PRODUCTION OF WOOD LIGHT FRAME CONSTRUCTION IN BRAZIL

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ABSTRACT: In recent years, the construction industry in Brazil has been increasing its activities producing wood light frame for the first time on a larger scale. This paper aims to analyze this innovative production. First, the data collected are organized to present two aspects: the main wall compositions and the different construction processes. Then, the paper analyzes the social housing complex named Haragano, which is the pioneer built with this wood system, consisting of 270 two-story and 10 single-story prefab houses. The results demonstrate that the wood frame components have been adapted to Brazilian needs according to climate and supply chain conditions and that the construction processes occur on- and off-site according to scale of production and factory facilities. At last, the paper concludes that the Haragano complex can be considered a positive outcome of joint efforts by university, industry and government.

KEYWORDS: wood light frame, social housing, production.

1 INTRODUCTION

Wood light frame constructions are mainly renowned in North America and Central and Northern Europe. Along the time, each region has developed specific technical solutions, leading to different building compositions. In Brazil, in spite of the potential of its planted forests, the innovation in the wood construction industry is characterized by isolated circumstances. Since the decade of 1990’s, academic researchers have analyzed the possibilities to adapt the wood light frame components to Brazilian necessities. For example, on the early 2000’s, after testing the structural performance of wood species from local planted forests, the Federal University of Santa Catarina (UFSC) and the Interdisciplinary Group of Wood Studies (GIEM) designed and built a social house prototype, applying technical features of the platform system. Figure 1 shows the construction of this prototype on site and its finishing with wood sidings [1].

The results were positive. Overall, the conclusions of this study pointed how the wood light frame can certainly be adjusted to the Brazilian context, improving building quality and reducing labor, time and costs of the construction. Accordingly, many other studies conducted on this subject have presented how this system can contribute to the technological development of wood construction in Brazil, by adopting innovative techniques with prefabricated and standardized components [3]. However, until mid-year 2010, the wood light frame was rarely produced by local constructors. In general, the low participation of wood on the Brazilian industry has occurred because of population’s prejudice over this material. Usually, this negative concept is based on incorrect practices, from the design process until the construction on site, causing a decrease in durability of wood components. Also, the low technological development of products offered by several constructors may detract these material superior advantages. Yet, going against these negative concepts, in recent years, the Brazilian wood construction industry has been increasing its activities producing the light-frame, especially on the South and Southeast regions. The technological transformation of the sector is taking place through joint action by the State, production chain and research institutes. The highlight of these efforts was the construction of the social housing complex named Haragano. Composed by 270 two-story houses and 10 single-story houses, Haragano was the first social complex built with wood frame. Based on this recent situation, this paper aims to analyze the contemporary and innovative wood light frame production on Brazil, describing components and

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Figure 1: Social house prototype built in wood frame [2]
methods of construction. And to conclude, the production of Haragano’s social housing complex will be the case study outlined over this subject.

2 METHOD

The data presented on this paper is part of a PhD research in progress. The overall research of this thesis aims to present the inclusion of the wood frame system in the Brazilian national program for social housing. This paper focus is part of this study that characterizes the production process of this newly introduced system in the Brazilian context.

Therefore, at first, since 2012 until 2015, six construction companies were visited in order to collect data about the production process on the South and Southeast regions. This field research included interviews, observation notes, public documents, photographic registers. The data collected provided information to describe the main components, specially wall compositions, and the construction methods off- and on-site.

Then, the paper ends with the analysis of the social housing complex named Haragano, which is the pioneer built with this wood system. The data from the case study of Haragano’s was collected on factory and on site during production, in the end of 2012 on the city of Pelotas on Rio Grande do Sul, on the South region. Also, important public documents complemented these data with information about codes and regulation, design, costs, labour and factory facilities [6-9].

3 RESULTS

Currently, wood frame construction in Brazil are applied mainly for residential use. However, there are some institutional buildings such as day care, school and research laboratory.

By the year of 2009, only one or two construction companies used the wood frame techniques. But gradually this number is increasing. By 2013, five companies were contacted in the South and Southeast. In addition to these companies, this research has added a group of self-employed builders who acquired their practical knowledge by working in countries like the United States and Australia.

Based on the research data, the following two items of this article shows the main building components and their production methods. Also, on the third point, the Haragano complex will be characterized because it is the first major residential development in wood frame in Brazil. And it is believed that it was an encouragement to current industry growth.

3.1 WOOD FRAMING COMPONENTS

After visiting six Brazilian wood frame construction companies, this research has noticed different designs and layers of components, especially on the interior and exterior walls. However, in general, these compositions are based on American and European models.

First, the foundation is usually built with concrete slab on grade. Over this concrete floor, the wooden walls are fixed as e.g. in Figure 2.

![Figure 2: Foundation and exterior walls components](image)

In the study, various types of layer composition of the walls were found. Diversification of materials in these layers varied mainly in the exterior walls. Although, some of these components is generally maintained. For instance, describing the exterior wall from the inside layer to the outside, numbered from one to five in the Figure 2, usually these components are the ones who do not change: (1) gypsum board and interior finishing, (2) fiberglass wool insulation, (3) wood frame, (4) OSB sheathing, (5) sheathing paper.

Usually the changes occur on the external finishing and its materials, characterized as the number six of the Figures 2 to 4. For this article, two major compositions were selected.

The first one is illustrated on Figure 3. After the OSB and waterproof building paper, it applies a wire lath and stucco over it. Finally, after the finish coat, the wall is painted.

![Figure 3: Type 1 of exterior walls components](image)

Like the previous wall, the second one maintains the same components from one to five. But it changes the last
component – number six – to cement board and exterior painting.

![Cement board](image)

**Figure 4:** Type 2 of exterior walls components

The wood frame practice is considered new on the Brazilian construction context. Therefore, these components continue to be adapted according to climate conditions and supply chain availabilities. Thus, the diversity of materials layers is still increasing as construction companies make adjustments.

Another model is shown on Figure 5. For the internal side of the exterior walls, this company has chosen to use interior finishing, gypsum board, wood frame and wool insulation. And for the external side, the following materials: sheathing board, water resistant barrier, adhesive, rigid insulation such as EPS, fiberglass reinforcing mesh, base coat, finish coat and painting. This wall system is known as Exterior Insulation and Finish Systems (EIFS).

![Model of exterior wall with EPS](image)

**Figure 5:** Model of exterior wall with EPS

Neverthele$$ss$$, this negative view of the timber may be reducing. Because, on the beginning of the year 2016, there are records of 21 construction companies that produce Wood Frame in Brazil [4].

3.2 CONSTRUCTION PROCESSES

Next, the two main wood frame construction methods in Brazil will be featured: fabrication on-site and off-site.

3.2.1 Fabrication On-site

Two of the six constructors visited on this research presented the method of fabrication on-site, similar to the North American stick-frame. Usually, the elements are received, cut and nailed on site, where the construction is also erected and finished, i.e. in Figure 6.

![Basic steps of construction on-site](image)

**Figure 6:** Basic steps of construction on-site

However, as can be seen, the use of wood as a finishing material is not taking place in the Brazilian wood frame buildings. The construction remains with the external appearance of a “material house” – popular expression for constructions built with concrete structure and masonry. One of the reasons for the low application of this material is the prejudice and doubts of both the population and the technical on the efficiency and durability of wood.
3.2.2 Fabrication Off-site
Currently, the main production of walls, floors and roof trusses occurs on factory based on European models. The prefab assembly lines differ according to scale of production and available facilities. The production lines are organized by workstations. The main difference is the variation between manual, semi-mechanized or mechanized activities.

In automated production, after the selection of the wood pieces, mechanized machines controlled by computer perform all manufacturing of the frame and boards. On the semi-mechanized production, the wood elements are cut and positioned manually on the assembly table with turning function. On this table, frame and boards are nailed and cut by the computerized machine. Then the table rotates, as illustrated in Figure 7, and the insulation material is added manually. Finally, the last materials are fixed in the wall panel. The prefab components are stored in the factory waiting for transport to the site where they will be assembled.

The basic steps of manual assembly line can be seen in Figure 8. First, the pieces of treated wood are checked. Then, the wood is cut and stored near the assembly table. This table is pneumatic, so it’s able to fix the height of the walls and provide more security on the manufacturing. But this the table is fixed on the ground, then the workers move around or over it, placing the wooden elements and nailing them with pneumatic machines. The OSB board is nailed and the insulation is placed in. Finally, the open panel is storage on factory to be transported to site.

The first company of wood frame prefabrication began its activities in 2010. In the beginning, it was observed that its staff was sectored in three main activities: design, manufacturing off-site and assembly on-site. At the office, there were about 10 people, including engineers, architects, sales staff and marketing. There were 7 workers on factory and 5 workers on-site. In mid-2012, its activities have increased considerably and a second plant was installed in partnership with another construction company.

In parallel, another company opened a factory in mid-2011. Its owner was a representative of machinery for mechanized production from abroad. In July of 2012, the company had a total of 6 workers. But, for lack of demand...
associated with the type of production semi-automatized, this company has paralyzed its activities for a brief moment. Soon after, in 2013, it had returned its production in partnership with a longstanding constructor of traditional precut wooden buildings. Therefore, until mid-2013, there were only three shops for prefabrication of wood frame components in Brazil. All of these were located in the South region. Over time, their production practices are being systematized and evolved.

3.3 HARAGANO SOCIAL HOUSING COMPLEX
Haragano is located in the South region of Brazil, at the city of Pelotas, state of Rio Grande do Sul, in a land measuring 3.99 hectares [7]. As already mentioned, this was the pioneering complex to be financed by a public national program for social housing. It was built in a historic moment, when the first guidelines for the wood frame system were approved as will be discussed below.

3.3.1 Regulations and codes
In June 2009, a group formed by Brazilian entrepreneurs and engineers visited factories located in Germany to comprehend the industrialized production of wood frame systems. A partnership was established between the National Service for Industrial Training (SENAI-PR) from Brazil and the Ministry of Finance and Economy of the German state Baden-Württemberg to enable the transferring of these technologies to Brazil. In November 2009, a group in the wood industry formed a network called Smart Home Commission in order to define the first guidelines for wood frame construction in Brazil. Initially, the committee was attended by builders, consultants, equipment and technology suppliers, financing agent, wood suppliers, supplementary materials suppliers, regulatory agents, research and teaching institutions and designers. Among those, it was included the representative of the Ministry of Finance and Economy of Baden-Württemberg [5]. In September 2011, the guidelines proposed by the committee were approved, resulting in the document entitled “Guideline Number 005: Building systems framed with sawn timber components, closed with sheathing – Light Wood Framing” [6]. This Guideline is limited to single-story dwellings and defines parameters for floor, wall and roof components of the light wood frame. It’s based on the national code for building performance: structural, thermic, acoustic, fire, waterproof, maintenance and durability. After testing the performance of building components, in 2012, the first Document of Technical Evaluation was approved. This document allows the financing of wood frame social dwellings [7]. On the same moment, in mid-year of 2012, the Haragano social complex was produced in partnership by two construction companies. And, it was funded by the government social housing program named My House My Life – Minha Casa Minha Vida. Next, its design and production process will be detailed.

3.3.2 Design
The complex consists of 270 two-story and 10 single-story prefab houses. Each unit has approximately 45 m² and consists of living room, kitchen, bathroom and two bedrooms. To provide accessibility, the one-story house was reserved for families with special needs, i.e. Figures 9 and 10. The journal Construction published a simplified budget for this dwelling of 45 m², considering the amount of materials and labour. The cost in July of 2013 was approximately R$ 28,000.00, on the Brazilian currency - real. On that moment, one American dollar was equivalent to R$ 2.30 reals, so the single dwelling costed approximately $12,200.00 [8]. And according to other estimates, the same unit built in conventional masonry exceeds this value of approximately R$ 2,000.00 reals or more [8].

Figure 9: One-story dwelling design [8]
On the ground floor of the two-story dwellings are located: living room, kitchen and bathroom. The laundry space is external. And the second floor is accessed by a metal spiral staircase. There are two bedrooms upstairs, as is illustrated on the plan of Figure 11. The two-story houses are townhouses, because they’re attached to each other as can be seen on Figure 12.

3.3.3 Prefabrication
Components of wall, floor and roof were prefabricated on a factory located in the city of Pelotas by 18 workers. The assembly line was organized in work stations, for example: wood selection, framing, OSB sheathing, cement board sheathing, gypsum board, i.e. in Figure 13. Initially, before the manufacturing, the raw materials were inspected, selected and registered for future tracking. Then, during the manufacturing, after the conclusion of each stage, a check list was done, scoring the data about the product quality. Finally, each component finished in the factory was inspected by the responsible engineer for the production.
3.3.4 Assembly on site
After the prefabrication, floor and wall panels were transported to the construction site where they were erected on the foundation slab-on-grade, as i.e. Figure 14. This assembly was controlled by a specific engineer who followed the work, checking the position of each prefab component to maintain its traceability.

On the façade, house wrap or moisture barrier was placed especially on the joints of units and on the platform floor of each unit, as i.e. Figure 16. Then, this joints were completed with cement board and all façade received external finishing and painting.

Finally, the roof trusses were prefabricated in steel and covered with ceramic tile, as i.e. Figure 17.

During the execution of this housing complex, the financing bank followed monthly reports written by the responsible constructor to monitoring and control of technology.

From the results presented, the positive attitude of the financial agent of the wood frame system was based on the management of the production of prefabricated components and assembly on site, including the quality control throughout the process.

4 CONCLUSIONS
The research presented that the construction industry in Brazil has been increasing recently by producing wood light frame on-site and off-site.

Some construction companies produce wood frame on site. There, all the elements are cut, framed, erected and assembled. However, other companies have specific facilities and machinery to prefabricate the building elements such as wall and floor panels and roof trusses. Prefabrication has presenting advantages and increases of quality for wood construction industry and, therefore, should be encouraged.

According to climate and supply chain conditions, different types of wood frame components are tested and applied. For example, wall panels mostly change the exterior layers, varying between cement board, stucco and EFIS.

An important point that impelled the construction industry to apply this innovative wooden system in the Brazilian context was the approval and publication of its first
official guideline in order to control quality and performance of these wood frame buildings. The institution of the Smart Home Commission was essential for this, including the participation of builders, consultants, equipment and technology suppliers, financing agent, wood suppliers, supplementary materials suppliers, regulatory agents, research and teaching institutions and designers. Among those present was also the representative of the Ministry of Finance and Economy of Baden-Württemberg. As a result, the first social housing complex named Haragano was built. Its production on factory and on site of 280 dwellings proved the efficiency of this system built according to guidelines proposed to the Brazilian context.

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REFERENCES