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**ECONOMIC ASSESSMENT OF INSULATION PANELS MADE WITH PLATES
OF AGROINDUSTRIAL WASTE PARTICLES FOR SOCIALLY-ORIENTED
HOMES.**

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Abstract

The considerable housing shortage in Brazil is due to several factors, due to the lack of incentives for socially-oriented homes. This factor together with the continuous increase in urban populations demand an urgent quest for new solutions for this issue, including research with new and less expensive materials. Thus, the economic factor is one of the most important characteristics in the analysis of an innovative material. Therefore, the objective of this study was to produce plates made from discarded agroindustrial waste (paper, Tetra Pak and *Dendrocalamus giganteus* bamboo bark) to be applied in insulation panels (ceilings and walls) in buildings, and analyze their economic viability. Two different methodologies have been applied. The plates made out of Tetra leftovers were economically assessed with an approximation process that used the indications (expenses) presented by Mendes & Albuquerque (2001). To calculate the cost of the bamboo plates we

used a more solid theory – Life Cycle Assessment. The amount resulting from the first method was R\$ 21.32 (U\$ 10.70) for a 2.42 m² plate, while LCA resulted in R\$ 33.20 (U\$16.60). To conclude this analysis, we proposed some changes in the particleboard laboratory production process, through which we were able to decrease the final cost of the plates by about 52%.

Key-words: particleboards, solid residue, carton packing, housing deficit.

1. Introduction

Concern for the environment arose in Europe right after World War II with the return of industrialization. Ecological accidents began to get headlines and to contribute towards changes in policy, legislation and management concepts. Society was increasingly giving more importance to environmental issues. This created the need to develop management approaches and tools that would allow companies (and in a more general sense, the diverse interested parties in society, such as the government, research institutes and others) to assess the environmental consequences of decisions they were taking in relation to their processes or products (ACV, 2006).

This scenario suggests the channeling of plans and actions geared towards conservation, cooperation and partnerships in the search for reusing waste and optimizing raw materials in the production of different materials. Thus, reevaluation in the already implemented technological process seeks harmony with the new attitude for the third millennium: reduce aggression to the environment. This new attitude is called *Sustainable Development*, characterized as the search for meeting the needs of the current generation without compromising the rights of future generations (FERREIRA, 2004).

Environmental concern affects every human activity Governments are adopting more rigorous environmental legislation. On the other hand, citizens are demanding products and processes with less impact on the environment. These new attitudes comprise a series of pressures that have led companies to environmentally improve their processes and products, introducing the environment differential as another element for competitiveness (BITENCOURT *et al.*, 2001).

In order to reduce environmental impacts, and also improve production, Environmental Management is becoming one of the most important activities related to any venture, especially industrial. Industrial environmental management demands the integration of organizational systems and programs that can control and reduce the generation of industrial waste, comply with environmental laws, develop alternative technologies that are appropriate to minimize or eliminate environmental risks and reduce costs, monitor and assess current environmental processes, anticipate related problems that may lead to fines and jeopardize the company's image (DIAMANTINO & OTTOBONI, 2004).

The environmental issue is incorporated into the company as an important variable for decision making and with significance to the business. The environmental aspects are thus included in the company's strategic plan like economic and market factors. Environmental Management also permits the company to have rigid control of the process with regard to production, disposal, treatment and even revenues that may be derived from the waste.

According to Environmental Management System guidelines (ALMEIDA, 1998), in a way, environmental degradation is waste and an indication of an inefficient production process. In most cases, industrial waste represents losses in raw materials and inputs. As

companies develop new technologies and new environmental quality concepts, production ends up becoming more efficient. The wastes and pollutants released by the company diminish or disappear, which is evidence of a relative optimization of the production process.

Industries are thus seeking to implement environmental guidelines for their products, modifying aspects for their production processes in order to adjust to new demands.

2. Development

The continuous growth of the paper and cellulose industrial sector has caught the attention of researchers due to the huge quantities of residue produced during processing, and the potential it presents for civil construction, reusing these fibers in new materials.

Along these lines, this paper focuses on reusing waste in a new construction material through the production of plates for insulation panels in buildings. The plates are made of cellulose residue from VCP - Votorantin Celulose e Papel – Jacareí Unit, and reinforced with two different composites: fibers from *Dendrocalamus giganteus* bamboo bark and fibers from Tetra Pak packing.

For material characterization, panels were produced with different proportions of cellulose residue, 100%, 70%, 60%, 50%, 40% and 0% in relation to the composite's total mass, and they were analyzed in standardized tests: specific mass, moisture content, water absorption, swelling, resistance to parallel traction, perpendicular traction, static flexion and the material's thermal conductivity. All tests were carried out according to the American ASTM D-1435 (1994) norm recommendations for particle board panels, with financial aid from FAPESP (State of São Paulo Research Foundation).

The produced panels demonstrated satisfactory results in all tests carried out as well as good cohesion, good superficial quality and excellent esthetics. The results obtained through testing point to the technical feasibility of cellulose residue in insulation plates made of bamboo fiber as well as Tetra Pak packing. It was thus decided to check the material's economic feasibility, where in a capitalist society, the "price" is the most important factor in product choice.

The economic issue is one of the most important characteristics when analyzing feasibility in using residue in a new material. A series of factors are determined as a result, such as, if the companies will truly have an interest in investing in this new material.

Two different methodologies were employed to carry out this study: the first uses the "expense" indicator, presented in the study by MENDES & ALBURQUERQUE (2001) for cellulose and Tetra Pak packing plates; and the second uses Cost Accounting in cellulose and bamboo fiber plates.

2.1 Costing for cellulose and Tetra Pak composite plates

In order to obtain an approximate cost for particleboard made of cellulose residue and carton packing waste, the following items used in MENDES & ALBUQUERQUE (2001) are applied:

- Energy cost is around 18%;
- Labor cost is 12%;
- Input cost equals 6%.

In the case of this study, the input cost encompasses the following: residue cost; urea cost; aluminum foil cost; ammonia sulfate cost; paraffin cost; cost for a pair of thermal gloves and safety glasses.

The particleboard made in this study measures approximately 0.16 m². Establishing a parallel between industrial and laboratory production, the following costs for plate manufacturing at a laboratory scale were obtained:

- Energy cost = R\$ 0.28
- Labor cost = R\$0.18
- Input cost = R\$ 0.95

For a plate measuring 0.4 x 0.4 cm (on a laboratory scale) total cost will be R\$ 1.41 reais. Thus, calculating the plate after changing the dimensions from 0.16 m² to 5.08 m² (example of a commercial plate), we obtain an approximate cost of R\$ 46.00 for plates made of cellulose residue and Tetra Pak packing fiber.

For comparison purposes, the values for insulation plates made of carton packing industrial residue (Table 01) are shown below.

Table 01 – Price Estimate for Particleboards.

Description (10mm thickness)	Area - m ²	Cost - R\$
Market particleboard (general)	5.08 m ²	R\$ 50.00
Particleboard developed in this study	5.08 m ²	R\$ 44.76
Particleboard from IBAPLAC – Ibaté/ SP	2.42 m ²	R\$ 32.00
Particleboard from Regiplac – Piracicaba/ SP	2.42 m ²	R\$ 27.00
Particleboard developed in this study	2.42 m ²	R\$ 21.32

2.2 Costing for cellulose and bamboo fiber composite plates

In order to calculate the average cost for producing particleboard from bamboo fiber, the parameters established by MENDES & ALBUQUERQUE (2001) were used once again (energy cost; input cost and labor cost); however, this time associated with Cost Accounting in order to obtain a truer value.

These expenses were quantified for the production of 1 m² of RCB (cellulose residue with ground bamboo bark) board, proportion 05, with 40% cellulose residue and 60% bamboo fiber. The choice of this proportion for measuring expenses (energy, labor and inputs) is linked to other physical and mechanical tests not shown in this study. These values were derived from LCA (Life Cycle Analysis) for the entire manufacturing process of a plate cited in the study by SANTOS *et al.* (2007). Only the quantified numbers at the end of the process were used here.

Thus, Tables 2, 3 and 4 show a summary of this quantification, presenting the expenses on electric energy, inputs and labor, respectively, for producing plates.

Table 2 – Electric energy expenses.

Electric Energy		
Process	Quantity (KW/h)	Cost - R\$
Bamboo - chopper	2.400	0.4320
Cellulose - kiln	6.500	1.1700
Scale	0.001	0.0002
Gluer	1.850	0.3330
Hydraulic press	5.035	0.9063
Exhaust	1.135	0.2043
Warper	0.073	0.0131
Circular saw	1.275	0.2295
Total		R\$ 3.28

Table 3 – Input expenses.

Inputs		
Process	Quantity (kg)	Cost - R\$
Cellulose residue	6.40	14.278
Bamboo	9.60	0.004
Resin	2.40	7.200
Paraffin	0.24	0.240
Total		R\$ 21.72

Table 4 – Labor expenses.

Labor		
Process	Quantity (min)	Cost R\$
Residue drying	11	0.95
Bamboo grinding	60	5.00
Material weighing	03	0.25
Material mixing	15	1.25
Pressing	07	0.60
Panel cutting	02	0.15
Total		R\$ 8.20

3. Conclusions

Table 1 shows that the approximate value for the panel developed in this study is R\$ 21.32 (2.42 m²), less than the other quoted data. It is worth noting that the indicators used to get to these values were based on the study by MENDES & ALBUQUERQUE (2001). Since the estimate was made in relation to a laboratory produced panel, this value is expected to fall when manufactured in an industry.

It is thus possible to conclude that the average cost to produce an RCB board, proportion 5B, is about R\$ 33.20 (Tables 2, 3, 4). This cost is completely inappropriate since none of the boards currently found on the market have a similar commercialization

value (in relation to 2.42 m²). According to Table 1, the closest value is for the panel made by IBAPLAC, R\$ 32.00 reais. From this analysis, some modifications in the panel production process could be made to make it more feasible:

a) With regard to energy costs: begin to dry the cellulose residue in the open air, without using the kiln, thus reducing energy costs by 35%, from R\$ 3.28 to R\$ 2.11.

b) With regard to input costs: look for cellulose residue at an industry closer to the production unit, thus reducing fuel consumption to obtain raw materials. We suggest getting the residue from LWARCEL, a LWART group company, located in Lençóis Paulista, just 44 km from Bauru, where the panels were produced. This change would reduce the cost for obtaining raw materials from R\$ 21.72 to R\$ 7.60; a 35% reduction in expenses on this item.

c) With regard to labor cost: mechanize the entire bamboo grinding process since nearly half of the procedure is manual, which causes great losses in time and excessive labor expenses. If the machine used to grind the bamboo is responsible for the entire process, there would be a 40% reduction in time spent on this phase, leading to a 24% reduction in expenses, from R\$ 8.20 to R\$ 6.20.

When these aspects of the production process are modified, the m² of panels goes from R\$ 33.20 to R\$ 15.91. This is a reduction of about 52% in the final cost of the board. This value can be considered appropriate since, according to data supplied by manufacturers, a composite residue board costs about R\$ 15.00 per m², as per data from Ibaplac/S.A., in Ibaté, São Paulo.

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