World Conference on Timber Engineering Oslo 2023

NLT DEVELOPMENT FOR BRAZILIAN MARKET – TESTS AND USE

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ABSTRACT: NLT is an old method of construction with a range of modern opportunity to create compelling architecture. Used in many historic applications, it is enjoying renewed interest as we rediscover the many benefits of mass timber and advance wood technology and manufacturing. Lightweight, low-carbon, and very compatible with high-performance buildings, innovation with NLT is inspiring new opportunities for large- and small-scale buildings across sectors and around the world. The use of new technologies in wood for construction is increasing every year in Brazil. This work aims to demonstrate the development and construction of the first NLT structure in São Paulo city.

KEYWORDS: NLT, Brazil,

1 INTRODUCTION

Part of the family of mass timber products, Nail-laminated timber (NLT) is mechanically laminated to create a solid structural element. NLT is created by placing dimension lumber on edge and fastening the individual laminations together with nails. Typically used as floors and roofs, NLT can also be used for walls, elevator shafts, and stair shafts. Plywood/OSB added to one face can provide in-plane shear capacity, allowing the product to be used as a shear wall or diaphragm.

The mass timber product range available in North America includes Glued-laminated Timber (GLT), Cross-laminated Timber (CLT) and Nail-laminated Timber (NLT). While this wide range of products affords many options for specific design applications, each has different design challenges, performance characteristics, and construction advantages.

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.

NLT is significant in the range of available mass timber options given the relative ease of fabrication and access to material; NLT requires no necessarily unique manufacturing facility and can be fabricated with local dimension lumber for use in applications across sectors and structure types. While products like GLT and CLT have modern publications and resources aimed at assisting designers and builders with specification, detailing, and installation, NLT resources are dated and focus on prescriptive rather than engineered applications.

In this work, test methods and results were performed at LaMEM (Wood and Timber Structures Laboratory), São Carlos Engineering School, São Paulo University, in Brazil. It was delivered 2 different NLT plates with dimensions of 91 x 1500 x 2600 millimeters. The element is made up of 34 lamellae of Pinus taeda, each measuring 44x80x2600 mm, nailed together by two distinct arrangements of ring nails measuring 35 mm in length and 3 mm in diameter. This set is coupled to an OSB APA Structural board 11.1x1200x2600 mm using nails of the same model as the previous one.

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https://doi.org/10.52202/069179-0564

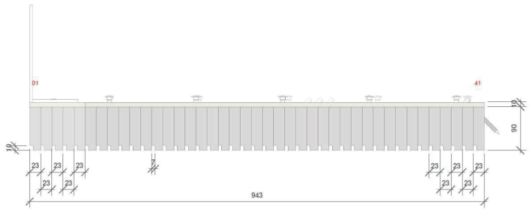


Figure 1: test scheme NLT plate

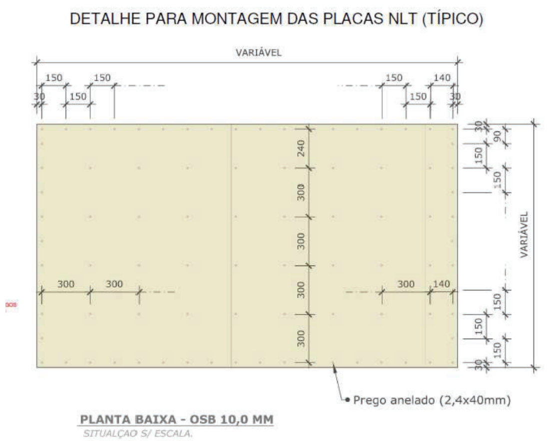


Figure 2: *test scheme NLT plate / OSB*

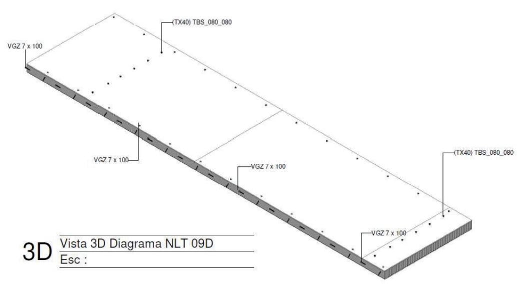


Figure 3: *test scheme NLT plate / OSB*

The NLT 1 board has 1 nail every 270 millimeters that alternates the height with respect to the section, as shown in Figure 1. The NLT 2 board has 2 nails every 270 millimeters, spaced 30 millimeters apart and 25 millimeters apart with in relation to the section limits.

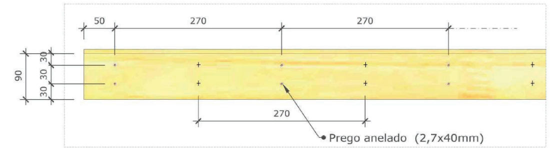


Figure 4: *test scheme Nail - NLT plate*

2 METHODS

The board tests were performed according to PEREIRA (2014) which is based on ASTM PRG 320 and whose scheme is illustrated in Figure 1.

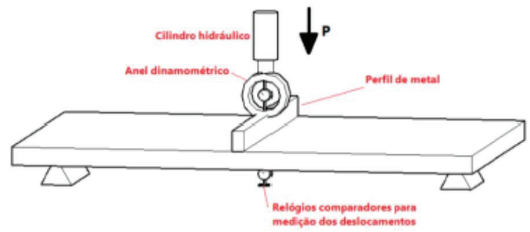


Figure 5: *test scheme*

This procedure was carried out by positioning the NLT plate, with the direction of the pine lamellae oriented towards the span, on two supports composed of metallic tubes positioned 100 mm from the edges of the plate. Then, a steel profile beam I was positioned on the central axis of the plate and the hydraulic cylinder was adjusted so that its center coincides with the center of the face of the NLT element. Finally, 3 strain gauges are positioned on the underside of the plate, along the axis of the metal beam. One of them is aligned with the axis of the hydraulic cylinder and the other two are equidistant in the middle of the distance between the center of the plate and its edge.

Figure 6: *NLT board assembly*

https://doi.org/10.52202/069179-0564

Figure 7: *Detail of the positioning of the strain gauges*

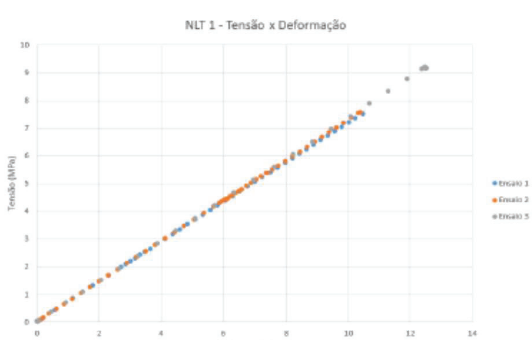
The procedure adopted was to apply the load gradually until the limit of l/300 was reached, with the value of the span being measured by the distance between the supports of the plate. Thus, the load was applied until the limit of 8 millimeters was reached. The load was then relieved and the procedure was repeated two more times, and in each process the applied force and the respective displacements were recorded by the software.

Finally, the load was increased until the NLT element ruptured, and the critical values were recorded. The figures below illustrate the rupture of both NLT plates, which was caused by traction on the lower fibers of the pine lamellae.

Figure 8: *NLT panel rupture details*

3 RESULTS

Based on the results obtained for certain forces and displacements, it was possible to generate 3 stress x strain curves for each plate. It can be observed that as the tests were performed up to a strain of 8 millimeters, there was no material flow in none of the 3 analyzes of each NLT plate, which corroborates the linear arrangement of the graphs presented, having elastic behavior in this interval.



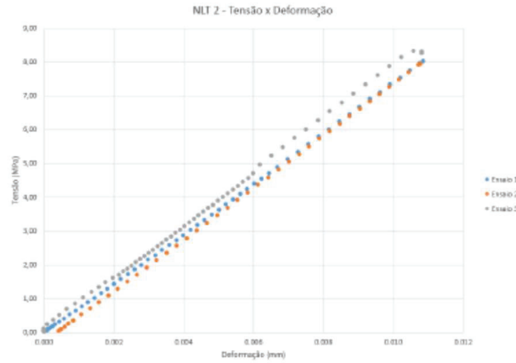


Figure 9: *Tension x Deformation curve of the NLT plate*

Next, the summary table of the performed assay is presented, containing the average of the MOE of the 3 assays performed for each NLT plate.

Table 1: *Margin settings*

NLT plate 1				
Test	Desity	Rupture	MOR (kfg)	MOR (kgf)
1	570,5	9327	8614	34
2			8725	
3			8824	
NLT plate 2				
Test	Desity	Rupture	MOR (kfg)	MOR (kgf)
1	580,1	9081	8839	33
2			9170	
3			9173	

The results obtained were imputed in the RFEM calculation program for the structural calculation of the architectural proposal. The project was designed by the architectural studio MK27.

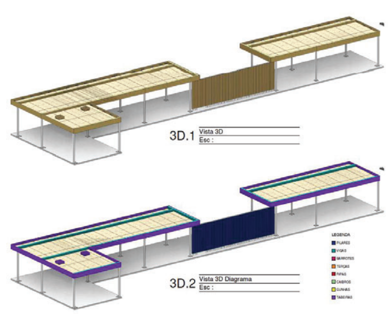


Figure 10: *architectural proposal*

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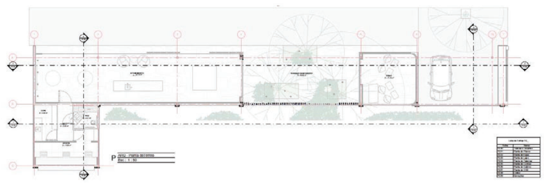

Figure 11: *layout structure*

The big difference in using NLT in this project was that instead of the boards being placed on top of the beams, they were actually used hanging.

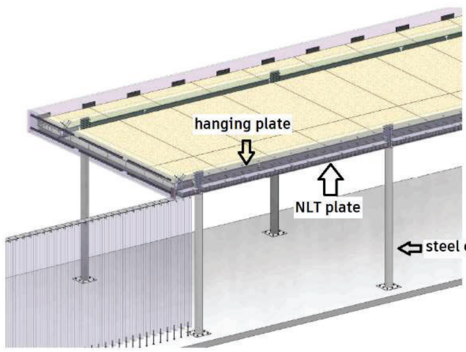

Figure 12: *structural detail*

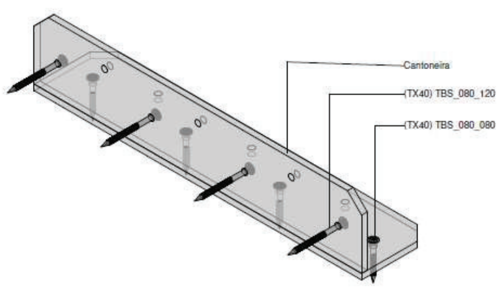

Figure 13: *structural detail*

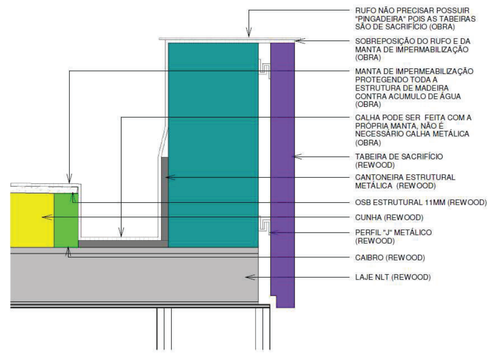

Figure 14: *structural detail*

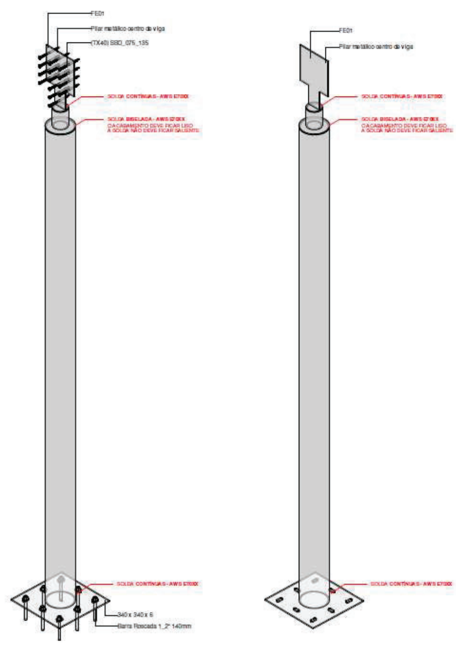

Figure 15: *structural detail*

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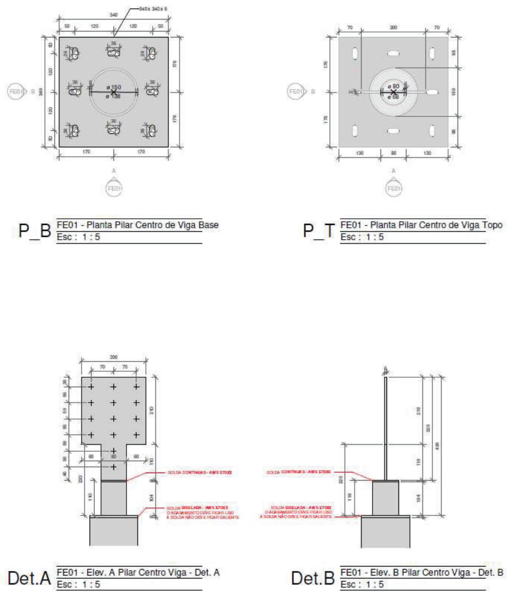

Figure 16: *structural detail*

The entire work, after being manufactured, was assembled in just 15 working days, showing not only its speed but also that wood is still and always will be a symbol of modernity.

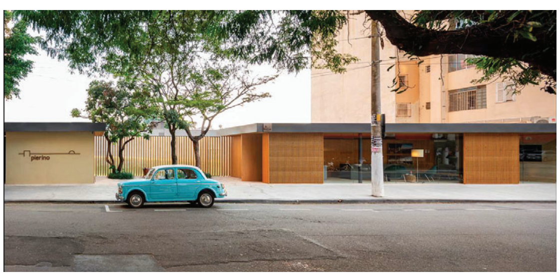

Figure 17: *completed work*

Figure 18: *completed work*

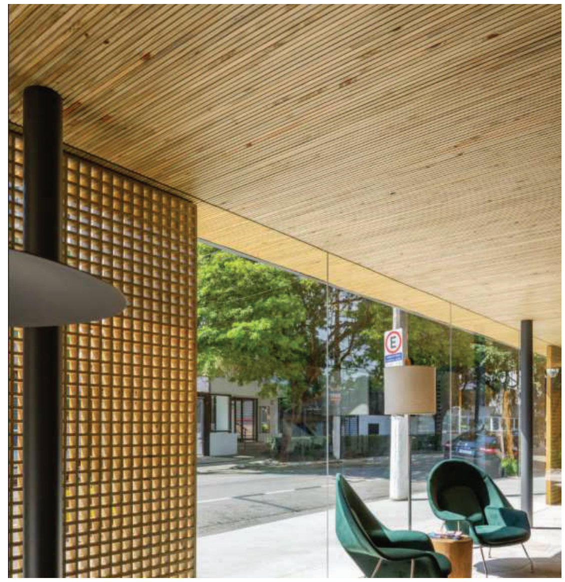

Figure 19: *completed work*

Figure 20: *completed work*

Figure 21: *completed work*

4 CONCLUSIONS

The NLT product, despite being very old technology, still demonstrates very interesting physical and mechanical characteristics for today's projects and when well designed and used, its cost benefit and beauty stands out among the products used today in the Brazilian market.

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