Binici and Kekili, J Material Sci Eng 2015, 4:5
DOI: 10.4172/2169-0022.1000186

Journal of Material Sciences & Engineering

Review Article Open Access

The Production of Thermal Insulation by Waste Animal and Vegetable Fibres

Binici H and Kekili M*

Kahramanmaras Sütçüimam University, Department of Civil Engineering, Kahramanmaras, Turkey

Abstract

World energy consumption refers to the total energy used by all of human civilization. Since the heating costs in winter, the cooling costs in summer are very high in Turkey, insulation is made to the buildings to reduce these costs. A great part of the raw materials of insulation materials have been imported. Rapid increase in the population, developments in the technology everyday bring rapid consumption of energy resources with them. Today, the energy consumption has reached serious proportions and precautions have already been started to be taken all over the world. Most of the energy in Turkey is spent in industry and in housings. Energy savings potential is available up to annual $ 7.5 billion by the dissemination of heat insulation applications in Turkey. Energy efficiency should be supported in buildings via heat insulation in order to prompt this potential. In the present study, animal and vegetable fibre doped insulation material has been produced at specified rates. Set out in the findings, research materials waste animal and vegitables fibers shows that it is possible to produce insulation materials enough to mix it with plaster. The thermal insulation coefficient of the obtained samples conforms to the TS EN standards

Keywords: Animal fibres; Vegetables fibres; Insulation material

Introduction

Since the heating costs the cooling costs are very high in Turkey, insulation is made to the buildings to reduce these costs. A great part of the raw materials of insulation materials have been imported. Rapid increase in the population, developments in the technology everyday bring rapid consumption of energy resources with them. Today, the energy consumption has reached serious proportions and precautions have already been started to be taken all over the world. Most of the energy in Turkey is spent in industry and in housings. While hot water supply lightening and, the use of electrical appliances constitute15% of the energy consumption in buildings, 85% is spent for cooling and heating [1].

Energy savings potential can be made to annual $ 7.5 billion by the dissemination of heat insulation applications in Turkey. Energy efficiency should be supported in buildings via heat insulation in order to prompt this potential. Animal and vegetable fibre doped insulation material has been produced at specified rates. The thermal insulation coefficient of the obtained samples conforms to the standards [2]. In the near future, all new buildings will be built thanks to the passive house and the available buildings will have been renewed in order to meet low energy building standard [3]. In recent years, more emphasis is given to ecological characteristics in the area of building heat preservation. Environmental consciousness is not limited with the energy saving any more, also it only takes place in ecological structure, in other words, it is to be a part of minimum energy input, resource consumption and pollution production, installation and insulation material should be used. It has been determined that the energy resources in the World are consumed away rapidly, and the about 40% of energy consumed in Turkey has been consumed in buildings [4]. 80% of this energy is for heating and more than 65% of the consumed energy in Turkey is imported. Therefore, insulation materials contribute to constructions for heating savings on a considerable amount. Different composites productions have been actualized from vegetable fibres [5]. For this reason, solving the problem of production and the production of composite plates from wheat straws has become successful. It has been determined that chip and fibre boards produced by wheat straw are more advantageous in many ways than those produced from wood. This has increased the demands of using agriculture wastes by the composite panel producers in Canada who makes researches especially about this issue. In Turkey that has great wheat straw potential, making studies for this kind of researches and applications is inevitable. On the other hand, the production of sunflower has been carried out at significant amounts. Sunflower stalks emerging after the production is very serious problem for our farmers. There are 2.500.000 tons sunflower stalks per year as waste [6]. On the other hand, the feature of light and new insulation material produced by cotton wastes and textile ash has been investigated. The experiments of compressive strength and thermal conductivity of the block insulation material have been carried out in accordance with ASTM and Turkish Standards. As a result of experiments; it has been emphasized that the light insulation materials produced have good insulation features and are light composite used in the production of brick, wall and ceiling panels. The coefficients of thermal conductivity of the composites obtained by using natural fibres have been determined [7,8]. It has been determined that the coefficients of thermal conductivity of the composites mentioned are lower than those that are produced by artificial fibres, and that they are economic, don't harm the environment and also have very good mechanical features.

The use of natural fibres in insulation is related to the ecological building sector [9], where selection of materials is based on factors including recyclable, renewable raw materials and low resource production techniques. In addition to cellulosic insulations have a higher moisture regainthanin organic materials and therefore only cellulosic materials are recommended for old timbered houses [10,11].

***Corresponding author:** Binici H, Kahramanmaras Sütçüimam University, Department of Civil Engineering, Kahramanmaras, Turkey, Tel:903442237406; E-mail: hbinici@ksu.edu.tr

Received July 21, 2015; **Accepted** July 28, 2015; **Published** August 10, 2015

Citation: Binici H, Kekili M (2015) The Production of Thermal Insulation by Waste Animal and Vegetable Fibres. J Material Sci Eng 4: 186. doi:10.4172/2169-0022.1000186

One reason for the relatively low utilisation is higher price of fibrein sulations compared to mineral wool. On the other hand, these insulation materials has low energy demand in production, potential forrecycling and positive effect on indoorair [12]. The thermal performance of bio-based materials has been investigated and confirmed generally as competitive with conventional insulations in some studies [13,14]. Considerable data is available concerning the technical properties of conventiona linsulations [15,16]. The implementation of agro-industrial residues in the development of composite materials for building trades is now a research of growing interest [17,18]. One of the major importance of this industry for the next decade is to improve the energy performance of existing building staking into account the increasing social emphasis on issues of the environment, waste disposal, and the depletion of non-renewable resources. The motivation includes cost, mechanical, thermal and acoustical performance, weight reduction, and environment concerns [19]. Thermal insulation is known to play a vital role in saving energy by reducing the rate of heat transfer [20]. Among them, those obtained from agriculturalby-products have numerous advantages as they are eco-friendly and renewable. Furthermore, the high fiber content of some of them authorizes the reinforcement of composites [21]. The bio-sourced material obtained had higher thermal conductivity and mechanical strength compared to cement alone [22].

As it is understood from the previous studies, it is of great importance to assess the wastes in the world any more. In this regard, the purpose of this study is to produce appropriate insulation materials that will assess the wastes .This study aims to produce a fire-resistant insulation material which has much lower heat transmission coefficient. Thus, both the local people will benefit from the wastes and employment will be provided by mass production and also they will contribute to the economy. On the other hand, since the studies made by thermal insulation are limited, the studies made by us will constitute to literature

Materials and Method

Material

Vegetable and animal fibres

Sunflower: Sunflower is one of the most important oil plants in the world and in Turkey and it is mostly produced for oil in our country. As it is understood from the previous studies, it is of great importance to assess the wastes in the world any more [6]. In this regard, sunflower stalk will be used in the production of insulation material in this study as vegetable fibre which is found plentifully in Elbistan Plain. In order to offer solution directly to components and elements produced from the plaster, the raw material of which is found commonly in our country, shortening the construction period, mitigating construction, preventing place and material losses, planning and bring flexibility of use, reducing maintenance and finally, the purpose of reducing costs of construction and usage, our country should find more application area in terms of construction sector [23]. Nine million tons sunflower stalks have been determined as waste in Turkey as of 2012. Approximately 5 thousand insulation materials can be produced by these wastes.

Wheat stalk: The wheat stalks (stubble) that are found abundantly on the region and burnt by farmers after harvest have been collected appropriately. This has aimed both to make it win for economy and to prevent it from pollution. Sunflower and wheat stalks and agriculture wastes in our country are pretty much and heat conservatism and void ratios are the most important parameters of providing insulation in the layers of composite. Evaluating these wastes will both contribute to the economy of the country and will provide to get ahead of air pollution as a result of burning these wastes.

Animal fibres (goat hair and sheep wool): Every year about 35 million tons natural fibres have been produced including animal and vegetable origin in the world. While vegetables origin natural fibres produced at industrial level are essentially cotton, coconut fibre, linen, hemp, jute, the animal origin fibres are wool, silk, mohair and Kashmir. They are Angora rabbit hair, goat upper coarse fibres and Asia and the fibres obtained from the South America camels. By using these fibres on different production areas such as textile, automotive, furniture, agriculture and handcrafts, they contribute to the country economy at significant level in the countries where they are produced and/or they are demanded. However, during the last half-century, petrochemical fibres such as acrylic, nylon, polyester and polypropylene taking part instead of natural fibres in different production areas have caused the production and usage of vegetable and animal fibres to be regressed at significant level. Today, fibre has been obtained for trade purposes from approximately 9 different animal kinds in the world. Those except silk worm fall into the group of mammals. In Turkey, mainly wool, mohair, silk, goat upper coarse hair, and very low levels Kashmir and Angora rabbit wool production have been produced [24,25]. Although some of the animal fibres mentioned above have continued in the usage of textile area, the fibres like goat hair are in the situation of waste. In this study, goat hair and sheep wool have been used as fibre.

The duty of goat hair in the composite which is collected from farms is to increase the flexural strength of samples and to provide tensile stress on the surfaces. These materials that have effect to the thermal insulation are not used today or used very little. While sheep wool continues to be valued in some sectors even if just a bit, goat hair is in the situation of waste.

The materials providing binding and fire-resistant

Vermiculite: Vermiculite long known as a kind of trioctahedral mineral mica is divided into sheets with rapid heating and takes shapes resembling a small worm. The term of vermiculite has been derived from Latin *vermıculare* by using this feature and has been used for minerals resembling to mica and that its layer load is bigger than simectic and that is expanded 2:1. In the Nature: according to the environment and to the formation, four type have been met including land, autogenic, metamorphic and macroscopic [26]. For the first time, the presence of water molecules has been determined among the mica layers by working the crystal structure of vermiculite. The most important vermiculite deposits discovered in Turkey are Sivas-Yıldızeli and Malatya regions. The reserve calculations indicate 6-7 million tonnes of probable reserves in these occurrences. Today, although the production of vermiculite has increased at a significant amount, it has not reached to the production of developed countries because of not knowing the usage areas. The heat resistance of vermiculite will be determined by this study, and will contribute to production and usage areas.

Plaster

Gypsum is a mineral, the chemical composition of which is calcium sulphate. Gypsum ($CaSO_4+2H_2O$) is called to the type having two molecule crystal water in its combination. The main purpose of using plaster is to be binding as well as to provide high temperature resistance. Since it is cheap, plaster has been proffered in the work.

Method

Samples production: The composites in the work consist of fibres,

wastes, main equipment and binding parts .Although the industrial usage of the vermiculite in the natural situation is limited, processed vermiculite has widespread usage area for especially hating and insulation. Although the fibres and wastes found in the Project are not fire-resistance, fire resistance has been provided in the vermiculated mixtures used in surface. The samples produced in preliminary works have been left in fire for 4 hour and deformation has been observed against burning. The samples have preserved their layers and have not been flamed. In the later stages of the work, the waiting times in the fire have been increased and its maximum durability has been observed. A material having much higher fire-resistance in comparison with other insulation materials in the market has been produced. Primarily, the animal fibre used has been brought to the appropriate size by being cut. Then, vermiculite has been added in accordance with the rates given in Table 1. Plaster as binder has been mixed in mixer homogeneously with water (Figure 1). After completing the mixture, moulding starts and the first layer has been poured by compressing it finely and then the exterior of sunflower stalk prepared beforehand has been sprinkled as intermediate layer, the mixture has been compressed by placing it as upper layer. After keeping the sample one day, it has been revealed and has been subjected to heat-treatment and the water and humidity in it have been purified. The composites have been designed both as laminated and granulated composite. The samples produced have been given in Figure 2.

Applied tests

Specific bulk density and water absorption rate: Unit weight of the insulation materials have been made in accordance with TS EN 2823 and water absorption values have been in accordance with ASTM C 67-03[27].

Ultrasonic sound penetration: There is a significant relationship between the speed of ultrasonic waves and the density of materials [28]. As the amount of space in the material increases, the speed of supersonic wave becomes less. After calculating in how much time the supersonic wave transmitted from a surface of the material block to inside have been passed, the speed of the wave is calculated as follows:

$$V=(S/t)\times10^{6}$$

here; V=P speed of wave (kilometre/second) S is the distance (kilometre) between the surface that material block has sent supersonic wave and the surface that the wave has been received, t=P is the time from the material surface that the wave has sent till the surface received (microsecond).The ultrasonic sound transmission experiment have been made on all the samples and the sound transmission speed has been found.

Fire test: After drying in a drying oven selected from six samples, 75, 100, 125 and 150°C temperature have been exposed for 10 minutes. The weight changes of these samples in these temperatures have been determined.

Thermal insulation coefficient: The composite insulation material produced has been measured by KEM brand QTM-500 brand thermal measuring device and its thermal insulation coefficient has been measured. The experiment of determination of thermal conductivity has been made in accordance with ASTM C 1113-90 [29].

Results and Discussion

Unit weight and water absorption values

The unit weight values of the composites have been given in Figure 3 and water absorption values have been given in Figure 4. It has been found that unit weights of the organic fibre added samples are lower than those that have pure fibre. On the other hand, it has been founded that the unit weight of the fibrous wheat stalk are slightly lower than those that have sunflower doped fibre. As the fibre contribution rate has increased, unit weight values have decreased. The water absorption rates of previous ones have showed differences. As the fibre contribution rate has increased, the water absorption rates have increased. The reason of this is the spaces consisting between fibres and main phase. However, the water absorption rates conform to the standards.

Ultrasonic sound speed

The Ultrasonic sound of the composites has been given in Figure 5. The Ultrasonic sound speeds of organic doped fibre samples have been found less. The Ultrasonic sound transmission speeds of animal doped fibre samples have been found similar. Naturally, sound absorption capacity of porous materials will be more. These materials have the capacity to provide sound insulation.

The Thermal conductivity coefficient

Thermal conductivity coefficients of the samples produced in the scope of work have been given in Figure 6. The thermal conductivity coefficients of the samples that aren't organic doped fibre have been found bigger than 0.1. These samples can be accepted as insulation material according to standards. On the other hand, the thermal conductivity coefficients of organic doped fibre have been found less. As the fibre doped rate has increased, thermal conductivity coefficient has declined.

Fire resistance

Weight losses obtained in the experiments made in order to determine fire resistance by the samples have been given in Figure 7. The reason of vermiculite coefficient is to increase the fire resistance.

Sample	Vermikulite	Sheep wool	Goat hair	Stubble	Sunflower Stalk	Plaster	Water
SI	300	20	-	-	-	100	300
S2	300	-	20	-	-	100	300
S3	300	20	-	-	20	100	300
S4	300	-	20	-	20	100	300
S5	300	20	-	-	30	100	300
S6	300	-	20	-	30	100	300
S7	300	20	-	20	-	100	300
S8	300	-	20	20	-	80	300
S9	300	20	-	30	-	80	300
S10	300	-	20	30	-	80	300

Table 1: Mix proportion of samples (g).

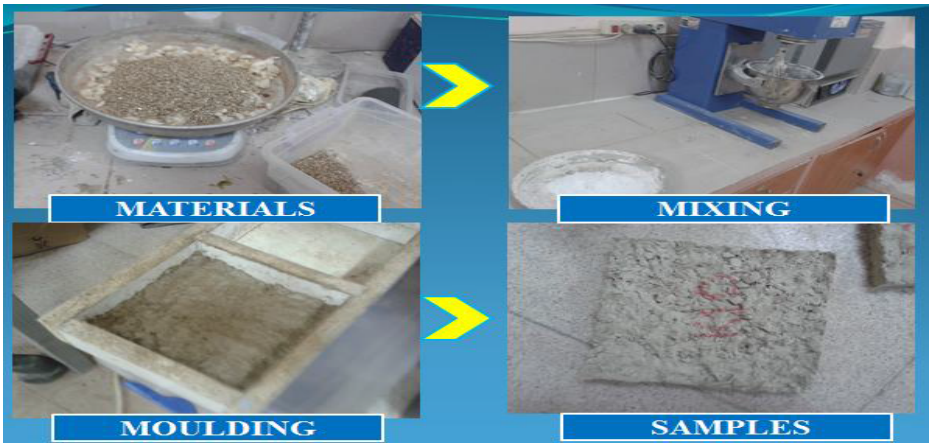

Figure 1: Samples preparation process.

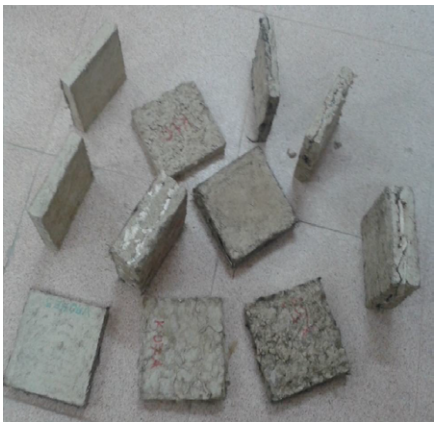

Figure 2: Produced samples.

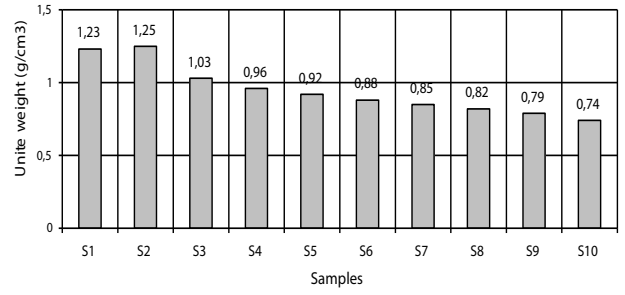

Figure 3: Unite weight of samples.

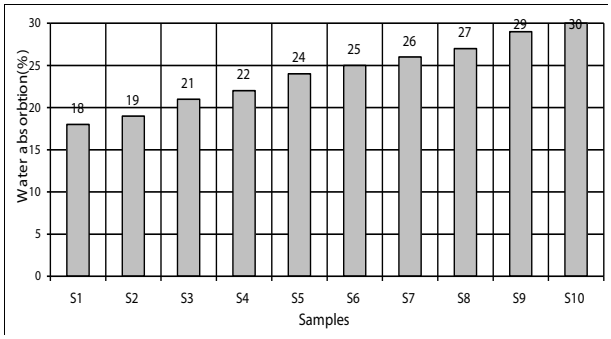

Figure 4: Water absorption of samples.

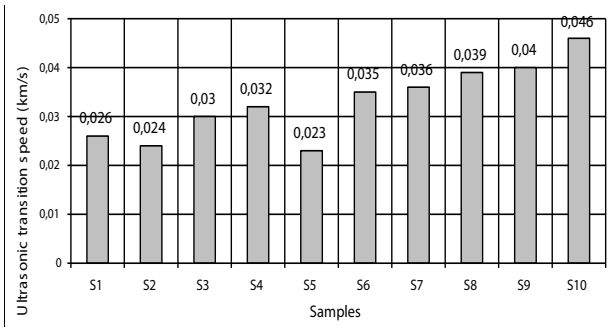

Figure 5: Ultrasonic transition speed of samples.

As expected, this period has extended a little more. The burning period of organic doped fibre samples has been gotten longer from the animal doped fibre samples. However, harmful fumes from the materials have not been observed during fire in both groups. As the oven temperature has increased, naturally, weight loss has increased in all samples. A significant weight loss has not been observed in 75°C temperature.

Conclusion

It has been seen that the layered samples have less than grained samples in the produced samples in the thermal conductivity coefficients. In the samples that vegetables fibres are used, it has been determined that tensile stresses have been met and they have prevented the dispersal of the samples completely. Since the thermal conductivity coefficients of most of the samples are below 1.00, the composites produced can be used as insulation materials. These materials will be evaluated and a local insulation material has been produced. These new insulation materials can be declined about insulation material. The sunflower and wheat stalks in the waste case will provide important contributions to economy. The cost price of insulation materials to be produced by these wastes can be more economic according to the closest pers.

From the fire test, it has been seen that only animal fibres on the surface has been burnt but its surface deformation has not occurred.

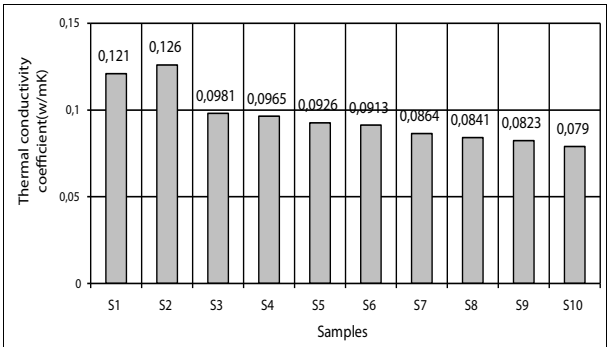

Figure 6: Thermal conductivity coefficient of samples.

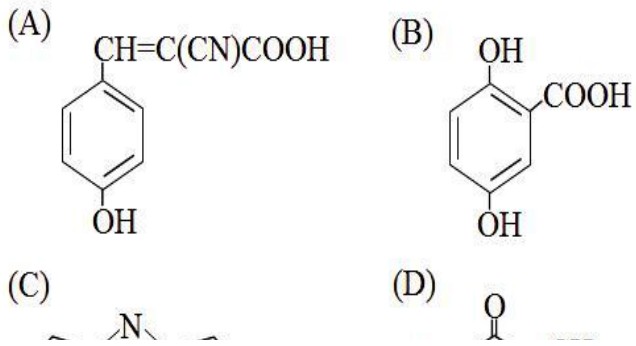

Figure 7: Mass loss of samples after fire test.

During experiment, any flame burning has not been observed. Fume cannot be produced in this period; there will no fume-poisoning deaths that are the main reason of the deaths in the fires. Since it is taken into consideration that the materials mentioned in the work is fire-resistance, it can be said that it is technologically superior to others.

Finally, the most important result of this study is that waste materials satisfactory insulation material is produced entirely of animal and organic fibers.

References

1. de Wilde P, Voorden MV (2003) Providing computational support for the selection of energy saving building components. Energy and Building 36: 749-758.
2. Aksoy TU (2008) Investigation of the effect on on overall heat transition coefficient and heat loss of wall applications with sandwich and aerated concrete. Erciyes Universty Journal of Science 24: 277-290.
3. Berge B (2009)The Ecology of Building Materials (2ndedn.) CRC Press, United States.
4. Thorsnes P, Bishop T (2013) The value of basic building code insulation. Energy Economy 37: 68-81.
5. Mengeloglu F, Alma MH (2002) Wheat stems using composite panel production. Kahramanmaras Sutcu Imam Univrsty Journal of Engineering Science 5: 37-48.
6. Binici H, Eken M, Dolaz M, Aksoğan O, Kara M (2014) An environmental friendly thermal insulation material from sun flower stalk, textile waste and stubble fibres. Construction and Building Materials 51: 24-33.
7. Binici H, Aksogan O (2015) Engineering properties of insulation material made with Cotton waste and flyash. Journal of Material Cycles and Waste Management 17: 157-162.
8. Monika M, Ramaniah K, Ratnaprasad AV, Mohana RK, Hema CRK (2012) Thermal conductivity characterization of bamboo fibre reinforced polyester composite. J Mater Environ Sci 3: 1109-1116.
9. Murphy DPL, Behring H, Wieland H (1997) The use of flax and hemp materials for insulating. Proceedings of flax and other bast plants symposium 30: 79-84.
10. Heier L, Heintges M (1999) Produktion von Industriefaserlein. Landtechnik 54: 174-175.
11. Institut N, Karus M (2003) Daskleine Hanf-Lexikon. Verlag DieWerkstatt, Gottingen, Germany.
12. Ringleb A, Schulz H (1996) Der Dammstoffaus Lein—eineernstzunehmende Alternative, Landtechnik 51: 40-41.
13. Turner WC, Malloy JF (2001) Thermal insulation handbook. Krieger Publishing Company, FL, USA.
14. Strother EF, Turner WC (1990) Thermal insulation building guide. Krieger Publishing Company, FL, USA.
15. Cole RJ (1999) Energy and gren house gas emissions associated with the construction of alternative structural systems. Build Environ 34: 335-348.
16. Gustavsson L, Sathre R (2006) Variability in energy and carbon dioxide balances of wood and concrete building materials. Build Environ 41: 940-951.
17. Morel JC, Mesbah A, Oggero M, Walker P (2001) Building houses with local materials: meansto drastically reduce the environmental impact of construction. Build Environ 36: 1119-1126.
18. Mati-Baouchea N, Baynast H, Lebert A, Suna S, Lopez-Mingo CJS, et al. (2014) Mechanical, thermal and acoustical characterizations of an insulating bio-based composite made from sunflower stalks particles and chitosan. Industrial Crops and Products 58: 244-250.
19. Glé P, Gourdon E, Arnaud L (2012) Modelling of the acoustical properties of hempparticles. Constr Build Mater 37: 801-811.
20. Keynakli O (2012) A review of the economical and optimum thermal insulation thickness for building applications. Renew Sust Energ Rev 16: 415-425.
21. Liu Z, Erham SZ, Akin DE, Barton FE (2006) Green composites from renewable ressources: preparation of epoxi dizedsoybeanoil and flax fiber composites. J Agric Food Chem 54: 2134-2137.
22. Korjenic A, Petranek V, Jiri Z, Jitka H (2011) Development and performance evaluation of naturalthermal insulation materials composed of renewable resources. Energy Build 43: 2518-2523.
23. Patnaika A, Mlando M, Sudhakar M, Anton B, Rajesh DA (2015) Thermal and sound insulation materials from waste wool and recycled polyester fibers and their bio degradationstudies. Energy and Buildings 92: 161-169.
24. Briga-Sa A, Da Teixeira N, Pinto J, Caldeira F, Varum H, et al. (2013) Textile waste as an alternative thermal insulation building material solution. Construction and Building Materials 38: 155-160.
25. Bolat M (2005) Use of Biomass Sources for Energy in Turkey and a View to Biomass Potential. Biomass and Bioenergy 29: 32-41.
26. Guler C, Bektas I, Kalaycıoglu H (2006) The experimental particle board manufacture from sunflower stalks. Forest Production Journal 56: 56-60.
27. ASTM C 67-03 (2003) Standard test methods for sampling and testingbrick and structuralclaytile. American Society for Testing and Materials, Philadelphia, PA.
28. ASTM C 597 (1994) Standart Test Method For Pulse Velocity Through Concrete. Annual Book of ASTM Standard.
29. ASTM C 1113-90 (1990) Test method fort hermal conductivity of refractoriesby hot wire. Annual Book of ASTM Standard.