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THE FIRST MASS TIMBER BUILDING IN BRAZIL

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ABSTRACT: The use of new technologies in wood for construction is increasing every year in Brazil. This work aims to demonstrate step by step the entire building system that was used for the construction of the first massive wooden building in Brazil located in one of the main avenues of São Paulo city.

KEYWORDS: First massive timber Brazil, Wood building, Massive Timber, Glued Laminated, Cross Laminated Timber.

1 INTRODUCTION

The mass timber revolution is on the rise, Architects and engineers are working around the world to understand and revolutionize the building industry of how to use wood and create large-scale and sustainable buildings. The move to mass timber is even farther along in North America and Europe. That's because mass timber panels and systems like posts and beams glued under pressure or floor and wall systems nailed together in layers, is not only prized as an innovative building material, superior to steel and concrete in many ways, it is also hoped it will come into its own as a significant part of a climate change solution. In Brazil, this revolution already started with the first mass timber building just have been finished located in the city of São Paulo, Brazil.

__Figure 1:__ First Timber building in brazil – render

The four-storey commercial building has a construction system based on the use of CLT (Cross Laminated Timber) panels as floors, walls and slabs. The Glulam (Glued Laminated Timber) panels are used as posts and beams systems. The connections between these elements are made by self-tapping screws developed for this type. application, facilitating and reducing assembly time.

This system has been widely accepted in the European and North American market that besides being able to build single-family residences, it is possible to build multi-floor buildings. Unfortunately, in Brazil this system is not yet as widespread as it could be most of the works are performed in the traditional masonry system with bricks or structured concrete blocks with reinforced concrete columns and beams or steel structures. The choice for the traditional building system is linked to factors such as culture, ease of access to material and especially the wide dissemination of knowledge of the building system that is chosen.

The building owner is DENGO, a Brazilian company that manufacture healthy and sustainable chocolates, and this mass timber building will be a model store for the company. The building has a net area of 1500 m2 and the basement, which holds parking facilities, technical rooms and storage rooms, that has a net area of 564 m2. Rewood is the Brazil's largest glulam manufacturer, and delivers and installs the glulam and CLT. KLH in Austria provides the CLT to Rewood. The architect for the project is the São Paulo based company MFMM. Rewood and Stamade are the responsible for the technical design and design management.

This work aims to demonstrate step by step the entire building system that was used for the construction of the first mass timber building in Brazil located in one of the main avenues of São Paulo.

2 LOCATION

The building site is in an urban and central area of São Paulo, the largest city in Brazil, and is located at Avenida Brigadeiro Faria Lima, one of the main avenues of São Paulo City, see map on Figure 2.

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Figure 2: *First wood building in Brazil - outside view*

Figure 2.1: *First wood building in Brazil - outside view*

Brazil has a deficit of 6 million housing units to attend its population, with the projection of a 20 million deficit by 2024. This represents a need for investment of around R$ 76 billion annually to solve the problem. The challenge of sheltering these people clashes with the pressing challenge in addressing in a proper way climate change and the need to reduce greenhouse gas emissions in the recent commitments assumed by the country under its NDC – National determined contributions. Such as many other places around the world, the dominant construction system in Brazilian larger cities is based on two materials: steel and concrete, which are materials thar have been widely used in last century, whose production is based on enormous energy consumption and low concern about GHG emissions.

There are estimates that show that only the production of these two materials accounts for 8% of all humanity's GHG emissions. Also, based on these materials, the construction industry accounts for 47% of the total emissions, the transport sector, 33%, and the primary industry, 19%. Thus, meeting this growing demand for housing, while combating the effects of GHG emissions on climate change, is the challenge posed.

3 WOOD IS THE SOLUTION

Among architects, manufacturers, and environmentalists, many want nothing less than to turn the coming decades of global construction from a giant source of carbon emissions into a giant carbon sink by replacing concrete and steel construction with mass timber. It will avoid the CO2 generated in the production of those building materials and sequester massive amounts of carbon by tying up the wood in buildings.

Wood is the only renewable building material that has grown with sunlight and uses atmospheric CO2 to develop. However, this potential for the use of wood as a smart alternative for GHG emission in the construction industry generally meets the Brazilian tradition in processing timber in the way of keeping the focus on the production of solid high density wood, which has its charm and usefulness. However, to shift the general logic of using wood in the construction industry to upscale its reach and competitiveness for the housing sector it is needed to develop a new industry and a new market for highly processed wood products, such as wood-frame panels or laminated wood panels.

Glulam and or CLT are industrialized products and like any industrialized product the value of its cubic meter is increasingly taken into account the more it is produced. Increasingly wood technology has been well received in the Brazilian market and the engineered wood product has gained shape and knowledge.

The Brazilian market needs to understand that we need a fast and sustainable solution for the next generations and that is why our company Rewood worked hard to build the first timber building in Brazil and to show that it is possible to build large structures with the engineered wood product.

4 STRUCTURAL TIMBER SYSTEM

The main material of the building is wood. Wood is flexible to apply a huge range of building types and applications (structural and aesthetic) and renewable. In addition, engineered wood is innovative, adaptable, and efficient for the uses in construction, therefore, the architects tried to bring out those strengths in design and construction.

The Building has a strong and geometric shape with modern design. The first floor has an opened (wide) rectangular shape and also other floors have rectangular medium spaces. The design objective of the DENGO is to maximize the use of wood in the structural and non-structural application rather than any other material.

The main structural system is made of glued laminated timber (glulam) post and beam grid structure with cross-laminated timber panels (CLT). The CLT is used as slab on glulam beams and glulam columns. The Columns are typically on a 5,4m x 5,4m grid, supporting the CLT floor assemblies. The columns were manufactured continuous with 10 meters length over the three floors with a typical cross-section dimension is 270x270 mm.

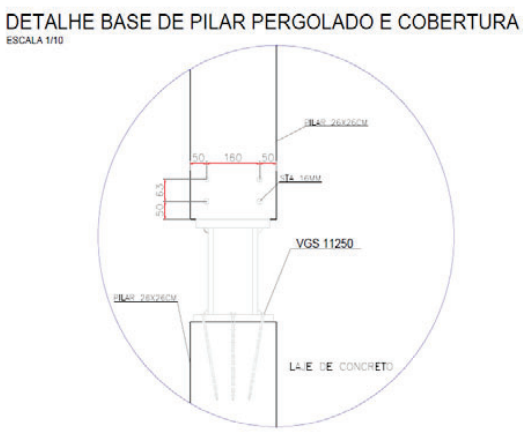

Figure 3: *Connection columns to column*

The 270x320 mm cross-section beams were framed into the column faces using a customized steel connector. The glulam elements are connected by steel plates and dowels. This is a commonly connection used in orther timber structures. Typically, 6 mm steel plates manufactured in Brazil and 12 mm dowels are imported from Rothoblaas in Italy. All the connections were recessed and encapsulated by the surrounding wood material, and is therefore inherently fire resistant.

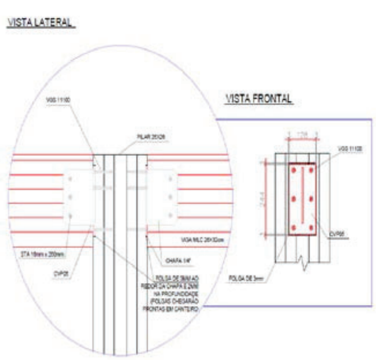

Figure 4: *Detail of connection Columns / Beams steel plate.*

The structural timber is with few exceptions covered behind either glass or metal sheeting. This protects the timber from rain and sun, increases durability and reduces maintenance.

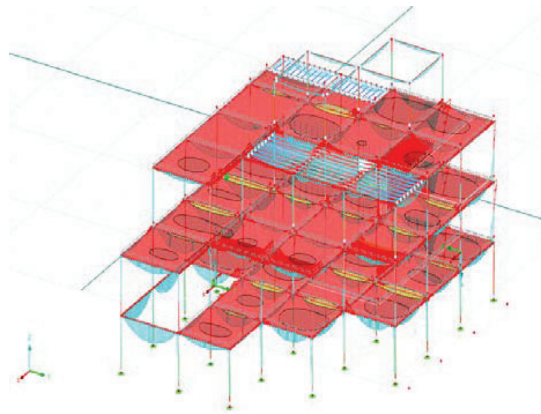

Figure 5: *Global RFEM-model of DENGO*

5 STRUCTURAL FIRE DESIGN

The current Brazilian codes and standards do not adequately address or provide engineering guidance for modern mass timber structures. Base on that, to made the building system we commonly adopt design methods and requirements from regions with well-established mass timber industries, such as those in Europe Eurocode-5.

For a building of this size, Brazilian standards require a 60 min fire-resistance rating on the primary structural frame. This rating is achieved through the charring effect of wood, which provides thermal protection of the competent wood below the char layer. The structural fire design is also performed according to the Eurocode 5. The so-called reduced cross-section method has been used, which determines the effective residual cross-section after charring, A notional charring rate of 38 mm/hr leads to a charring depth of 38 mm after 60 minutes.

Steel connectors are typically designed to rely on wood cover as their protection against fire. A similar concept is used to evaluate the required wood cover thickness to achieve a fire-resistance rating on a steel connector, they are not able to be protected with an adequate wood cover, care must be taken to provide some other means of fire protection. In the typical cases of column base plates and column- to-column connections, the steel is typically protected with a grouted pedestal or by painting the exposed steel surfaces with intumescent paint.

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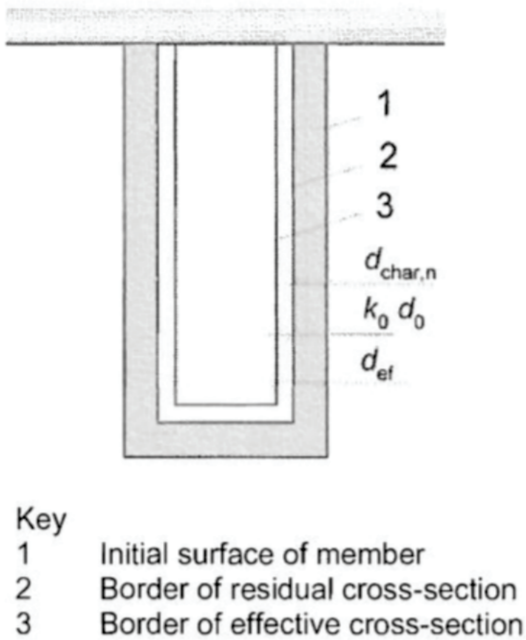

Figure 6: *Definition of residual cross-section and effective cross-section*

6 MATERIALS

All load-bearing structures in the building are wooden. Glulam is used for the columns and beams. Cross-laminated timber (CLT) panels are used for floor/ceiling and internal walls as the wood-frame system.

In the structural model, the properties stated for glulam strength classes GL24h are used. The CLT specifications have bending strength fmk=24 MPa, and properties similar to C24 structural timber. The totally of the glulam is made out Pine of Brazil. Glulam that can be exposed to weathering is made of copper-treated lamellas from Nordic Pine. Structural timber in the building modules and CLT is produced one side from Spruce and the other side is Pine of Brazil.

7 LOADING

The Eurocodes with national annexes for Norway were used to determine the design loads. The wind loading turned out to be the dominating load in the design combinations. The calculated maximum wind speed became V = 45.0 m/s, giving corresponding wind pressure of q = 0,90 kN/m2. The wind load was applied as a transient static load on two sides of the building. The wind load directions considered were 0° e 90°.

Self-weight is set to 5,5 kN/m3 for glulam and CLT, and 25 kN/m3 for the concrete topping. The following loads were applied:

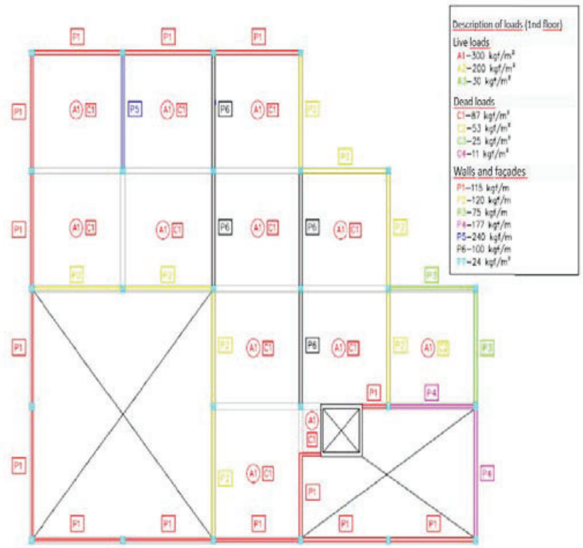

Figure 7: *First floor Loadings*

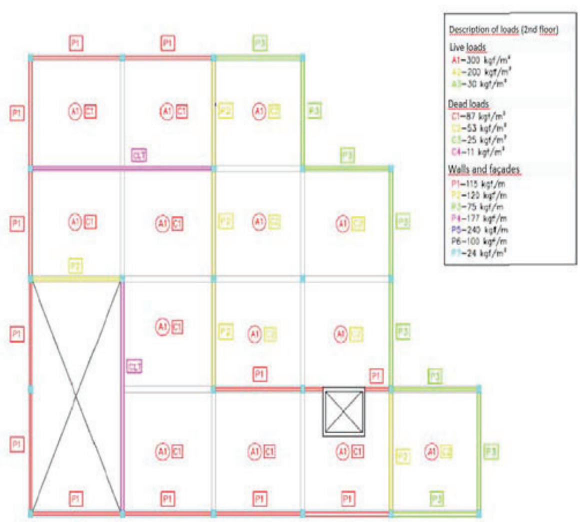

Figure 8: *Second floor Loadings*

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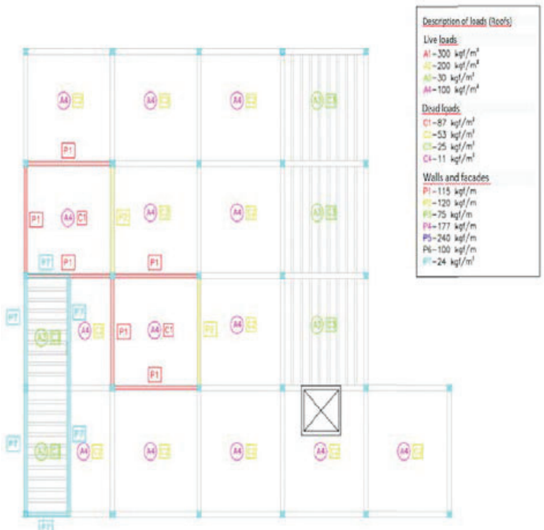

Figure 9: *Third floor Loadings*

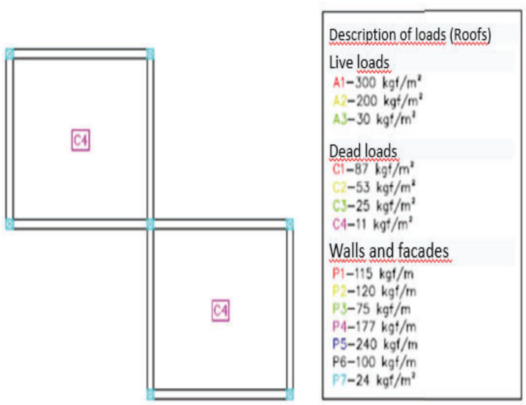

Figure 10: *Roof floor Loadings*

8 ASSEMBLY

The assembly of the building is mostly about installation of prefabricated elements on site. Optimizing the logistics and installation procedures are important to get a smooth building process. Rewood and Pedra Forte use a tower crane as well as a climbing scaffolding system during the building erection.

A step-by-step model ensures that the building can be built correctly. Below is a simplified visualization of the assembly.

The main structure was assembly with 37 days of work. At the moment of this study, the building is already finished September 2020.

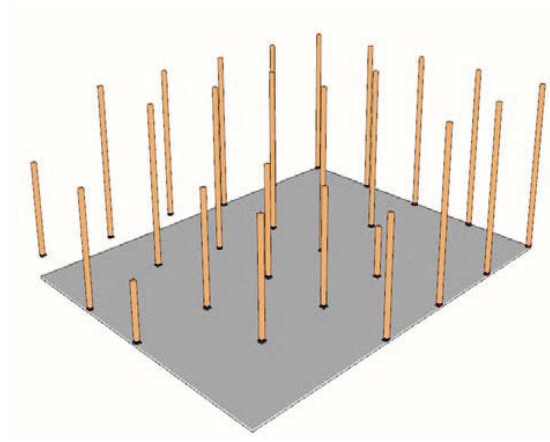

Figure 11: *Step 1*

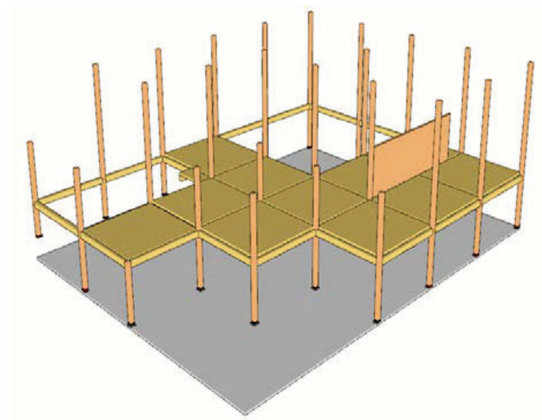

Figure 12: *Step 2*

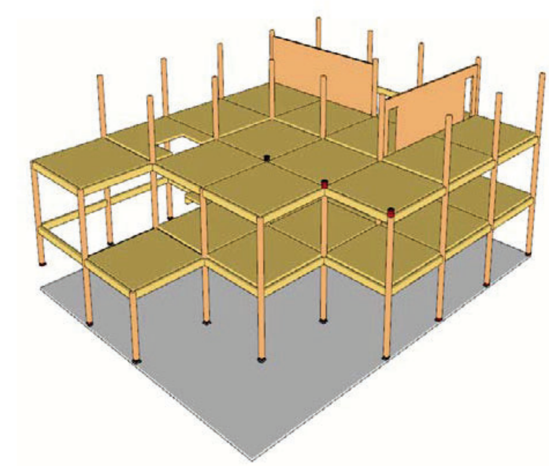

Figure 13: *Step 3.*

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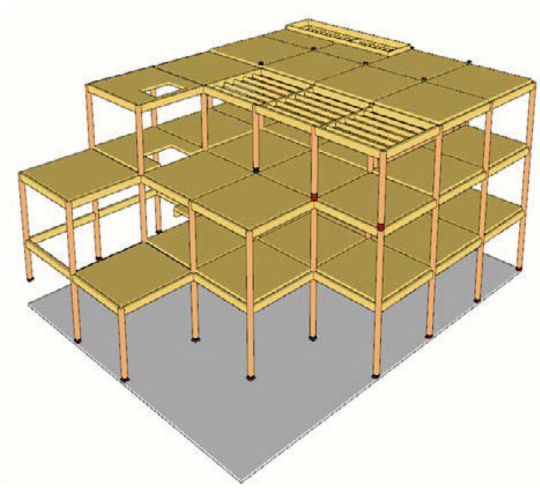

Figure 14: *Step 4.*

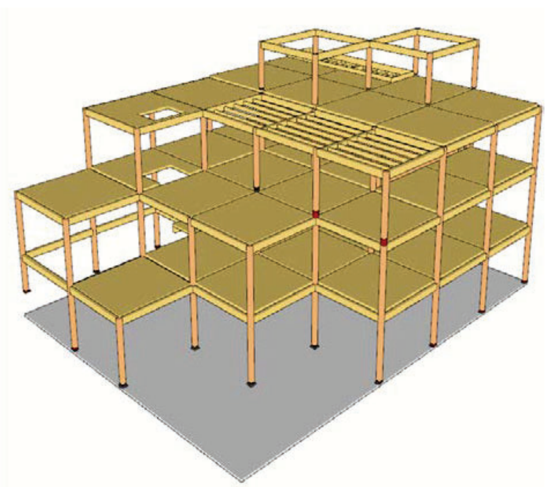

Figure 15: *Step 5.*

Figure 16: *First wood building in Brazil – outside view*

Figure 17: *First wood building in Brazil - outside view*

Figure 18: *First wood building in Brazil – under construction.*

Figure 19: *Completed buildng.*

9 CONCLUSIONS

We can conclude that the use of wood for building structures has high potential in the Brazilian market because besides presenting a fast and clean solution it provides volume in the production of engineered wood products. Consequently lowers the value of the product thus allowing a greater opportunity of competitiveness with other materials - it is a renewable and sustainable solution.

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10 ACKNOWLEDGEMENT

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