT STALK AND CORN STALK ASH, PEANUT SHELL ASH, FLY ASH, SAWDUST, PERLITE, BARITE AND GYPSUM

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ABSTRACT

In this study, engineering properties of composites containing polyurethane, wheat stalk and corn stalk ash, peanut shell ash, fly ash, sawdust, perlite, barite and gypsum are investigated. Radiation absorption, unit weights, ultrasonic pulse velocities, thermal insulation coefficients of the specimens produced in standard 16x16x4 cm molds were found. All tests were found to be in accordance with standards. Also, it was found out that specimen no. 3 has the lowest thermal insulation coefficient. It was found out that specimens containing more sawdust have higher unit weight. Specimens with high thermal insulation coefficient and unit weight were found to have low capacity of ultrasonic sound absorption. This case was explained with spaceless structure of materials. It was found that specimen no.3 with the lowest ultrasonic pulse velocity has the lowest thermal insulation coefficient. Unit weight for the same specimen was found to be under average. It was found that specimens containing peanut shell ash have higher radiation absorption rates. This study showed that wheat stalks, corn stalks and peanut shells can be recycled for economy by burning process in appropriate environment. Also, this composite can protect people from negative effects of radiation when used in medical buildings and X-ray rooms.

Keywords: Polyurethane, Wheat Stalk Ash, Corn Stalk Ash, Fly Ash, Peanut Shell Ash.

INTRODUCTION

In order to improve sound absorption and heat insulation features of a composite, natural cotton, bamboo and wool fibre were added to a die based on polyurethane and various specifications of the composite were analyzed. Also, the study was aimed at recycling textile wastes and using less polyurethane for material production. Adding natural wool fibre is known to improve sound insulation feature of the polyurethane foam. Polyurethane composite supported with cotton fibre was found to have high capacity of sound absorption. Adding wool fibre, bamboo and cotton to polyurethane foam was proved to reduce thermal heat transfer. It was found that the composite with %4 cotton fibre in it has the lowest heat transfer coefficient [1].

Heat bridges in cold stores were analyzed to see the effect of assembly mistakes of door cases etc on energy performances. Regarding the acquired results, it was aimed at improving thermal transmittance by keeping assembly areas of a cold polyurethane store at 0°C ve -18°C by means of finite elements. To prevent condensation on the external surface, alternative ways were proposed. In analyses, in case that performance loss based on heat bridges in some points reaches %20, the studies to decrease this loss with the help of the developed model. At the end of the study developed, application areas and cooling capacities were evaluated [2]. The method of acquisition, thermal and radiation transmittence and chemical structure of polyurethane foam material were analyzed [3].

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Diversity, need and usage areas of wooden panel products have beeb şncreasing. Due to the fact that composite materials with polyurethane and honeycomb structure are lighter, more elastic and include proper resistance and thermal transmittance features, its usage in navigation, industries of furniture and internal decoration etc. is wanted to be increased. Production, advantages and disadvantages of panels with foam and honeycomb structure composites were stated. Results were discussed. Products similar to panels with composite material were analyzed in terms of technological features. It is beneficial that composites with foam and honeycomb are lighter around %40-70 than others, more resistant to moisture, easier to carry, recycle, cut, rasp and ecological [4].

In 2000, Regulation of Heat Insulation In Buildings came into force to ensure heat conductivity economy in Turkey. And it has been paid attention to. With this regulation in force, heating energy requirement was reduced by heat insulation in buildings and energy saving was ensured. It was stated that choosing correct material and determining maximum insulation thickness are important. In this study, an insulation material in accordance with TS 825 standard was developed and maximum insulation thicknesses based on different heat insulation materials for 4 regions of Turkey were given. In the study, the effect of exterior wall and window changes on heating energy requirement and maximum insulation thickness of the building was analyzed [5].

Waste material from Kahramanmaraş textile factories(cotton waste), resin and fly ashes were analyzed in terms of usability in production of chipboard used for insulation. Produced in different sizes, chipboards have been analyzed regarding heat insulation, sound insulation and bending resistance. On the other hand, radioactive permeability of chipboards were studied by using barite on them. It was seen that composite materials composed of fly ash and cotton waste improve insulation features of chipboards. It is seen that radiactive permeability of light building materials with barite was reduced [6]. In experiments, plastering material was acquired by using perlite, waste paper and borax for composite material. Eco-friendly plaster material was acquired by this study [7, 8]. In the studies, Physical and chemical features of brickdust mortar containing expanded perlite were looked into. For specimens, expanded perlite at the rates of 0-10-20-30-40% was used as aggreagate instead of 0-2 mm brickdust. As a result of the experiments, an decrease in bending resistance, pressure resistance and values of weight per unit of specimens was observed besides an increase in heat insulation values [9]. Lignocellulose was also used in the past and in ancient Egypt adobe was produced with the mix of mud and chaff [10].

Decrease in present forest resources, price increase of timber and environmental pressure against deforestation created the thought of finding new fibre sources. This topic was dealt with by scientists in many developed countries. Producing a successful composite material with wheat stalks is possible thanks to rapid technological developments and solution of production problems. It was determined that specifications of acquired composite plates are extremely good. This situation caused the producers to use agricultural wastes more and take advantage of this [11].

In this study, two of polyurethane, wheat stalk ash, corn stalk ash or fly ash, sawdust, barite, perlite and peanut shell ash were used to produce a composite material. Heat transfer coefficients, ultrasonic sound permeability speed, weights per unit of volume and radiation absorption rates of specimens were determined.

MATERIAL AND METHOD
Material
Polyurethane

Polyurethane, a good heat insulation material, has been used in buildings since 1950s. All over the world, sandwich panels filled with polyurethane have been increasingly preferred by investors and designers. Polyurethane, which has the best insulation values among the insulation materials used in buildings, makes a saving up to %40 for the costs of heating and ventilating. Polyurethane foam was used in specific thicknesses.

Wheat Stalk Ash

Wheat stalks that are burned by farmers and found widely in the region after harvest were collected in a proper way. Collected wheat was burned in appropriate environment. After burning, ashes were added to specimens at specific rates.

Corn Stalk Ash

It is a pland indigenous to America. During the discorvery of America, the indians only knew corn agriculture. Today, density of the corn cultivated in many regions of Turkey is 2.2 – 2.4 g/cm³, softening temperature is 810–1090 °C, melting temperature is 1260 – 1340 °C and density is 1.45 kg/l.

Fly Ash

The reason for using fly ash is to reduce costs and produce a light building material.

Peanut Shell Ash

It is plant from legume family containing fat around %45-60, protein around %20-30, carbonhydrate of %18, vitamins and minerals. Mechanical properties of ash acquired by burning peanut shell were examined. Chemical and physical properties of wheat stalk ash, corn stalk ash and fly ash hare given in Table 1.

Table 1. **Chemical contents** and **Phisical Properties of materials used**

Maretials	**Chemical contents**								**Phisical properties**			
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	SO_3	Density (g/cm^3)	Blaine (cm^2/g)	Resude on 200 micron sieve (%)	Resude on 90 micron sieve (%)
Wheat stalk ash	33,5	1,2	0,9	25,4	4,6	20,7	1,3	6,9	2,5	3500	0,15	1.85
Corn stalk ash	37,3	2,3	2,2	23	7,4	17	2,3	4,3	2,4	3500	0,24	1.45
Fly ash	32.4	9.7	11.1	31.6	3.1	0.6	0.5	8.4	2.3	3500	0,34	1.65

Sawdust

It is a waste material arising out of the process of turning, planing, sifting woods from Kahramanmaraş wood storages. This waste was collected and used as admixture material for insulation material. Appearance of sawdust sifted with a 2 mm sifter is given in Figure 1.

Fig 1. View of chips on 2 mm sieve

Perlite

When it comes to perlite, it means a special type of volcanic glassy rock that arises from extension occurring due to cooling in petrographics, concentric structure that can be seen by the eye or a microscope or its breaking. Also, perlite is the name of naturally occuring silica-based volcanic rock. In the study, 0-3 mm perlite was used.

Barite

Barite is barium sulfate which is the most common element of barium(BaSO4). Barite is the heaviest of non-metallic minerals. High density (4.45 gr/cm3), low erosivity(Moh's 3-3.25), chemical stability under high pressure and temperature, low dissolution in acids and water, magnetism and low costs of barite are the factors to increase its usage in various industries commonly.

Gypsum

Gypsum is a naturally occuring calsium sufate mineral containing two moles of water. Alçı taşı (jips) doğal olarak oluşan ve iki mol su içeren bir kalsiyum sülfat mineralidir. It is building material gaining binding properties when mixed with water, and it is acquired by heating, blowing and grinding of gypsum that containes two molecules of crystal water, leaving only half a molecule of water. In the study, plaster of paris was preferred for decoration works.

Method
Preparation of Raw Materials

In the study, polyurethane, Afşin-Elbistan fly ash, barite from Osmaniye Barit Bahce Madem Türk A.S, perlite from Kocaeli Aksel Bahçe Tesisleri, wheat stalk, corn stalk and peanut shell ash acquired by being burned in proper environment were used. Mix ratios of specimens are given in Table 2.

Table 2. Mix proportions (g)

Sample no	polyurethane	Wheat stalk ash	Corn stalk ash	Fly ash	Peanut shell ash	Sawdust	Perlite	Barite	Gypsum	Water
1	30	30	-	-	-	45	30	-	40	130
2	20	25	-	-	25	-	30	-	30	150
3	20	25	-	-	-	45	-	30	30	150
4	20	25	-	-	-	45	-	40	30	150
5	20	25	-	-	-	45	-	50	30	150
6	20	25	-	-	25	30	-	-	30	140
7	20	-	25	-	-	45	30	-	30	150
8	20	-	25	-	25	-	30	-	30	150
9	20	-	25	-	25	30	-	-	30	110
10	20	-	-	30	-	-	30	30	30	100
11	20	-	-	30	25	-	-	30	30	70
12	20	-	-	30	-	15	20	-	30	130
13	20	-	-	30	12	30	-	-	30	100
14	20	-	25		-	45	-	30	30	140
15	20	-	25	-	-	-	30	30	30	150
16	20	-	25	-	25	-	-	30	30	110

Production of Insulation Material

At the first stage of specimen production, 1 cm organic and inorganic material was added as homogenously with plaster to 1 cm polyurethane and then polyurethan was poured again (Figure 2).

Fig 2. Samples propeired

After polyurethane took shape, specimen was cut from upside to reach the tickness of 3 cm. Due to higher swelling in middle, when cut from upside, mineral mortar appeared. As a result, mineral morter with 1 cm thickness was added to solidified polyurethane with 1 cm thickness and then again polyurethane with 1 cm thickness was placed on the mortar(Figure 3).

Fig. 3. Samples afret dried

Despite the usage of plaster as binder, the material scattered after it was taken out of oven. In this case, new specimens were made and polyurethane foam that was placed to mold before the specimen was used. Solidified foam was taken out of mold and cut as 1 cm (Figure 4).

Fig 4. Sample cutting on 10 mm size with polyurethane

Acquired foam layers were placed to mold. From the edges of foam placed to mold, 0.5 mm was cut(Figure 5).

Fig 5. Samples in mould by polyurethane

Mineral mortar with 1 cm thickness was added to polyurethane foam placed to mold and then polyurethane was placed to mortar (Figure 6).

Fig **6.** View of mineral admixture

Lastly, redundant polyurethane foam was cut and specimen was acquired in desired size. In total, 16 specimens were created by using organic and inorganic materials at different sizes.

Specimens with layers of 1 cm thickness were produced both with organic materials and inorganic ashes.

EXPERIMENTAL STUDIES

Thermal Conductivity Coefficients of Samples

Thermal insulation coefficient of composite insulation material was measured by KEM QTM-500 thermal transmittence measure device at USKIM (Fig. 7).

Fig. 7. Thermal conductivity measuring device

Ultrasonic Sound Permeability

There is a specific relation between ultrasonic wave speed and densities of materials. The more space material has, the lower ultrasonic wave speed gets. After measuring how long it takes for ultrasonic wave sent inside the block to reach other side, wave speed is calculated with (1)expression below:

$$V = (S / t)\times 106 \qquad (1)$$

Expressions here are: V = P wave speed (km/sec) S= the distance between surface of block receiving ultrasonic wave and the other side(km), t = p the time passed between touching the surface and reaching the other surface(microsecond). Ultrasonic sound permeability test was performed on every specimen and the sound permeability speeds were determined (Figure 8).

Fig. 8. Ultrasonic pulse velocity measuring device

Unit Weight of Samples

Unit weight for produced plate specimes were calculated.

Radiation Absorption

Gamma ray absorption percentages of some specimens were calculated in Pyhsics Department as 6, 17.7, 26 ve 60 KeV energy levels. Sawdust, perlite and peanut shell ash were evaluated as different parameters and radiation absorption tests on these specimens were performed.

RESULTS AND DISCUSSION
Thermal Insulation Coefficients

Thermal insulation coefficients of specimens are given in Figure 9. Thermal insulation coefficients of all specimens were found to be in accordance with standards. Because, in order to use a material for insulation, it must have heat transfer coefficient value of 0,065 and lower according to TS 805 [12]. Thermal insulation coefficients of all specimens were found to be lower than that. Also, specimen no.3 has the lowest coefficient. The reason for this is that specimen has less barite in it than fourth and fifth specimens. Although specimen no.10 that has the highest thermal insulation coefficient and no.11 have the same compositions, only specimen no.10 has perlite and specimen no.11 has peanut shell ash.

This case was explained with dependent or independent space structure that peanut shell created in die. Both organic and inorganic ashes created more cavernous structure in composite.

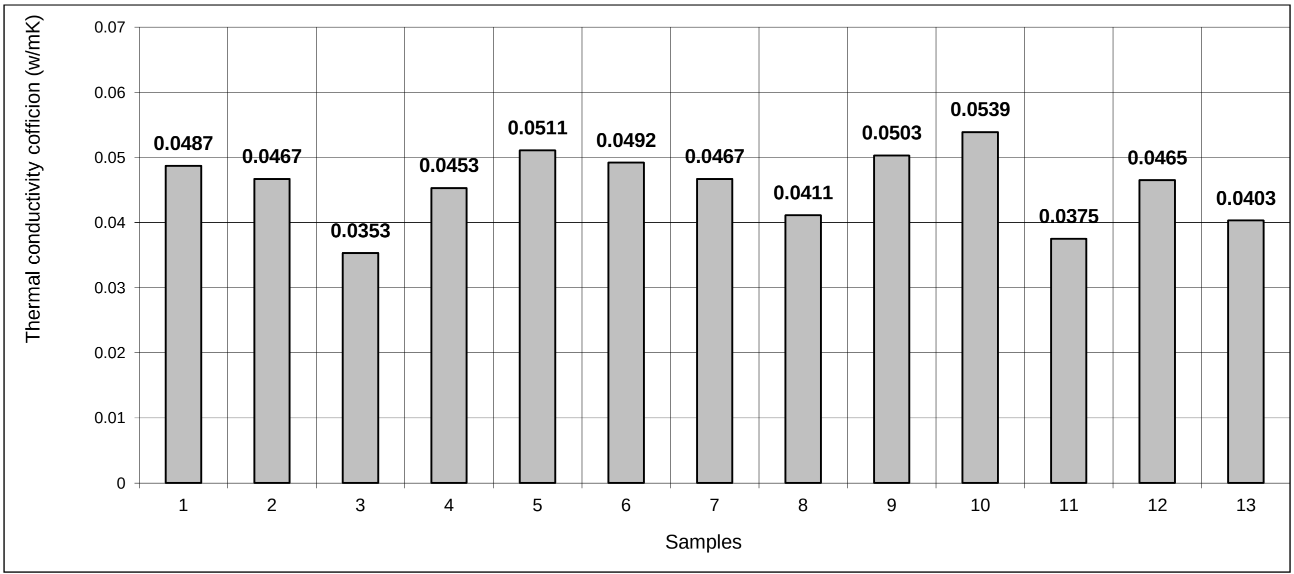

Fig. 9. Thermal conductivity coefficionts (kcal/mh°C)

Ultrasonic Pulse Velocity and of Unit Weight

Ultrasonic sound velocity and unit weight of samples are given in Table 3.

Table 3. Ultrasonic Pulse Velocity and Unit Weight of samples

Sample no	Ultrasonic Pulse Velocity (km/s)	Unit Weight (g/cm^3)
1	147,4	0,18
2	40,2	0,14
3	38,0	0,14
4	114,4	0,19
5	109,5	0,21
6	75,1	0,14
7	64.0	0,17
8	35,2	0,14

10	140,4	0,14
12	70,9	0,16
13	64,6	0,15
14	78,2	0,11
15	67,4	0,15
16	58,1	0,17

Specimen no.5, which has the highest weight per unit of volume, has more sawdust in it. This material is in a denser structure for it collects more ash during the mortar phase. Also, it was found out that this material has a high weight per unit of volume for it has the highest barite in it. Heat transfer coefficient of this specimen is also higher than others. On the other hand, specimen no.14, which has the lowest weight per unit of volume, has different material parameters than others(specimens no. 3, 10, 11, 15 and 16) and less barite in it(specimens no.4 and 5).

Generally, specimens that have high weights per unit of volume and heat transfer coefficients were found out to have low ultrasonic sound absorption capacities. This was explained with their spaceless structures. It was found out that specimen no.3, which has the lowest ultrasonic sound permeability speed, has the lowest heat transfer coefficient and weight per unit of volume under average.

Radiation Absorption

Lineer absorption percentages are given in Figure 10.

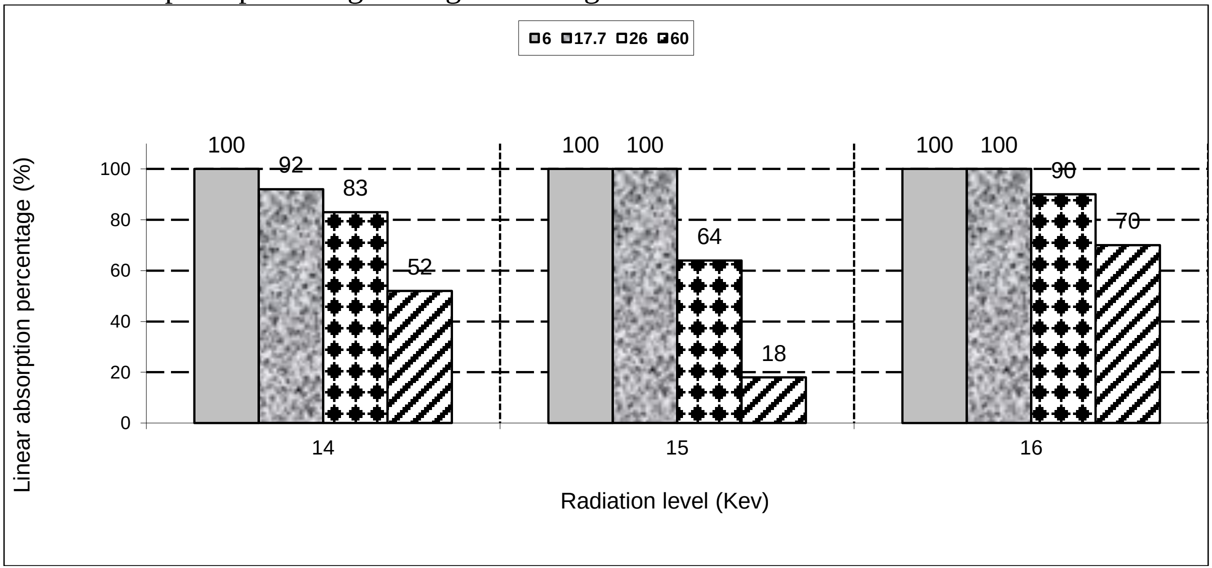

Fig. 10. Linear absorption percentage

Specimens that have sawdust, perlite and peanut shell ash as different parameters were evaluated and their radiation absorption rates were found. It was seen that specimens absorbed all radiation at the energy level of 6 keV. Also, at 17,7 keV, specimen no.15 and no.16 absorbed the all radiation and specimen no.14 absorbed %92 of radiation. These results showed that perlite and peanut shell ashes make a better absorption than sawdust. Radiation absorption values of specimens at 26 keV were found to be different. At this level, the highest absorption rate belongs to specimen no.16. This case was explained with that the stated specimen has peanut shell as different parameter. At 60 keV energy level, again specimen no.16 has the highest radiation absorption rate among the others. This case was explained with peanut shell ash again.

CONCLUSİONS

The results obtained from this study are shown below.

1- Thermal insulation coefficients of all specimens were found to be in accordance with standards. Also, it was seen that specimen no.3 has the lowers thermal insulation coefficient. Because, the parameters of this specimen are different and it includes less barite than specimen no.4 and no.5.
2- It was found out that specimens with more sawdust in them have higher unit weights. This case was explained with that it collects more ash due to its spaceless structure during the mortar phase.
3- It was found out that specimens with high thermal insulation coefficients and unit weights have low ultrasonic sound absorption capacities. This case was explained with their spaceless structures. It was seen that specimen no.3 which has the lowest ultrasonic sound permeability speed has the lowest thermal insulation coefficient. Unit weight fort the same specimen was found to be under average.
4- It was found out that specimen containing peanut shell ashes has a higher radiation absorption rate.

With this study, pollutant organic materials such as wheat stalk, corn stalk and peanut shell can be recycled by being burned in a proper environment. On the other hand, this composite can be used in walls surrounding medical buildings and X-ray rooms. Thus, people can be protected from the negative effects of radiation.

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