# USE OF THICK FIBER CEMENT BOARDS IN INDUSTRIALIZED HOUSE MANUFACTURING PROCESS

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## ABSTRACT

The worldwide demand for affordable and decent living space is enormous. The construction of houses in the traditional way cannot satisfy demand either in terms of quantity or costs. In many countries traditional building materials such as wood are no longer available. Building houses in the traditional way also takes a lot of time. Therefore, the provision of industrial house systems made in a factory on the basis of thick fibre cement boards is a possible solution to many of the current problems. For every ton of raw material used, a multiple of living spaces can be created. Natural resources are also conserved. Instead of wood, etc., houses may be built from up to 30 mm thick fibre cement boards made from recycled cellulose fibres. There is minimal pollution of the environment on site by construction waste and packaging materials because the components are manufactured in the factory and the waste can be recycled. Due to the low weight and compactness of the prefabricated elements, specific transport costs per square meter of living space are reduced several times over. About 25 years ago, the then NUEVA-PLYCEM Group began to gain initial experience in the industrialised production of houses in various Latin American countries. From the first tentative steps, in a relatively short period of time, a business that was also interesting in volume terms for the manufacturers of fibre cement boards developed. But also the companies that produced and sold the house kits grew rapidly. In each of the countries, house types were developed that were adapted to the local market and local needs.

What started almost 25 years ago in Latin America by the NUEVA-PLYCEM Group is now being successfully continued by the ConWOOD Group in Asia. About 2 years ago, ConWOOD Indonesia, supported by construction specialists, started the development of different house types made of thick fibre cement boards for the local market but also for export to other Asian countries.

Another potential market for these industrially manufactured housing units is their use in the event of natural disasters or the accommodation of people on the run. The units can be produced in stock and require little storage space due to their compactness. In an emergency the units can be transported quickly by truck, ship or even plane and in just a few days, high-quality and safe living space can be created and offered to those in need.

Industrialized house construction with fibre cement panels as the main building material in many countries of the world has a very good future ahead of it.

## KEYWORDS:

Low cost houses; recycled cellulose fibres; thick fibre cement boards.

## INTRODUCTION

Today millions of people have no roof over their heads for other reasons. The shortage of houses and living space has never been greater. This problem can no longer be solved with the traditional way of building a house. There is simply a lack of the necessary capacities of experts and building materials to build these houses. Not to mention the overexploitation of nature when all the necessary building materials, especially wood and bricks, first have to be provided on site. Whole forests would have to be sacrificed for extraction as timber or then as fuel for brick production. (1)

Only an industrialization of the house building process and the use of building materials made of recycled raw materials can lead the various countries out of this dilemma.

The characteristics of the fibre cement boards manufactured by our unique production process (FLOW-ON process, low density product, board thickness up to 30 mm, cellulose fibres from the reprocessing of newspapers and cardboard, etc.) are ideal for their use as starting material for the industrial production of the various house elements. The boards are easy to process, similar to wood, but sufficiently strong for use in house construction. In addition, their behaviour against fire, termites, moisture, etc. is very similar to that of concrete products; thus termite-resistant and non-flammable. Because the individual boards are up to 30 mm thick, the residents have the feeling of living in a solidly built house. The feeling of space is also extremely pleasant for the residents.

Some 25 years ago, the then PLYCEM group of companies in Venezuela and other Latin American countries took its first steps to produce industrially manufactured houses from fibre cement boards up to 30 mm thick, made from recycled cellulose fibres and cement. The various companies developed solutions and construction systems adapted to their respective markets. Over the years, several hundreds of such houses have been built and erected in Venezuela and the various countries of Latin America.

For a short time now, the ConWOOD Group in its plant in Indonesia has also begun to develop industrially manufactured living solutions in addition to the production of ConWOOD fibre cement products. Apart from the large domestic Indonesian market, the target markets are Bangladesh and other Southeast Asian countries. The goal is to be able to offer the buyers inexpensive houses of high quality that fulfil the needs of the different interests of the buyer and for the production of which the environment and its natural resources can be conserved as far as possible.

The numerous advantages of the industrial production of houses and housing units made of fibre cement boards made of recycled cellulose fibres are obvious:

- Large numbers of residential units can be produced in a short time. Per production line over 5,000 units per year.
- Cost control because the exact manufacturing costs can be calculated.
- Time control because you can plan the production as well as the installation exactly.
- The industrial production of the individual elements and the optimisation of the blanks allow an almost 100% utilisation of the fibre cement boards.
- Environmentally friendly because the use of fibre cement boards made of recycled cellulose instead of wood prevents the deforestation of entire forests.
- Natural resources are conserved because the raw materials are almost 100% used and no waste is produced or can then be recycled.
- Compared to the traditional construction method, a multiple of living space can be created from one tonne of cement.
- The energy required for the production of the fibre cement boards and house elements is used much more efficiently than in the production of clay bricks in the traditional way.
- The transport costs per accommodation unit are low because you only transport material that is also used.
- Allows the production of the house kits on stock and in case of a disaster they can be brought very quickly to the place of use and installed.

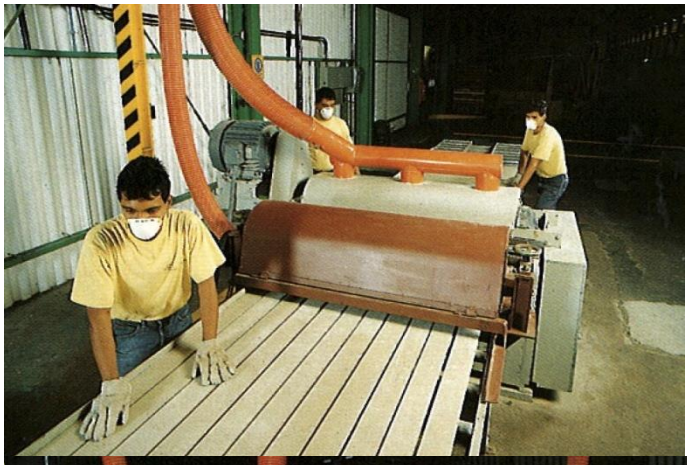
- Neither experts nor special tools are required for installation
- The modular construction allows adaptation of ground plans of the houses to the needs of the project.
- International quality standards are met (fire, earthquake resistance, durability, etc.).

## FIRST STEPS: INDUSTRIALIZED CONSTRUCTION USING ECOSISTEMAS LAMACO SA IN VENEZUELA AS AN EXAMPLE

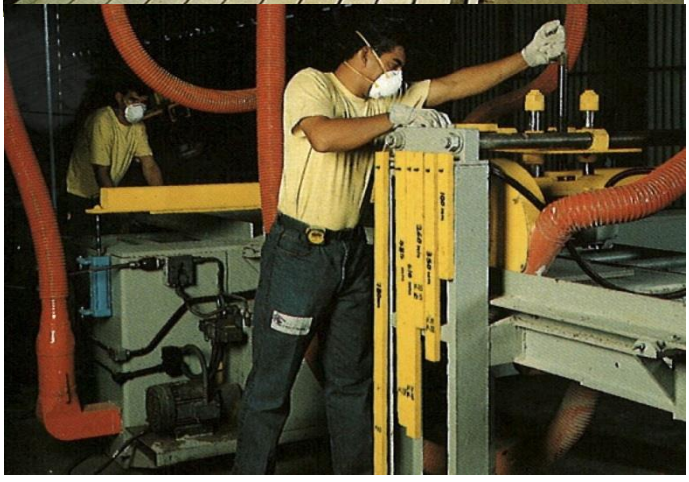
The following section provides information on initial experiences in the industrialized construction of simple houses almost 25 years ago with the small company "ECOSISTEMAS DE LAMACO SA" in Venezuela (a subsidiary of PLYCEM de VENEZUELA). With the simplest means and a minimum of investments a simple production line was created for the production of the different house elements. With the exception of a few auxiliary tools, all systems and machines for this production line were manufactured locally. The 22 mm thick fibre cement boards were purchased from the parent company "PLYCEM de VENEZUELA SA" and then cut and perforated on the production line according to plans. The door and window frames, doors, windows, water pipes, electrical wiring, washbasin, shower, WC etc. were purchased in the local market or manufactured according to our plans. The goal was to give the customer a complete kit of a house. The buyer then only had to cast the concrete foundation on site, including laying the supply lines for electricity and water and the drains for waste water. Then 4 people could set up the house delivered by a truck in 7 days.

### Production of the various house elements

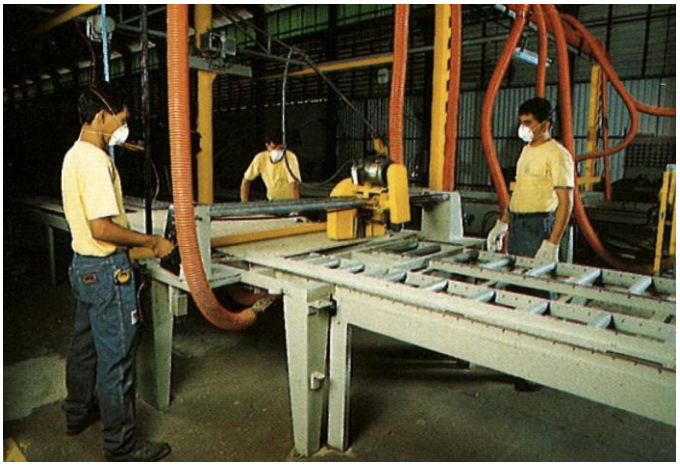
On simple machines specially developed for this purpose, the 22 mm thick fibre cement boards were cut to the required dimensions. The different parts were then perforated according to the plan.



The fibre cement boards are cut into strips. These serve to connect the individual house elements.



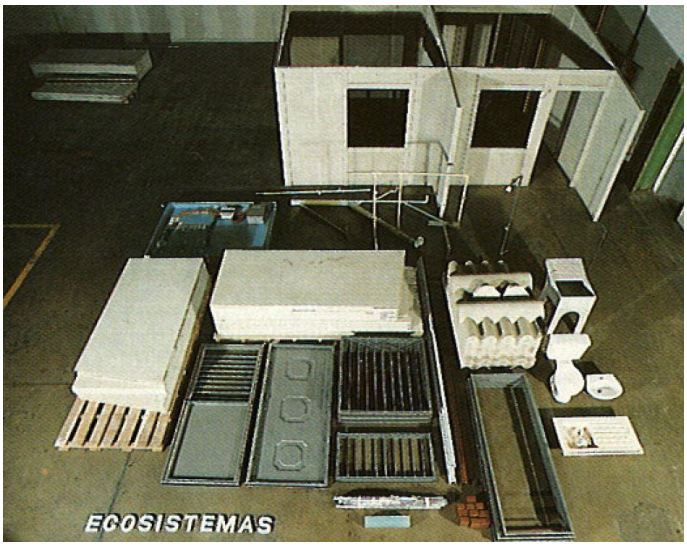
Cutting machines for longitudinal and cross sections.



This machine allows angular cutting of the front wall elements on which the roof rack profiles are mounted.

**Complete kit for one house**

A description of the complete kit for a residential house with 45 $m^2$ living space and 5 $m^2$ covered forecourt is presented here. This whole kit is typically loaded onto a single truck and driven to the construction site.




The kit includes all parts needed for the house:

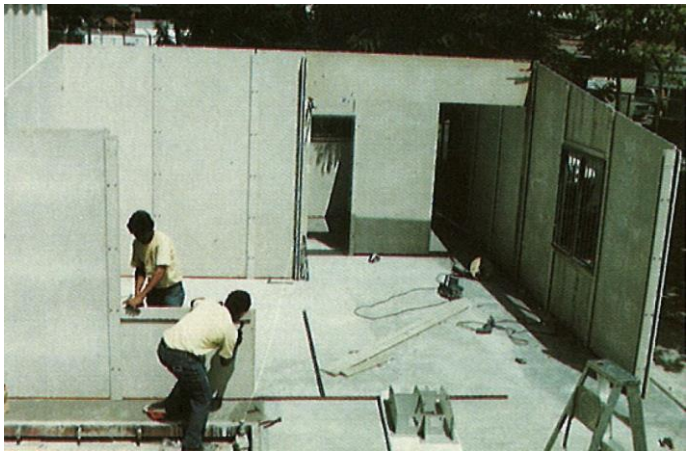
All wall elements, corrugated sheets of fibre cement for the roof, supporting structure for the roof panels, metal parts for door and window frames, doors, windows, electrical equipment and pre-assembled wiring set, PVC pipes for fresh and waste water, kitchen furniture with washing trough, washing trough, shower, WC etc.

Costs: The house kits, as described above, had a price between approx. US $ 4'500 (45 m2 model, 3-room) and US$ 7'000 (75 m2 model, 5-room).

**The different steps for setting up the house**

The concrete floor slabs had to be poured on site according to the specified plans. All supply and discharge pipes for fresh and waste water had also already been laid in the base plate. Afterwards the truck delivered the house kit and the installation was carried out by 4 people who were not specially trained. Within 7 working days the house was ready to be lived in.

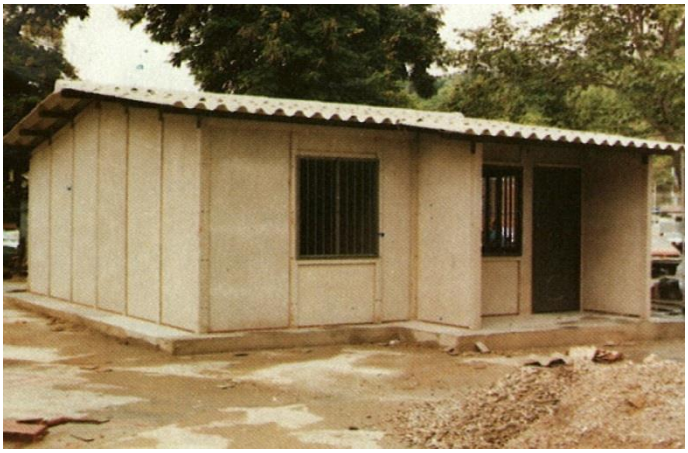
The concrete floor slab is produced exactly according to plan.



The individual wall elements are set up according to the plan and glued and screwed together. The walls and the corner joints are also the only supporting elements of the house.

The metal door and window frames are installed.

After the Omega profiles of the roof construction have been installed, the fibre cement corrugated sheets of the roof can be laid and fixed.



The shell of the house is ready after only a few days.

With paint and some decorative elements, the house now becomes a beautiful new home for a family.

The house has two bedrooms, a living room with adjoining kitchen, shower and toilet and a covered forecourt in front of the entrance and a washing area at the back of the house.

## PROJECT “FUNREVI / BARQUISIMETTO” (LARA / VENEZUELA)

The project "FUNREVI / Barquisimetto" comprised 120 units of the house type ECO-1000 with 2 bedrooms, a living room/kitchen, shower, toilet, covered forecourt and a washing area behind the house. The total living area is approx. 45 m2 plus 5 m2 covered entrance area.

This project was a support of the State of Lara to 120 needy families who were assigned new houses.

### The construction project in its various stages

The floor is prepared for pouring the concrete floor slab: the kit for the inlets and outlets of the drinking and waste water have already been laid. The surface is next poured with concrete.

The different stages of construction are clearly visible here:

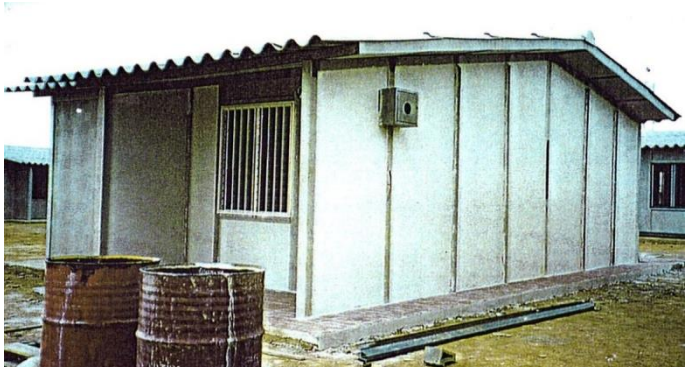
In the foreground, the floor slabs on which the houses are to stand are prepared. In the background you can see the houses under construction or units that have already been completed.

The installation of the various house elements on the floor slab is being prepared. First, the metal fastening elements are laid and bolted to the concrete slab.

The house kits (i.e. all necessary elements for the house construction) are delivered by truck.

The installation of the house can begin!

Within a few weeks the 120 units of this house project of FUNREVI are set up. The new residents can expect a house with the space and comfort they had never had before.



The installation of the house is finished and now only needs to be painted outside and inside.

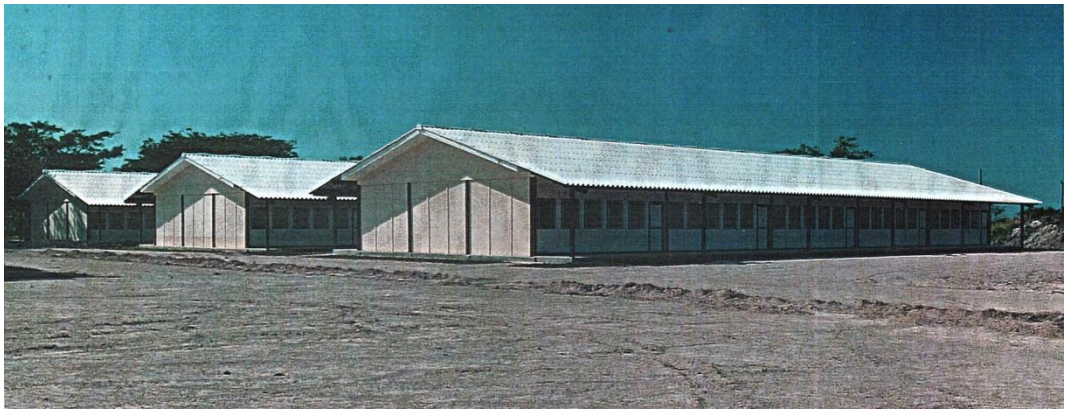
## FLEXIBILITY OF THE SYSTEM

The well thought-out system makes it possible to build larger buildings such as schools, infirmaries, training centres, dormitories, etc. from the same individual elements that are used for building small types of houses. In San Salvador / El Salvador (Central America) an entire camp consisting of dormitories and training rooms was set up in the shortest possible time for the training of the new National Police.

**Training camp of the "Nueva Policia Nacional de El Salvador»**

General view of a building of the type "training rooms" of the camp. The training buildings were divided into 5 classrooms each.

It is easy to see that these buildings have also been assembled from the same individual elements as they are used for the small detached houses.



View of a part of the camp.

The buildings were developed and erected within a few weeks.

## INDUSTRIAL CONSTRUCTION AS IMPLEMENTED BY CONWOOD INDONESIA.

About 2 years ago ConWOOD Indonesia started to develop an industrially manufactured house that meets the special requirements of the Indonesian market. The residential units have a modular structure and can therefore be easily adapted to the various requirements of a project.

**Concept idea:**

## Concept Idea

- Modular System with fiber cement boards
- Fast to build
- Easy to install
- Consistent quality
- Beautiful like wood
- Zero wood
- Easy to deliver even to remote areas
- Affordable house

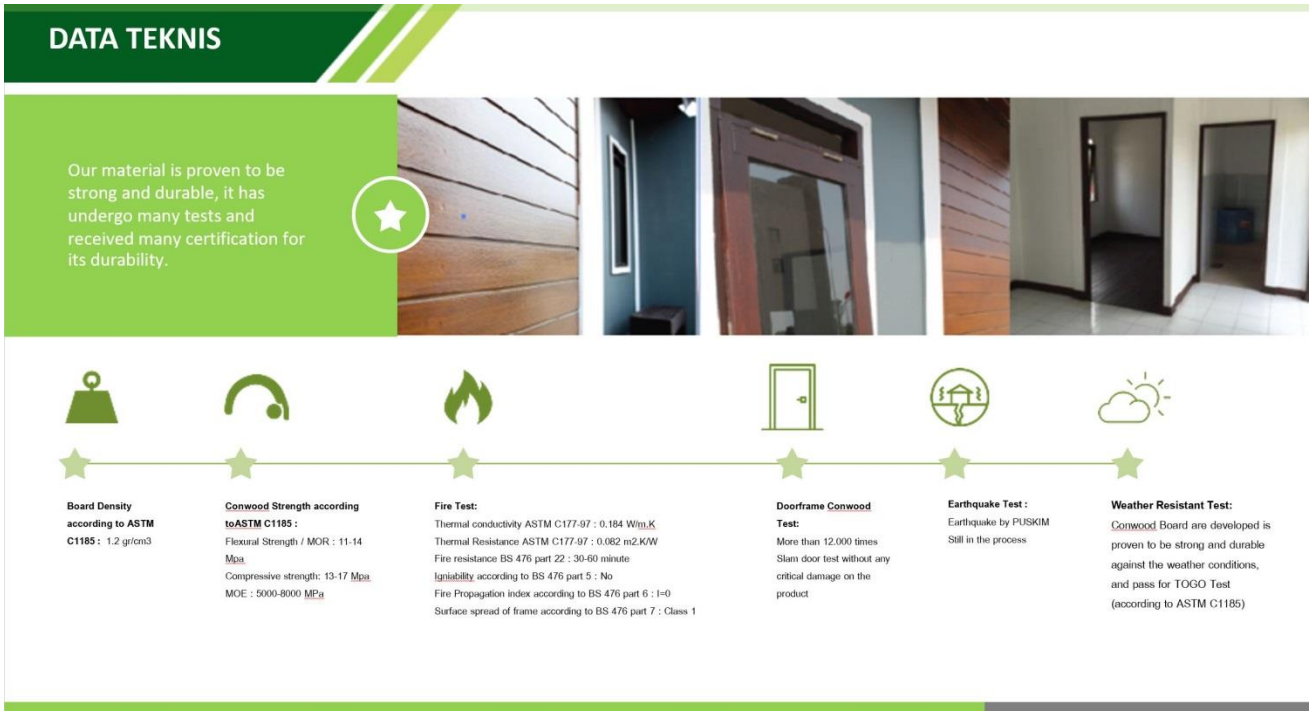
**House specifications:**

## TYPE 36

**Conwood House Specifications :**

| | |
|---|---|
| Wall | : White-painted Conwood board |
| Floor | : White Ceramic 30 x 30 cm, Bathroom Ceramic 20 x 20 cm |
| Ceiling | : Conwood board 8mm. |
| Roof | : Spandek |
| Eave | : Conwood Plank 8" |
| Door Frame | : Conwood , Main entrance door 210 x 90cm, Bedroom door 210 x 80 cm, Bathroom 210 x 70 cm |
| Window Frame | : Conwood Frame 60 x 120, Clear glass 5mm. |
| Doors | : Conwood Door Set |
| Roofing Frame | : Lightweight steel (Zincalume / Galvalume) |
| Sanitary | : Fiberglass Tub and KIA Squat Toilet (or other similar brands) |
| Front Door | : Conwood Door (with metal and Conwood frame) |
| Electricity Instalation | : According to SNI (Indonesian National Standard) |

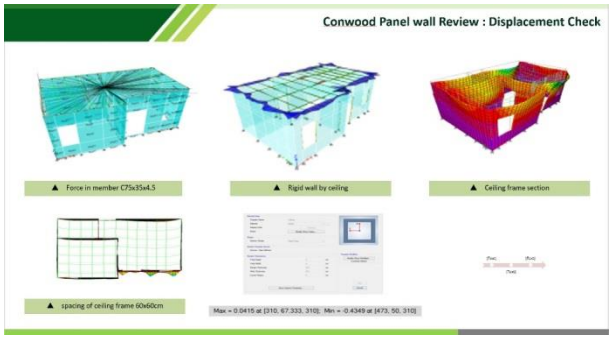
**Technical data:**



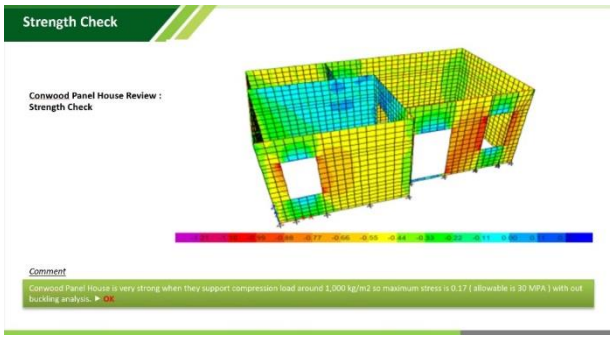

The various house models meet all the tests required by the authorities.

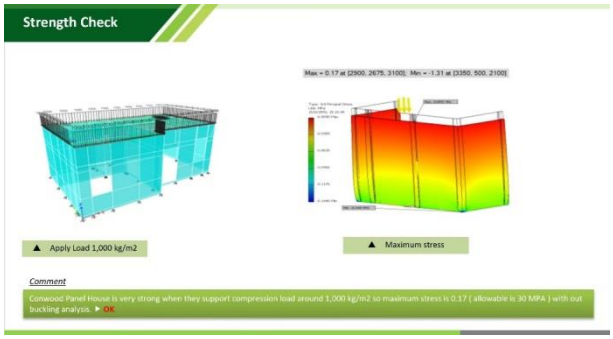
**Design and development of the different house models:**

During the development of the different models, the various details were optimized with the help of special computer programs. Fire and earthquake resistance tests were also carried out on model houses.







**Setting up the houses:**


Neither specially trained construction specialists nor special tools or machines are required for setting up the houses. It takes 7 working days to set up a house.

**Completed projects in Indonesia:**


In Indonesia, housing units produced by ConWOOD were delivered to: private housing projects, military housing projects, houses for workers in remote plantations and construction sites. The first house kits have already been delivered to Bangladesh.

**Prices of the houses and scope of the kit:**

## CONCLUSION

Based on 25 years of experience it can be concluded that:

i. The problem of millions of missing or inadequate dwellings can no longer be solved in the traditional way of building houses and using the traditional building materials.
ii. The industrialised production of housing solutions using thick, low-density fibre cement boards can be the solution for many countries to remedy the housing shortage.
iii. The use of fibre cement boards made of recycled cellulose fibres prevents deforestation and protects the environment.
iv. The construction of a production plant for industrialized house construction with a capacity of approx. 5,000 units per production line takes approx. 1 ½ to 2 years.

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