

Plybamboo wallpanels for housing

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1. INTRODUCTION

The first part of this paper will highlight the research on plybamboo wallpanels for housing which has been carried out by Dr. Guillermo Gonzalez from Costa Rica for his PhD at Eindhoven university in 1999-2003. He started his study with housing design method and bamboo boards in general, and next turned his interest to wall-panel connections. These are the key problem in wallpanel housing. After testing series of corner and T-connections, he built a full scale house which was loaded horizontally with airbags to simulate a hurricane. The test was ended at a simulated continuous wind velocity of 200 km/h; the house showed no defect at all.

The second part will give some information on the opportunity to enter the European market with bamboo based panels and boards. The paper will give some data on the use of wood based panels in housing in Europe, mainly on requirements given by the Eurocode (European building regulations) and some data on prices and quantities used in building.

2. RESEARCH ON PLYBAMBOO PANELS FOR HOUSING

Housing design method.

Gonzalez started his study (Gonzalez 2003) with a theoretical framework concerning housing design, in which the following factors have been taken into account.

1. Hurricanes.
2. Earthquakes.
3. Impact forces, mainly burglary.
4. Sunlight or artificial light.
5. Regular air flow passing through house openings.
6. Transfer of heat from outside to inside.
7. Water, rain and moisture.
8. Transmission of sound .
9. Fire.
10. Termites, insects, vermin, fungus, dust, and more.
11. Durability.
12. Execution.
13. Maintenance.

14. Adaptability.

This wide approach is in line with the policy of our faculty: each research should be embedded in a full background. This means also this research presents a full design methodology for bamboo. Hurricanes and earthquakes would play a major role in Latin America; in Europe however these factors are irrelevant, but insulation against the climate is a must. All such factors are being taken into account and each is given its proper weight. This is a design tool for bamboo housing in Europe.

Selection of joints.

Next he studied how to join flat sheets or boards in corner, T- or parallel connections, see Fig. 1.

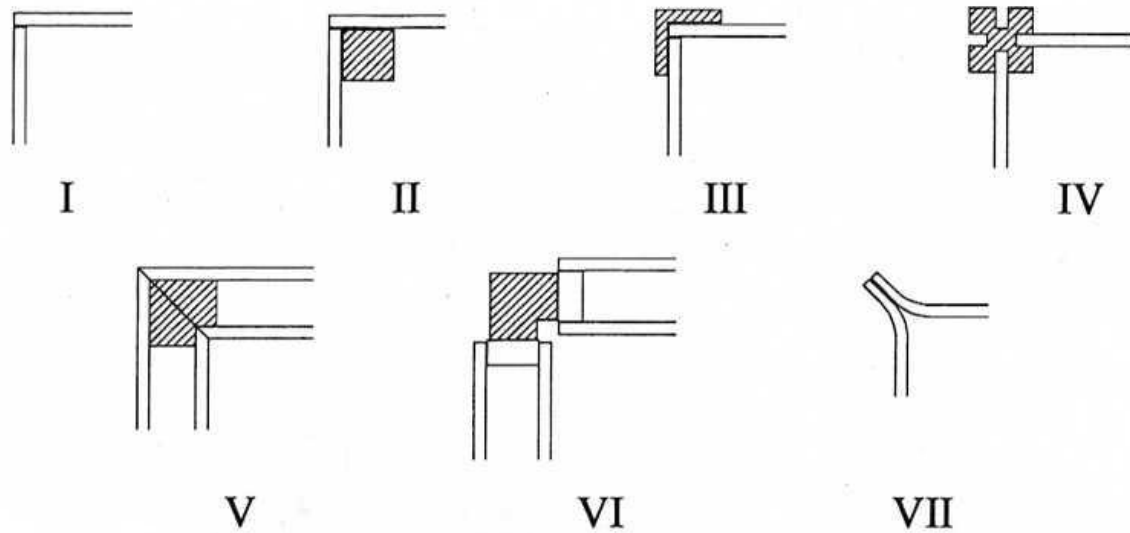


Figure 1, Principles for corner joints with flat sheets or boards.

Using the 13 factors given ahead, and adding a weight for each factor, three joints have been selected, of which one finally became the first, see Fig. 2.

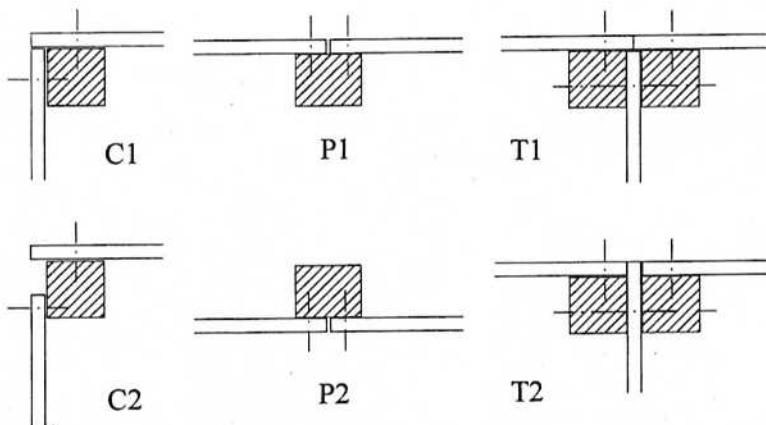


Figure 2. The selected design for corner joint.

Materials.

For the panels bamboo mat board (BMB) and bamboo strip board (BSB) has been studied with a literature review and own research, to determine the properties: modulus of elasticity in compression (in its own plane) and bending, and mainly the embedding strength (nail holding capacity).

Wall-panel connections.

The next step was building full scale connections of panels: a corner connection (Fig. 3) and a T-connection (Fig.4), and to test these on strength and deformation.

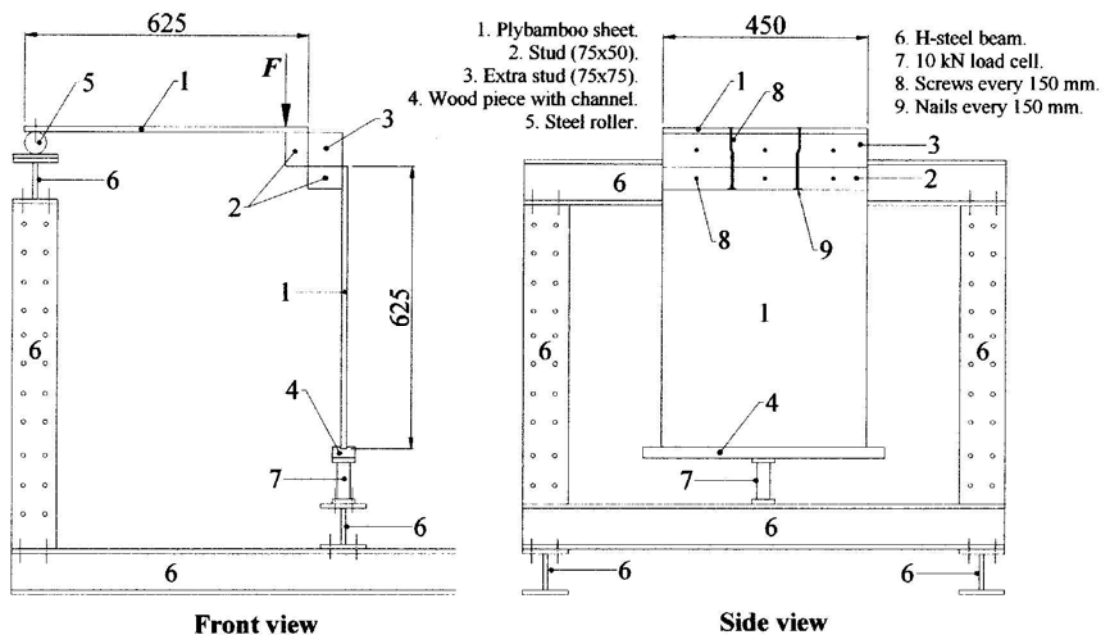
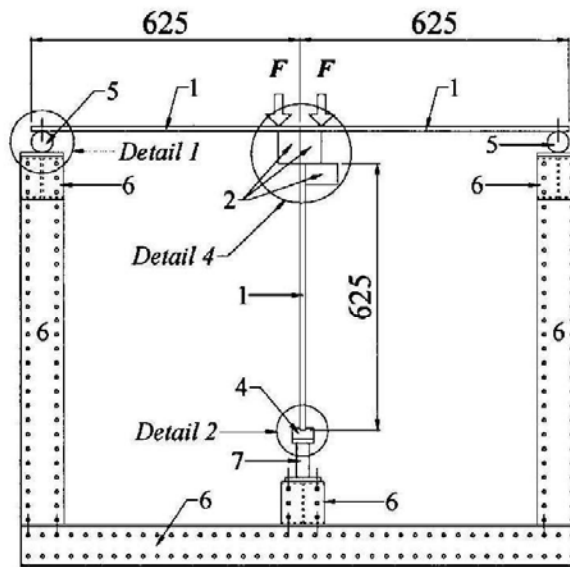


Figure 3, test set-up of a corner connection.



1. Plybamboo sheet.
 2. Stud (75×50 mm).
 4. Wood piece.
 5. Steel roller.
 6. HE 300.
 7. Load cell (10 kN).
 8. Screws (5×50 mm), spaced at 150 mm on center.
 9. Nails (4×90 mm), spaced at 150 mm on center.
 12. Loading steel plate.
 13. Steel tube, 5 mm thickness, 50 mm external diameter.
- Detail 1, 2 and side view, see Figure 5-1.

(a) Front view

Figure 4, test set-up of a T-connection.

Wall-panel structural properties.

The wall-panels are about 2.40 wide and high, and they have been tested on a horizontal force (like if they act as shear wall in case of a hurricane or earthquake), on out-of-plane bending (like if they are loaded by wind perpendicular to their plane), and on axial compression (like if they carry a heavy roof or a storey) (Fig. 5).

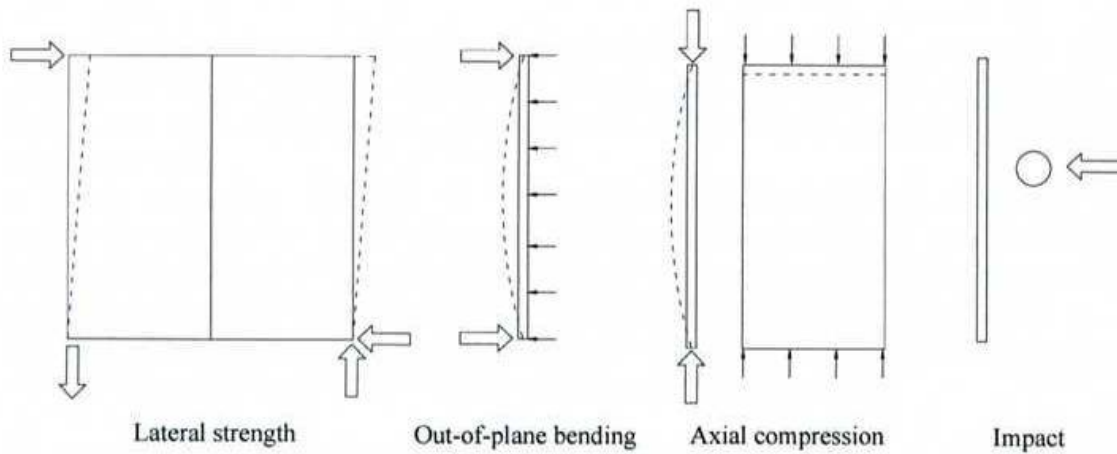


Figure 5. Load cases of wall panels.

Lateral strength

Walls play a major role in the resistance of any house in an earthquake or hurricane prone area. For this reason the panels have been tested on a horizontal force in their own plane, see Fig. 6.

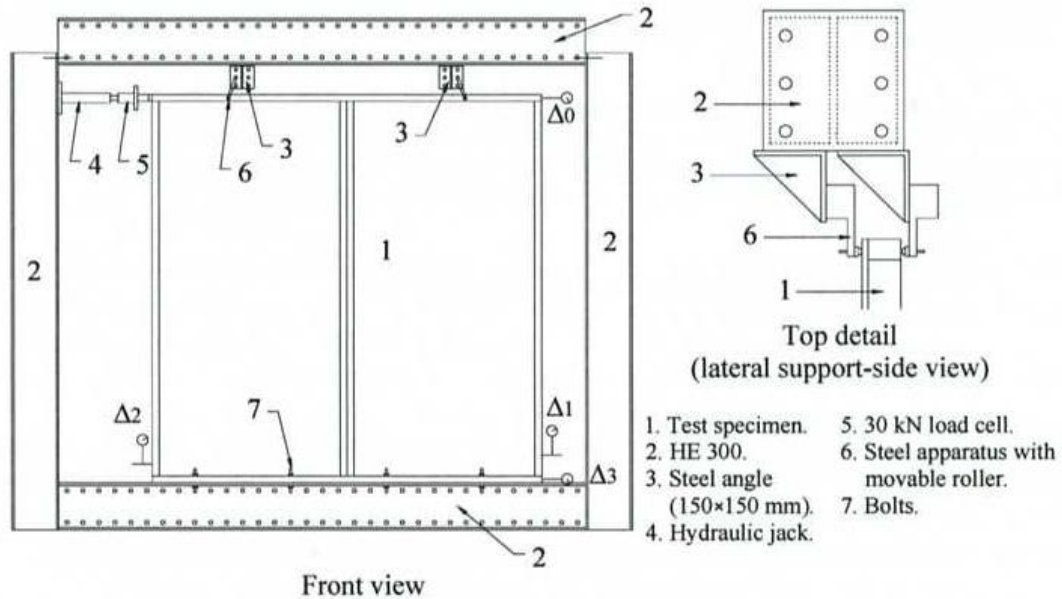
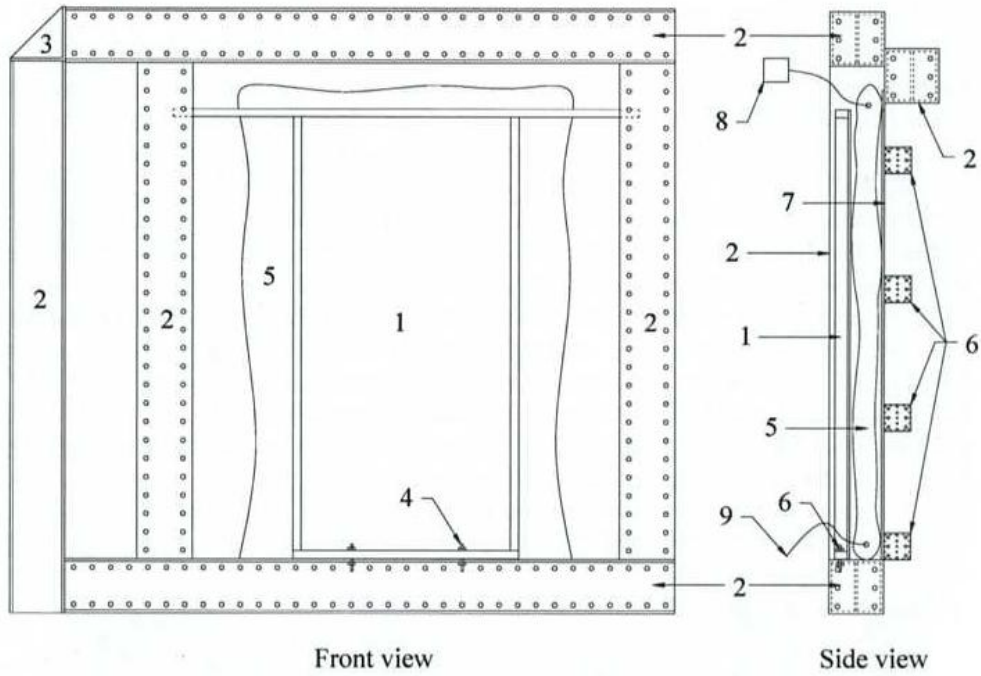


Figure 6. Test set-up on lateral strength

Wind load on a wallpanel.

This type of loading happens during a hurricane with the direction of the wind perpendicular on the outer wall of the house. Tests have been carried out with airbags, see Figure 7.



- | | | |
|---------------------------|-------------------------|-----------------------------------|
| 1. Test specimen. | 4. Bolts. | 7. Plybamboo sheet (12 mm thick). |
| 2. HE 300. | 5. Air bag (2800×1800). | 8. Pressure transducer. |
| 3. Steel angle (300×300). | 6. HE 160. | 9. Air input. |

Figure 7. Test on out-of-plane bending (windload)

Vertical load.

This occurs when the wallpanel has to carry a heavy roof or a storey. The test set-up was like in figure 8.

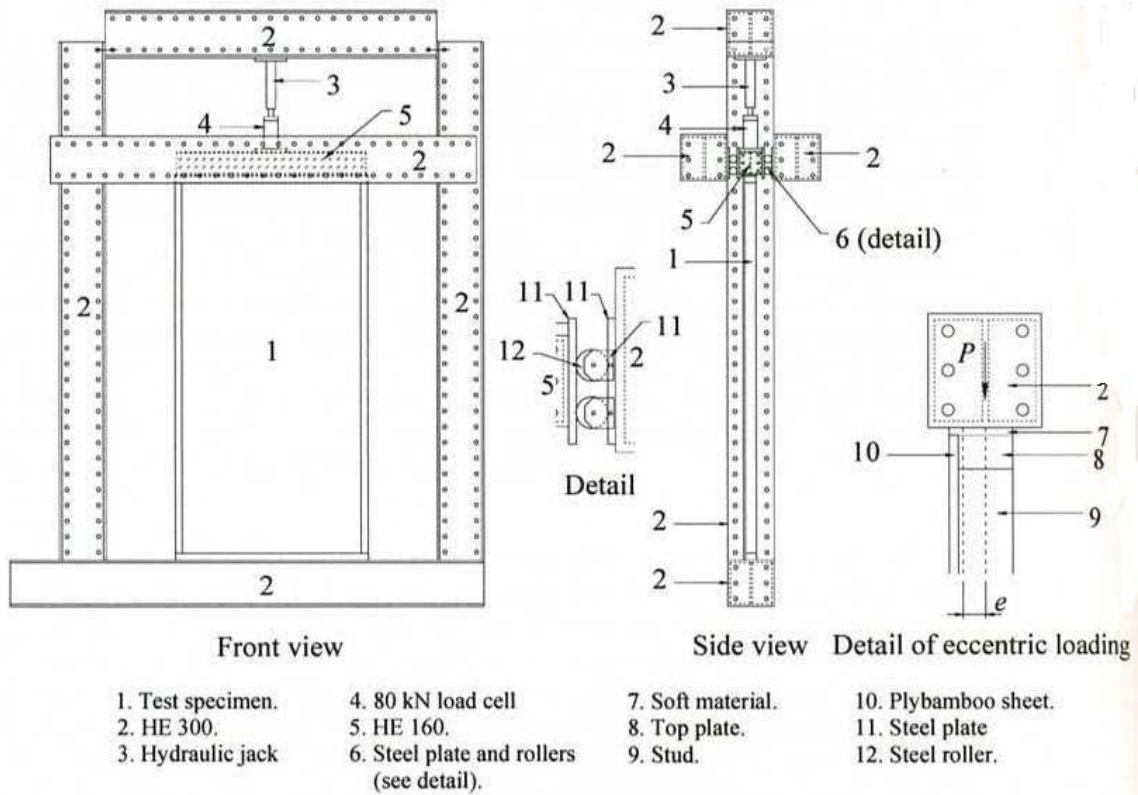


Figure 8. Test on vertical load.

Tests on a full house.

After all these tests on full panels, a series of tests have been performed on panels with a window or a door; such panels are much weaker, especially when the wall acts as a shear-wall. And finally a full house has been built in the laboratory, see figure 9.

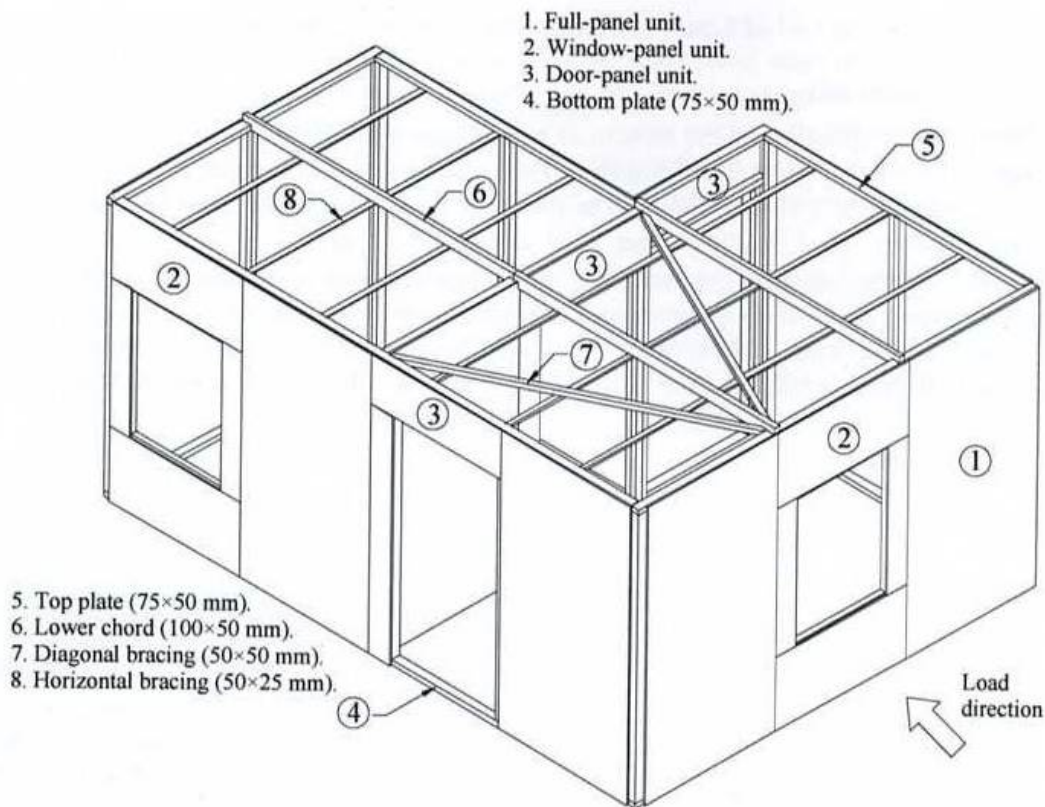


Figure 9. Full house with test scheme.

This house has been tested on a horizontal force with airbags till a force was acted as big as caused by a steady wind of 200 km/h. Two steel frames has been built and used, one to keep the airbags in place and another independent frame for measuring the deformations.

Conclusions.

The previous text shows a complete way to design houses with plybamboo wallpanels and to test them on all loads which can occur in practice. The advantage of this method is also that it allows to design and test similar houses in different climates and cultures. The author got his PhD on this research; now he is an Ass. Prof. at the university of Costa Rica, which university has a laboratory fully equipped for tests on houses in earthquake situations.

3. BAMBOO AND WOOD BASED PANELS IN EUROPE

Prefab bamboo module housing in Europe.

Evidently this does not occur as yet in Europe. The author made some telephone contacts with several people to find out if wood based panels play a role in prefab module housing. My spokesmen said it hardly plays a role; wood based prefab houses and other buildings are always made on client's specification. Production of wood based prefab houses occur e.g. in Germany, where some factories make such houses which the client can buy from a catalogue; in The Netherlands this is unheard of.

In view of the green and sustainable outlook of bamboo, the market would be ready to welcome bamboo based prefab houses, provided the prices are reasonable and they meet the standards. However in the author's opinion this will be a cumbersome process which will require a long term action and quite some capital investment. Therefore the author proposes to consider entering the market for wood based boards and panels used for floors and roofs first. This would enable to become accustomed to European market specifications and standards, to make the product well known, and to get a relative quick return on investment. This approach would enable the effort to start with bamboo based prefab module housing in Europe.

Market data.

To get a complete statistical overview about the import, production and export of wood based panels and boards in Europe one needs more time. The next overview of data on the export of The Netherlands on its own shows already how promising this market is, see table 1.

Table 1. Export of wood based panels and boards for The Netherlands, 2004.

Category	In m3	In 1000 Euro
Plywood	46.800	26.700
Chipboard/OSB	470.000	60.000
Fibreboard	199.200	58.900
Veneer	9.500	11.800

The total amount is about EUR 157 million! This means this country must import even more to cover the own need (inland production is negligible). A remarkable detail is that much of these products is exported to bamboo growing countries like Malaysia, Thailand, Vietnam, and even to Hong Kong and China. Imagine what it would mean if we managed to penetrate this market for even a few percent. Other countries like Germany have a similar market.

Bamboo is green

No participant in this symposium will disagree with this statement, and the general public shares this opinion. However to penetrate the market this is only a way to open the door, but immediately after this import firms, authorities and the like will require a hard proof for sustainable production. This means we will need a certification system for the

sustainable production of the bamboo used for the production of boards and panels, in a similar way as for sustainable produced tropical hardwood.

Prices to beat

To penetrate a market, one has to offer a product which looks friendly and meets the standards, but one must be competitive with the current prices. Table 2 gives an overview of the prices paid by building contractors for wood based products.

Table 2, prices paid by building contractors in The Netherlands, January 2005.

Type	Sizes in cm	Thickness in mm	Price in EUR/m ²
For concrete formwork	250 x 125	18	3.75
OSB	244 x 122	18	5.15
Plywood	250 x 122	6	6.13
		25	21.11
Chipboard	250 x 125	10	1.82
		25	3.78

This table gives an impression only; the author has many more data available. The prices given are for the most simple version; no paint or any other extra treatment is included. This table allows a comparison with the prices for similar bamboo based products, to see where the market can be entered in a promising way.

Standards to meet

Europe has a system of European standards which are obligatory in any country. Each bamboo product has to meet these standards, which are published by the European Committee for Standards CEN (www.cenorm.be

). One has to look for standards in the following categories:

- 79.060 wood based panels
- 79.060.00 wood based panels
- 79.060.01 wood based panels in general, 26 documents,
- 79.060.10 plywood, 16 documents,
- 79.060.20 fibre and particle boards, more documents, some duplications,
- 79.060.99 other wood-based panels.

In general these standards cover test methods, characteristic values for properties, load bearing capacities, requirements for the use of formaldehyde, influence of moisture, and more. Evidently one should approach a laboratory which is familiar with this world to get the bamboo based products through this process of approval.

Germany is active in Asia

Coming to an end, the author found that Germany is very active in its export of wood based boards and panels. They even organise a symposium “European Wood Days 2005” in Tokyo and in Beijing in October 2005! (See www.Inf Holz.de, in German)

Conclusion

This paper has given an overview of the research methodology for bamboo panels in housing, developed at Eindhoven university, as well as some ideas and data how to penetrate the European market with bamboo based panels and boards. Both parts provide us with tools for this marketing operation.

REFERENCES

G.E. Gonzalez-Beltran, 2003. Plybamboo wall-panels for housing. PhD thesis Eindhoven University of Technology, The Netherlands, 210 pp. Also available as PDF on www.tue.nl. (go to English, Library, Search in TUE catalogue, “Plybamboo wall-panels for housing” as title, full text; gives you access to a PDF file).