Journal of Science and Technology
ISSN: 2456-5660 Volume 06, Issue 01, Jan-February 2021

www.jst.org.in *DOI: https://doi.org/10.46243/jst.2021.v6.i1.pp162-166*

Effect of Thickness and Pressing Time on the Properties of Fiber Insulation Boards of Spent Biomass of Lemon Grass

N. Ismita[1], Ritam Basu[2], Prince Raj[3], DikshaBisht[4]
[1]*(Scientist-D, Forest Products Division, Forest Research Institute, Dehradun)*
[2]*(Junior Project Fellow, Forest products Division, Forest Research Institute, Dehradun)*
[3]*(M.Sc. Wood Science and Technology,Forest Research Institute (Deemed to be) University, Dehradun)*
[4]*(Field Assistant, Forest Products Division, Forest Research Institute, Dehradun)*
[2]*Corresponding Author: basu.ritam7@gmail.com*

To Cite this Article
N. Ismita, Ritam Basu , Prince Raj and DikshaBisht, "Effect of Thickness and Pressing Time on the Properties of Fiber Insulation Boards of Spent Biomass of Lemon Grass ", Journal of Science and Technology, Vol. 06, Issue 01, Jan-February 2021, pp162-166.

Article Info
Received: 25-09-2020 Revised: 28-12-2020 Accepted: 05-01-2021 Published: 10-01-2021

Abstract: *Insulation boards of three thicknesses, of dimension 90 x 30 cm were prepared using spent biomass of lemon grass. Boards were given contact pressure under hot press, at 150 -165°C temperatures, for 50-60 minutes. The boards were tested for density, water absorption, transverse strength and sound absorption. Densities of insulation boards of the three thicknesses were not significantly different. Average transverse strength of test samples for the three thicknesses (T_1, T_2, and T_3) ranged from 12.60 kg/cm^2 to 37 kg/cm^2.T_1(21 mm)board had higher strength than T_2 (27 mm) and T_3 (30 mm) boards. The sound absorption increased with increase in thickness of board. The sound absorption coefficient of the boards ranged from 0.67 to 0.84 at 512 Hz and 1024 Hz frequencies. Numerically, the sound absorption value was higher for insulation board of higher thickness.*

Keywords*: Acoustic Boards, Biomass, Lemon grass, Sound absorption, Transverse strength*

I. Introduction

Insulation boards have shown increasing effectiveness for household purposes over the years. Since the dawn of 20th century, more and more buildings have propped up and the cost of production has started going down to ensure higher profits. This called for thinner walls such that the pressure on the supporting structure becomes less. Thinner walls meant that they will not be effectively resilient to sound or heat waves. In simpler terms, the walls are no longer very efficient in storing heat or sound within them. This led to the emergence and growth of insulation boards. Such boards are high in demand for the construction of conference halls, cinema halls and other such places. Insulation boards are also hugely used in the construction business to give homes an insulating layer which in turn helps to make the house warmer faster and longer.

Common materials that are used to construct insulation boards include fiberglass, polystyrene, polyurethane, and so on. However, these materials are synthetically obtained and can create chemical toxicity. These materials are not environmental friendly and that may lead to disastrous situations. Thus there is an acute need for bio-based materials. These materials, having come from an organic source, are not as poisonous or toxic as the synthetically produced substances. The best source of bio-based materials for the construction of composites is agricultural wastes. This waste is generally burned which leads to the production and evolution of large quantities of carbon dioxide, carbon monoxide and other pollutants. The use of agricultural waste for development of bio-composites is also beneficial as an alternative to incinerating the biomass.

Many agro-wastes have shown the potential to develop energy efficient and cost-effective sustainable construction materials along with enhanced thermo-mechanical behavior (Madurwar*et. al*. 2013). Korjenic*et al* (2011) carried out a research to develop a new insulating material from renewable resources such as jute, flax, and hemp with comparable properties required for insulation materials. Rajput *et al* (2011) utilized paper mills waste and cotton waste to manufacture waste-create bricks (WCBs). Bio-based materials are environmentally friendly and hence contribute towards sustainable development.

Lemongrass is a very desirable natural resource that has a huge demand because of its charismatic essence. It is used as the 2nd major spice ingredient in Malyasia preceded by ginger and followed by such spices as musk limes, limes, chili, galangal, turmeric, and nutmeg. The essence in lemongrass oil is caused due to high concentrations of α and β-Citral. Once the oil is extracted the rest of the leaf fibers are thrown away. According to a study conducted by Ang*et al.* (2013) Malyasia alone produced about 7,612 metric tons of lemon grass in 2012. Out of this batch about 5,328 metric tons was discarded as agricultural waste.

Lemongrass is treated as waste material and more often than not incinerated which leads to high amounts of atmospheric pollution. The use of spent lemongrass leaves has not been explored and serves as a lucrative and eco-friendly way to use these leaves. The leaves comprise of holocellulose up to 68.51% followed by α-cellulose and lignin in the range of 35.0 to 44.16% and 17.39 to 27.38% respectively (Kaur and Dutt, 2013). Cellulose has proved to be a very desirable, naturally obtained fiber material that can be put up to all kinds of constructional purposes. It can be used in both supporting and non-supporting structures. The spent lemongrass biomass may not be an adequate material to go for supporting structures, but has the potential of making good quality insulation boards or paper. Other agro-waste materials such as bagasse, rice stalks, cotton stalks, and so on have been extensively studied. The scope of this experiment is to understand the various ways in which spent lemon grass biomass may be put to use.

II. Materials and Methods

2.1 Materials

Distillery waste of lemon grass leaves was used for this experiment. The raw material in dry state was obtained from Quonto Agro World Pvt. Ltd. Dehradun.

2.2 Methods

Spent leaves of lemon grass were chipped to strands of 2-5 cm with the help of a fodder chipping machine. The strands were immersed in water for a period of 24 hours, containing NaOH 2% by dry weight of fibers. The soaked fibers were washed under running water carefully and properly till they showed a neutral pH.After washing, these were passed through a disc refiner to convert them to pulp. The wet pulp was then laid down uniformly within awooden frame of dimension 90 cm x 30 cm. Three boards were prepared out of which T_1 board wascold pressed for two days. $T_2$and T_3boards were cold pressed for one day. During cold pressing process, excess water oozes out of the boards and they retain the rectangular shape of the frame. The cold pressed boards were placed within aluminum cauls. A non-sticky sheet was applied between the board and the caul surface to prevent the sticking of boards to the caul. This arrangement was hot pressed at a temperature maintained between 150 °C and 165 °C for a period of 50 to 60 minutes. The boards were trimmed to a rectangular shape. The boards were then conditioned at room temperature for 48 hours. The required samples were cut out from these boards to conduct tests on physical properties, transverse strength, and sound absorption properties.

2.3 Physical Properties

The physical properties test comprises of water absorptioncapacity and density of the insulation boards prepared from lemon grass distillery waste. These tests were performed in accordance with the standards set in IS: 3348 (1965). The density was calculated using the weights and dimensions of the specimens. Water absorption tests were conducted by immersing the specimens in water such that there is a layer of about 25 mm of water above the specimens. The test samples were kept immersed for a period of 2 hours after which they were withdrawn. Initial and final weights were obtained up to an accuracy of ±0.5 g and the water absorption calculated in percentage.

2.4 Transverse Strength

The specimens used to measure the transverse strength of the boards featured a dimension of 20 cm x 10 cm. The procedure followed during the test was as per the guidelines set down in IS:3348 (1965). The following formula was used to find the Modulus of Rupture (MOR) values for each of the test specimens.

$$\mathbf{MOR\ (kg/cm^2) = (3F_{max}l)/(2bd^2)}$$

Where, l = length of the specimen; b= breadth of the specimen; d= thickness of the specimen; E_{max}= maximum load on board

2.5 Acoustic Properties

30 cm x 30 cm sized test specimens were used to calculate the sound absorption coefficient of the samples prepared from the insulation boards using the standing wave method. The tests were conducted in accordance with the standards set in IS 3308 which lists the specifications for wood wool building slabs.

III. Results and Discussion

3.1 Physical Properties

The density of all the boards prepared in this experiment lied in the optimum range as set by the specifications in IS:3348(1965). This standard specifies that insulation board should not have density exceeding 0.4 g/cm^3. The three boards having thicknesses 21 mm (T_1), 27 mm (T_2), and 30 mm (T_3) had densities ranging from 0.38g/cm^3 to 0.40 g/cm^3(table 1). The appreciable density indicated that there was good contact among consecutive particles. Statistical analysis revealed that ($p=0.23$) there was no significant impact on the density of the insulation boardswith change in their thicknesses.

The water absorption tendency of the samples was observed by immersing them in water for a period of two hours. The samples were weighed again after two hours. The thickness swelling of all the three boards was more than 50% of original dry weight that exceeded the specification limit set down in IS:3348(1965). However, the distortion of structure of these samples was almost negligible. T_1 (21 mm) samples showed significantly less water absorption over the other two thicknesses. Statistical analysis revealed $p=0.00$. The water absorbed by test samples with T1 thickness was much less than that absorbed by T_2 and T_3 thickness board samples. Jain and Mehra in 1974 evaluated the suitability of spent rosha grass for making hard boards. There observation led to the understanding that water absorption was greater by about a factor of 50% if the boards are not oil or heat tempered. Similar results for water absorption were also recorded by George and Joshi (1960) when they tried to construct hardboards using unretted coconut husks and coir waste.

3.2 Transverse Strength

For the transverse strength test, 12 to 15 rectangular test pieces of size 20 cmX 10 cm were cut from each board with ~~all~~square edges. The MOR of the boards with thicknesses T_1, T_2, T_3 ranged from 12.60 kg/cm^2 to 37.6kg/cm^2 (table 1).It was observed in a study conducted by Luamkanchanaphan*et al.* (2012) that the MOR values of insulation boards made from narrow leaved cattails increased with an increase in the density of the boards. The highest average transverse strength of 36.8 kg/cm^{2}was recorded for a board with density 400 kg/m^3.

The average MOR of test samples for board with thickness 21 mm (T_1) was 37.56 kg/cm^2 (table 1) which is at par with the MOR of narrow leaved cattail boards mentioned above. The average MOR values for boards with thicknesses(T_1) 27 mm and (T_2) 30 mm were 12.60 kg/cm^2 and 15.75 kg/cm^{2}respectively. The effects of thickness and cold pressing time on strength properties of the boards were evaluated using ANOVA. It was seen that there was significant effect of board thickness on transverse strength ($p<0.01$). Duncan's test gave three subsets for MOR values of three boards. It was observed that board with 21 mm thickness (T_1) and cold pressed for two days gave highest average value for transverse strength property. Other two thickness boards could not even attain permissible limits as per IS: 3348 (1965) required for transverse strength of boards. Panyakaew and Fotis (2011) reported that MOR values increase with increasing pressing time and temperature for thermal insulation boards from coconut husk and bagasse.Doost-hoseini*et al.* (2014) have claimed that the MOR of insulation boards hugely depended on the density of boards. They were successful in creating insulation boards that had an MOR of about 120 kg/cm^2. Philippe Evon*et al.* (2015) had concluded that the effect of binders on insulation boards was paramount and the right choice of resin led to boards having MOR of as much as 350 kg/cm^2. These boards were crafted to introduce a factor of strength along with impressive insulation properties.

In a study carried by Zuraider*et al.* (2017) it was observed that the fiber material also determines the MOR of prepared boards. They used kenaf, rattan, sugarcane bagasse and coconut husk to prepare binderless insulation boards. The highest MOR values was observed for Kenaf at 538.4 kg/cm^2 while the lowest values were obtained for coconut husk at only 97.1 kg/cm^2. This observation was in accordance with the conclusion by Panyakaew and Fortis (2011) that the MOR depends on the strength and geometry of each fiber as much as it depended on the bending strength among the fibers. Zhang *et al*. (2017) and Ferrandez-Garcia *et al*. (2017) separately concluded that the MOR varied greatly with change in particle size. A smaller particle size enhanced contact surface between fibers and hence the MOR. Incidentally a smaller particle also ensures a higher density of fiberboards.Yang *et al*(2002)in a study found out that the density of boards also played a key role in determining the MOR. They crafted boards with different densities and observed that the boards with higher density had a higher MOR. Instead, the present study suggests that at optimum densities, it is the pressing time that influences the MOR. The strength of the base raw material that contributed the fibers also must be playing a role in the strength.

3.3 Acoustic Properties

The boards developed from lemon grass distillery waste were quite potent in terms of sound absorption coefficient (α). The value of α was calculated using the transmission loss test at 512 Hz and 1024 Hz frequencies. The average sound absorption coefficient of the lemon grass boards of all the three thicknesses was evaluated. The effect of thickness in the value of α was easily noticeable. The results revealed that at higher thickness values of the prepared boards, the sound absorption coefficient was also improved. The average sound absorption coefficient of the boards prepared from distillery waste of lemon grass lies in the range of 0.78 to 0.81 which falls within the permissible limits as set by the BIS standards.A study conducted by Binici*et al.* (2016) revealed that the sound absorption coefficient of bio-composite boards depended upon the compaction of fibers. If voids are left in the fiber structure, then it led to lower sound absorption capabilities. The experiment revealed better sound absorption qualities at higher loadings of epoxy and gypsum with corn stalks because it led to better compaction of fibers. In the present experiment, the lowest sound absorption coefficient shown by the most pressed samples is rather intriguing.

Narime*et al.* (2016) tried to craft boards from sunflower stalk particles and chitosan. Compared to boards made from sugarcane waste materials by Putra *et al.* (2013) which showed a sound absorption coefficient (α) at greater than 0.5, these boards had nearly no dampening effect at all (α = 0.2). Saadatnia*et al.* (2008) revealed that the higher frequency sound waves corresponded to higher values for α. They conducted the experiment using wheat and barley fibers and they also revealed that the change in fibers did not affect the value of α significantly.

Table 1: -Mean values of physical and mechanical properties of Insulation boards

Boards Thickness	**Density (g/cm^3)**	**Water absorption %**	**Transverse strength (MOR) kg/cm^2**	**Minimum breaking load (Kg)**	**Range of Sound absorption Co-efficient**
T_1 (21mm)	0.39^a	162^a	37.56^c	59.70	0.67-0.72
T2 (27mm)	0.38^a	200^c	12.60^a	37.30	0.78-0.81
T3 (30 mm)	0.40^a	185^b	15.70^b	43.60	0.83-0.85

*alphabets represent significant differences obtained through Duncan's subsets

IV. Conclusion

Three insulation boards were made with thickness of 21mm (T_1), 27 mm (T_2) and 30 mm (T_3). The study revealed that the binder-less samples from boards prepared from distillery waste of lemon grass having thickness 21 mm and density 0.39 g/cm^3falls within permissible limits of the standard IS:3348 (1965). This board was cold pressed for 2 days unlike the other two boards with thickness 27 mm and 30 mm which were cold press for just one day. T_2 and T_3 boards failed to meet the standard set for transverse strength. The water absorption was found to be more than 50% for all three thicknesses of boards. It was, however, observed that the absorption of water was lowest for 21 mm board (T1). Water absorption also didn't lead to distortion of the surface of these boards.We can also conclude that the density of boards had no role to play in determining their MOR. The acoustic properties for all three thickness boards met the standard IS:3348 (1965). Spent biomass of Lemon grass could be utilized as a useful material to construct insulation boards. Sound absorption co-efficient increased with increase in the thickness of the boards. More pertinently, this studydemonstrates that good acoustic boards can be developed from lemon grass biomass. With a few additions such as oil or heat treated fibers, the other properties of lemon grass distillery waste boards such as water absorption may also improve.

References

[1] Ang SK, Yahya A, Abd-Aziz S and Salleh MM. (2013). Isolation, Screening, and Identification of Potential Cellulolytic and Xylanolytic Producers for Biodegradation of Untreated Oil Palm Trunk and its Application in Saccharification of Lemongrass Leaves. Journal of Preparative Biochemistry and Biotechnology, 45: 279-305.

[2] Binici H, Aksogan O and Demirhan C. (2016). Mechanical, thermal and acoustical characterizations of an insulation composite made of bio-based materials. Sustainable Cities and Society, 20, 17-26. DOI:http://dx.doi.org/10.1016/j.scs.2015.09.004 2210-6707

[3] Doost-hoseini K, Taghiyari HR, and Elyasi A. (2014). Correlation Between Sound Absorption Coefficient with Physical and Mechanical Properties of Insulation Boards Made from Sugar Cane Bagasse. Composites: Part B 58, 10-15. DOI: http://dx.doi.org/10.1016/j.compositesb.2013.10.011

[4] Ferrández-García CC, Ferrández-García E, Ferrández-Villena M, Ferrández-García M and García-Ortuno T. (2017). Acoustic and Thermal Evaluation of Palm Panels as Building Material. BioResources, 12(4), 8047-8057.

[5] George J and Joshi HC. (1960). Hardboards from Coconut Fibers. Research and Industry, 5(3), 66-68.

[6] Hussin H, Salleh MM, Siong CC, Naser MA, Abd-Aziz S and Al-Junid AFM. (2015) Optimization of Biovanillin Production of Lemongrass Leaves Hydrosylates Through *Phanerochaetechrysosporium*. JurnalTeknologi, 77:31, 55-61.

[7] IS 3308 (1981) Specification for Wood Wool Building Slabs. 11p

[8] IS 3348 (1965) Specification for Fiber Insulation Boards, New Delhi. 18p

[9] Jain NC and Mehra ML. (1974). Hardboards from Spent Rosha Grass *Cymbopagan martini*. VarMotiaIPIRIJournal,4(2):78-80.

[10] Kang W, Oh SW, Lee TB, Kang W and Matsumura J. (2012). Sound Absorption Capability and Mechanical Properties of a Composite Rice Hull and Sawdust Board. Journal of Wood Science, 58, 273-278. DOI: 10.1007/s10086-011-1234-5

[11] Kaur H and Dutt D. (2013). Anatomical, Morphological and Chemical Characterization of Lignocellulosic By-Products of Lemon and Sofia Grasses Obtained After Recuperation of Essential Oils by Seam Distillation. Cellulose Chem. Technol., 47 (1-2), 83-94. DOI:

[12] Luamkanchanaphan T, Chotikaprakhan S and Jarusombati S. (2012). A Study of Physical, Mechanical and Thermal Properties for Thermal Insulation from Narrow-leaved Cattail Fibers. APBEE Procedia 1, 46-52. DOI: 10.1016/j.apcbee.2012.03.009

[13] Madurwar VM, Ralegaonkar VR andMandavgane AS. (2013). Application of agro-waste for sustainable construction materials: A review. Construction and Building Materials, 38, 872–878.

[14] Mati-Baouche N, Baynast H, Lebert A, Sun 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, Elsevier. DOI: 10.1016/j.indcrop.2014.04.022.hal-01323684

[15] Omar L, Kamoga M, Kirabira JB and Byaruhanga, JK. (2015). The potential of *Cymbopogonnardus in* the production of pulp for paper industry. *International Conference on Computing, Mechanical and Electronics Engineering*, Singapore, pp. 21-28. DOI: 10.15242/IIE.E0715025.

[16] Panyakaew S and Fotios S. (2011).New Thermal Insulation Boards Made from Coconut Husk and Bagasse. Energy and Buildings, 43 (7), 1732-1739 DOI: http://dx.doi.org/10.1016/j.enbuild.2011.03.015

[17] Park HJ, Oh SW and Wen MY. (2012). Manufacture and Properties of Miscanthus-Wood Particle Composite Boards. Journal of Wood Science, 58, 459-464. DOI: 10.1007/s10086-012-1262-x

[18] Philippe E, Justine V, Matthieu R, Laurent L, Virgini V, *et al*. (2015). New Insulation Fiberboards from Sunflower Cake with Improved Thermal and Mechanical Properties. Journal of Agricultural Studies, vol. 3 (n° 2), 194-211. DOI: 10.5296/jas.v3i2.7738 . hal-01170688

[19] Raput D, Bhagade SS, Raut SP, Ralegonkar RV and Mandavgane SA. (2011). Reuse of Cotton and Recycle Paper Mill Waste as Building Material. Construction and Building Materials, Volume 34, 470-475. DOI: https://doi.org/10.1016/j.conbuildmat.2012.02.035

[20] Reixach R, Rey Tormos RMD, Alba Fernández J, Arbat G, Espinach FX and Mutjé P.(2015). Acoustic Properties of Agroforestry Waste Orange Pruning Fibers Reinforced

[21] Polypropylene Composites as an Alternative to Laminated Gypsum Boards. Construction and Building Materials, 77, 124-129. DOI:10.1016/j.conbuildmat.2014.12.041.

[22] Saadatnia M, Ebrahimi G and Tajvidi M. (2008). Comparing sound absorption characteristic of acoustic boards made ofAspen particles and different percentage of Wheat and Barely straws.*17th World Conference on Nondestructive Testing, China*.

[23] Samuel and Ariadurai. (2013). Bio-Composites: Current Status and Future Trends. 5th International Technical Textiles Conference – November 2012

[24] Vidil L, Fiorelli J, Bilba K, OnésippeC, ArsèneMA and Salvastano Junior H. (2016). Thermal Insulating Particle Boards Reinforced with Coconut Leaf Sheaths. Green Materials. DOI: 10.1680/jgrma.15.00029

[25] Xu J, Sugawara R, Widyorini R, Han G and Kawal S. (2004). Manufacture and Properties of Low-Density Binderless Particleboard from Kenaf Core. Journal of Wood Science, 50, 62-67. DOI: 10.1007/s10086-003-0522-1

[26] Xu J, Wydyorini R, Yamauchi H and Kawal S. (2006). Development of Binderless Fiberboard from Kenaf Core. Journal of Wood Science. DOI: 10.1007/s10086-005-0770-3.

[27] Yang HS, Kim DJ and Kim HJ. (2002). Combustion and Mechanical Properties of Fire Retardant Treated Waste Paper Board for Interior Finishing Material. Journal of Fire Sciences, Vol 20, 505-517. DOI: 10.1106/073490402031471

[28] Yıldızhan Ş, Çalık A, Özcanlı M andSerinH. (2018). Bio-composite materials: A Short Review of Recent Trends, Mechanical and Chemical Properties, and Applications. European Mechanical Science, 2(3), 83-91.DOI: https://doi.org/10.26701/ems.369005

[29] Zhang S, Li YY, Wang G and Wang X. (2017). Thermal Insulation Boards from Bamboo Paper Sludge. BioResources, 12(1), 55-67.
Zuraida A, Maisarah T and Wan-Shazlin-Maisarah WMY. (2017). Mechanical, Physical and Thermal Properties of Rattan Fibre-Based Binderless Boards. Journal of Tropical Forest Science 29 (4), 485-492. DOI: https://doi.org/10.26525/jtfs2017.29.4.485492