iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 **Issue:** V **Month of publication:** May 2018

DOI: http://doi.org/10.22214/ijraset.2018.5006

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue V, May 2018- Available at www.ijraset.com

Experimental Investigation on Thermal Conductivity of Building Materials Manufactured from Paper Wastes

Gurkan Altan[1], Burcin Deda Altan[2]
[1, 2]Department of Mechanical Engineering, Faculty of Engineering, Pamukkale University, Kinikli 20070 Denizli, Turkey

Abstract: The existing energy sources in the world are being highly consumed and running out day by day. This fact urges people to seek for new sources of energy and for the means of recycling the waste materials produced after consuming. Paper wastes make up a significant amount of these wastes. This study is, therefore, intended to deal with the thermal conduction coefficients of the new building materials made up from paper wastes. In this study, the materials with low thermal conductivity in the buildings have been analysed as part of the necessity for using the energy sources efficiently, which is the result of the debates over energy deficit and insulation of the buildings. Accordingly, the aim is to arrange the thermal conductivity coefficient to the levels of heat insulation materials by changing the percentage of paper waste and sawdust of pine wood included in the building materials. It has been concluded that the building materials produced with 80% paper waste could be used for the purposes of heat insulation.
Keywords: Thermal conductivity, insulation, building materials, energy, waste.

I. INTRODUCTION

Since the existing energy sources are limited today, it is of importance to use the existing energy effectively and efficiently. A lot of countries, especially the developed ones, have made their way towards seeking for and developing new methods of controlling the energy supply required for the comfort and living standards of where they live as well as using the energy more efficiently.

Considering that a large amount of the energy consumed in residents is used for the purposes of heating and cooling, it seems more than obvious that heat insulation has an important role in energy savings. Heat insulation is defined as preventing the heat exchange between two different environments. It is usually made with special materials. Energy efficiency rises with the heat insulation, and so it becomes possible to save money. The heat insulation applied to the buildings by jacketing them increases the comfort. The distribution of temperature jacketed becomes more homogeneous. Moreover, since the insulation material used is capable of absorbing the noise from out a little, noise insulation is also secured. As a general saving, harmful waste gas from the fuel burned for heating is decreased thanks to the insulation. External wall insulations make also possible the noise insulation, quake insulation, fire insulation and water insulation, depending on the materials used. Especially the cost of the energy used for heating and cooling the buildings is the highest price paid for comfort. The increased cost of energy and the decreased sources of energy have made it compulsory for the users to reduce the heat loss of the buildings and thus the expenditure for heating. Any insulation for the reduction of the heat losses also reduces the heat gains in the summer and lowering the cost for cooling.

With their high durability, low cost, remarkable strength, flexible design and wide range of uses, the composite materials are increasingly finding their ways into the buildings today. The oldest and widest field of use of the composite materials is known to be the construction sector. The mud-based walls reinforced by the hay fibers are the examples of the first composite material. They have always offered big advantages for the users in that they are durable, have a high insulation of heat and noise, are easily processed, are resistant to moisture and have a low cost.

While the sources of raw material decrease with the increased industrialization in the developed world, there emerge a lot of wastes. Recycling the waste for the industry decreases its harm to the nature somewhat and produces new fields of work. Of the industrial wastes in the world, papers occupy a significant place. Reusing the paper wastes, we can contribute to the protection of forests, reduction of environmental pollution and decrease in raw material inputs.

Paper-based composite materials have started to be used only recently. They are the composites that contain paper. In manufacturing, the paper makes up the composite material as solid or paste. In recent years, the world has witnessed the studies conducted in this field. New products are obtained by blending the paper paste and other bonding materials. Paper paste is often obtained from the recycled papers. This method produces various products in the manufacturing.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue V, May 2018- Available at www.ijraset.com

Many researchers have recently made research on thermal conductivity coefficient in terms of energy efficiency. Kumlutaş et al. [1] investigated the effective thermal conductivity of aluminum filled high-density polyethylene composites as a function of filler concentration. Sutcu and Akkurt [2] produced the porous brick with low thermal conductivity compared to local brick. There are different sources of paper residues suitable for use in bricks. Some researchers used residues obtained from primary paper mills [3-5]. Agricultural wastes are also of concern and currently mostly used as fuel, soil amendment, particleboard and building materails[6-9]. Khedari et al. [10] developed low thermal conductivity particleboards with optimized durian peel and cocount coir mixture ratio.

In this study, the mixtures of waste papers with various ratios and different raw materials like cement and sawdust of pine wood of different ratios have yielded to a new composite material. In addition, the effect of different volumetric concentrations on the thermal features of the new composite material produced. In this way, it is aimed to provide assessment of waste papers.

II. EXPERIMENTAL DETAILS

The stages of the experimental study conducted have been shown in Figure 1. As can be seen in it, the experimental study started with the construction material obtained and ended with the measurement of the thermal conductivity coefficients of the building material produced. According to the measurement of the thermal conductivity coefficients, the mixture ratios were assessed and other experimental studies were continued.

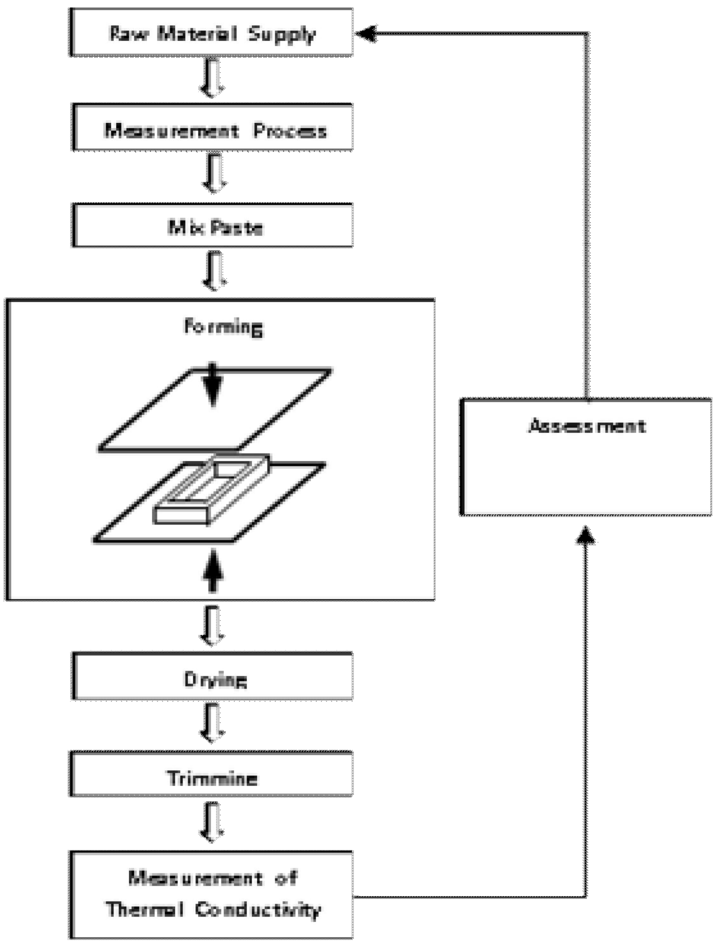


Fig. 1 The stages of the experimental study

A. Manufacturing the building materials from waste papers

The production of the paper-based building material was made by mixing the paper paste of the recycles paper wastes with the cement and sawdust of pine wood at different ratios. Six different paper-based specimens were manufactured according the ratios given in Table 1. In this study, six different ratios are considered because of specimen deterioration in other bigger or lower ratios. The total mixture ratios of the specimens produced were kept fixed and the mixture ratios were changed.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue V, May 2018- Available at www.ijraset.com

TABLE 1 MIXTURE RATIOS

Specimen	Mixture ratio (%)
1	%60 paper paste %40 black cement
2	%70 paper paste %30 black cement
3	%80 paper paste %20 black cement
4	%60 paper paste %10 sawdust of pine wood %30 black cement
5	%70 paper paste %10 sawdust of pine wood %20 black cement
6	%80 paper paste %10 sawdust of pine wood %10 black cement

Before passing to the production of the specimens of the building materials, the paper wastes obtained were made smaller into small pieces. These paper pieces were wetted in a bowl with water. Kept in the water for at least one day, the paper pieces were mixed with an industrial mixer and made into paper paste. The next stage was the production upon obtaining the other raw materials to be used in making the building material, such as cement and sawdust of pine wood.

For the production of the specimens, the paper paste with its abovementioned volumetric ratios, sawdust of pine wood and cement were weighed with an assay balance. Also considering the probable mass losses during the production of the experiment specimens, raw material measurements were made. Especially the water of the paper paste to be measured was filtered by about 85%. Thus, the ratios of the raw materials in the paste mixture to be obtained were obtained at the desired ratios.

The measured raw materials were mixed in a mixing bowl more homogeneously and better to get a paste mixture. As the amount of water in the paper paste was used for the paste mixture, no addition of water was made. The paste mixture required for each specimen was composed of the raw materials of different ratios. As seen in Figure 2, the specimen paste mixtures prepared were placed into the mould of 200 mm X 50 mm X 50 mm.

Fig. 2 The specimen paste mixture

The specimen mould was prepared for the process of pressing by placing an upper mould on the paste mixture placed in the lower mould. The specimen pastes prepared in the mould were placed in the testing machine with the maximum load of 1000kN as seen in Figure 3 (a). Then the compressive load was exerted on the mould by means of the testing machine and rigid paper-based building specimens were formed (Figure 3 (b)).

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue V, May 2018- Available at www.ijraset.com

(a)

(b)

Fig. 3 (a) Testing machine (b) Paper-based building specimen

Most of the water in the paper paste used to prepare the specimens was separated from the specimens while compressive load was exerted in the testing machine. However, the specimen remained wet though a little. As the specimens were supposed to be dry in measuring the thermal conductivity coefficient, the specimens were left to dry. The material burrs in the specimens having become dry were trimmed and made a smooth specimen as can be seen in Figure 4.

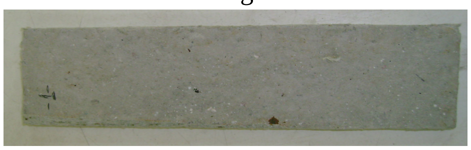


Fig. 4 Trimmed paper-based building specimen

B. Experimental Determination Of Thermal Conductivity

As far as the energy savings in the residents is concerned, thermal conductivity properties of the building materials are expected to be as good as possible. Therefore, the determination of thermal conductivity coefficient is a significant parameter in determining the thermal properties, so the effects on thermal conductivity coefficient of the addition and filling materials added to them are very important. Determination of thermal conductivity coefficient was made with a thermal conductivity coefficient measurement device, Kyoto Electronics QTM-500.

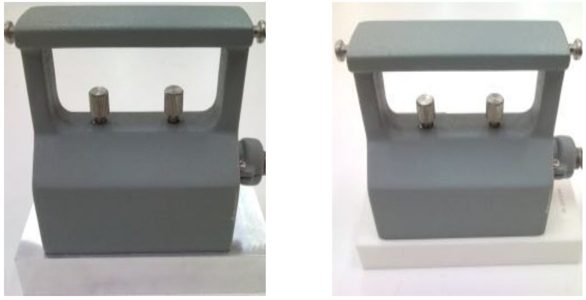
To measure the thermal conductivity coefficient easily, QTM 500 device was equipped with advanced electronic technology. As the measuring method with this device, hot wire method was used. In this method, the wire is heated and there occurs a temperature difference due to the cooling of the wire in the course of time. Thus, thermal conductivity coefficient is automatically calculated on the device’s screen with the electronic circuits. The minimum specimen dimensions to be used in the device have to be 150 mm x 50 mm x 20 mm.

For the device to be stable before starting the measurement, it is kept on an aluminium block (Figure 5a). The measurement apparatus of the device is placed on the aluminium after each measurement and cooled to be prepared for the experiment. Then thermal conductivity coefficient is measured from the reference plate (Figure 5b). Whether the device is ready or not is determined according to whether the measurements from the reference plate are quite close or similar to the thermal conductivity coefficient of the reference plate. Afterwards, at least three measurements are conducted on the experiment specimens with the device and their average is calculated as the below equation. After the repetition of each three measurements, a measurement is taken from the reference plate to confirm the measurements.

$\lambda=(\lambda_1+\lambda_2+\lambda_3)/3$

here;

- λ : The average thermal conductivity r coefficient (W/(m·K))
- λ_1 : First measured thermal conductivity coefficient (W/(m·K))
- λ_2 : Second measured thermal conductivity coefficient (W/(m·K))
- λ_3 : Third measured thermal conductivity coefficient (W/(m·K))



(a) (b)

Fig. 5 (a) Aluminium block and (b) Reference plate

This thermal conductivity coefficient measurement device is capable of making the measurement of thermal conductivity coefficient in two modes, the quick mode and the fine mode. To get better and more exact results, the fine mode was chosen as the measurement method, but the period required for this measurement mode is longer. The measurement of thermal conductivity coefficient on the experiment specimen is shown in Figure 6.

Fig. 6 Thermal conductivity coefficient measurement device

III.RESULTS AND DISCUSSION

Thermal conductivity coefficients of the paper-based specimens manufactured were measured according to the measurement criteria and given in Table 2. For each specimen, at least three measurements were made and their average values were given in the table. The deviation ratio of each value measured was determined to be about 3%. According to the table, thermal conductivity coefficients increase with the amount of cement. In other words, the higher the amount of paper is, the lower the thermal conductivity coefficient is. For an appropriate structure to be constructed, it is necessary that the cement, a bonding agent, should be added at a certain level in the paper mixture prepared. Accordingly, it was understood from the experiments that the amount of cement in the mixture should be at least 10%. In the specimen productions made in the lower levels of the amount of cement, it was observed that the specimen broken. Therefore, specimens were prepared at the cement ratios above 10%. The contribution of the sawdust of pine wood to the mixture of cement and paper was also analysed on specimens 4, 5 and 6. Accordingly, the amount of cement was decreased at a ratio equal to the sawdust of pine wood contribution by leaving the paper paste ratios fixed, so their potential effects on the thermal conductivity coefficient were examined. According to the analyses made, the mixture of 10% cement, 80% paper paste and 10% sawdust of pine wood yielded the best thermal conductivity coefficient.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue V, May 2018- Available at www.ijraset.com

TABLE 2 PROPERTIES OF PAPER-BASED BUILDING SPECIMEN

Specimen	Mixture ratio (%)	λ(W/mK)
Specimen 1	%60 paper paste %40 black cement	0.1979
Specimen 2	%70 paper paste %30 black cement	0.1814
Specimen 3	%80 paper paste %20 black cement	0.1658
Specimen 4	%60 paper paste %10 sawdust of pine wood %30 black cement	0.1894
Specimen 5	%70 paper paste %10 sawdust of pine wood %20 black cement	0.1572
Specimen 6	%80 paper paste %10 sawdust of pine wood %10 black cement	0.1285

The comparison between the thermal conductivity coefficients of the specimens prepared was given in Figure 7. As can be seen in the figure, some specimen types prepared in this study have lower thermal conductivity coefficients than some building materials available in the market.

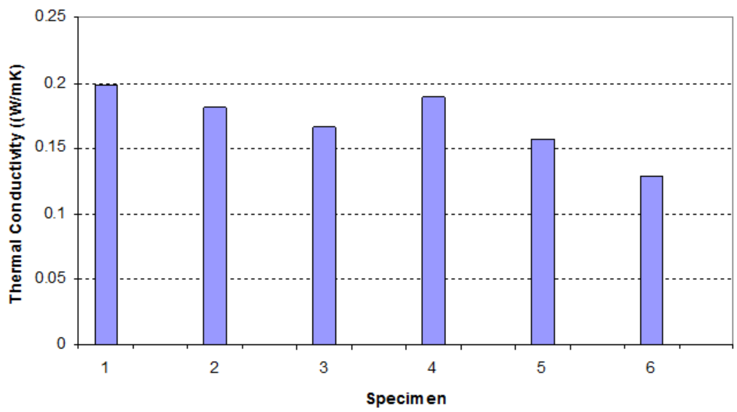


Fig. 7 The comparison of the thermal conductivity coefficients

IV. CONCLUSIONS

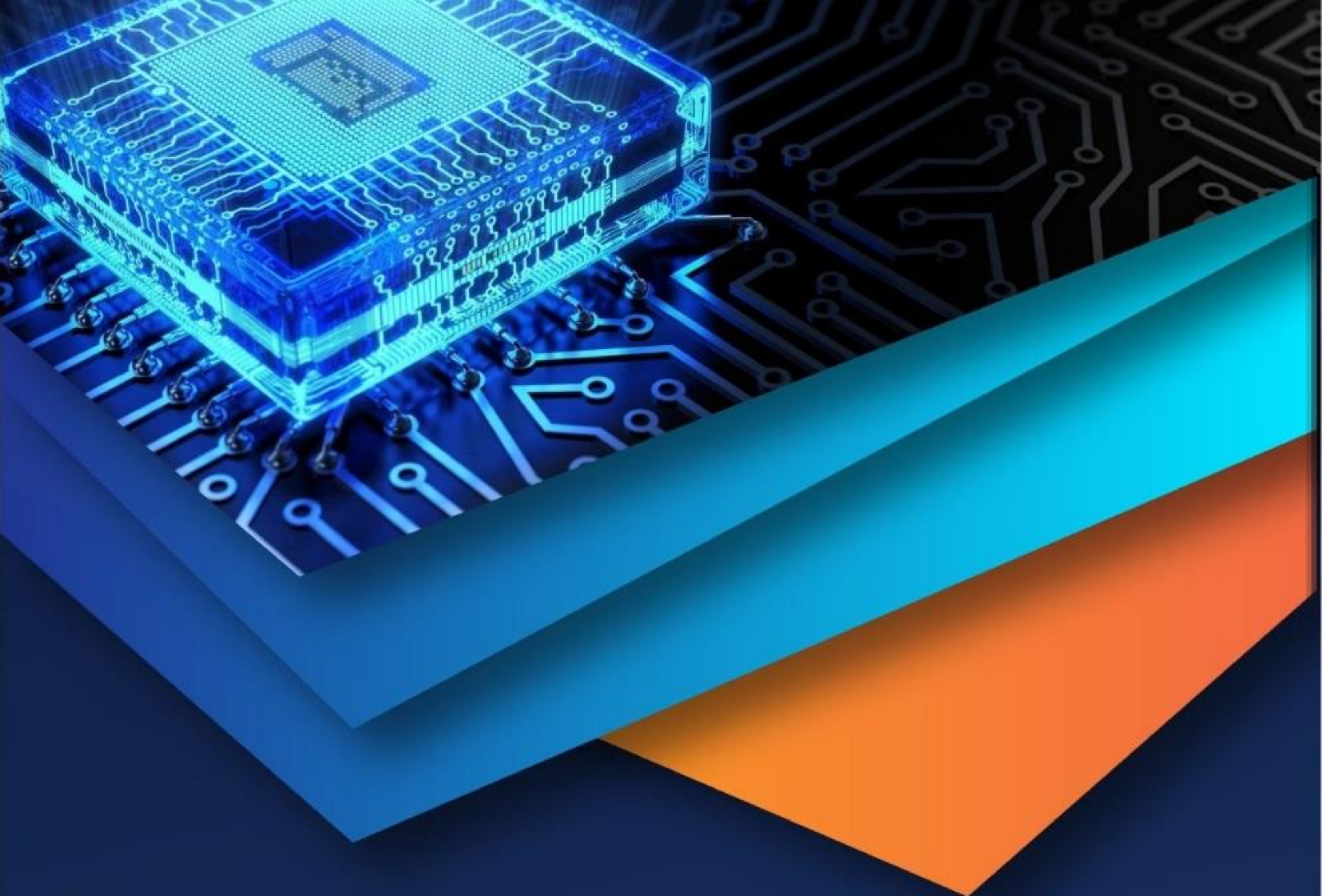
In this study, whether the composite materials made by using waste papers could be used in different sectors was analyzed. In this way, the aim was to make use of the waste papers. According to the results obtained, it was found out that the waste papers could as well be used in the production of building material and in the construction sector in particular. It is quite obvious that the waste papers could be used in a new sector in this way, which could contribute to the increase in the ratio of recycling the waste papers. Thus, among the advantages that could be obtained is that both the nature and forests could be protected; that pollution could be decreased; that raw material inputs would be lowered; and that new sectors would be created for this process.

It was determined that as the ratio of black cement in the building specimen materials increases, thermal conductivity coefficient also increases. The presence of both sawdust of pine wood and lowered ratio of black cement in specimens 4, 5 and 6, thermal conductivity coefficient decreases with the increased ratio of paper paste.

The specimens prepared could be used as plates for heat insulation in the buildings or as paper-based ceramic tiles with a lower thermal conductivity coefficient instead of the ceramic tiles used on the walls. In addition, paper-based building materials with a lower thermal conductivity coefficient could be prepared instead of the plaster or cement panels.

REFERENCES

[1] D. Kumlutaş, İ.H. Tavman, M.T. Çoban, "Thermal conductivity of particle filled polyethylene composite materials", Composite Science and Technology, 63, 113-117, 2003.
[2] M. Sutcu, S. Akkurt, "The use of recycled paper processing residues in making porous brick with reduced thermal conductivity", Ceramics International, 35, 2625-2631, 2009.
[3] M. Dondi, M. Marsigli, B. Fabbri, "Recycling of industrial and urban wastes in brick production", Tile and Brick International, 13 /3, 218-225, 1997.
[4] I. Demir, M.s. Baspınar, M. Orhan, "Utilization of kraft pulp production residues in clay brick production", Building and Enviroment, 40, 1533-1537, 2005.
[5] V. Ducman, T. kopar, "The influence of different waste additions to clayproduct mixtures", Materails and Technology, 4 /6, 289-293, 2007.
[6] P.W. Westerman, J.R. Bicudo," Management considerations for organic waste use in agriculture", Bioresource Technology, 96, 215–221, 2005.
[7] T.H. Yang, C.J. Lin, S.Y. Wang, M.J. Tsai, "Characteristics of particleboard made from recycled wood-waste chips impregnated with phenol formaldehyde resin", Building Environtment, 42/1, 189–195, 2007.
[8] R.R. Almeida, C.H.S.D. Menezzi, D.E. Teixeira, "Utilization of the coconut shell of babacu (Orbignya sp.) to produce cement-bonded particleboard", Bioresource Technoogy, 85, 159–163, 2002.
[9] S.Y. Wang, T.H. Yang, L.T. Lin, C.J. Lin, M.J Tsai, "Properties of low-formaldehyde-emission particleboard made from recycled wood-waste chips sprayed with PMDI/PF resin", Building and Environment, 42, 2472–2479, 2007.
[10] J. Khedari, N. Nankongnab, J. Hirunlabh, S. Taekasap, "New low cost insulation particleboards from mixture of durian peel and coconut coir", Building and Environment, 39, 59-65, 2004.



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY