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Metallic Trellis Project, Using the Cype 3d Program

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Abstract: In this article, a project is carried out for a metallic truss, a type of structure used to cover buildings and buildings, whether industrial or commercial. For this research, a computer program known as Cype 3d® was used, a program that contains a wide library of profiles with the main Brazilian and world manufacturers, registered, in addition to allowing the editing and registration of new profiles within existing series. Aware of the need to optimize resources, the design of metallic trusses using computer programs brings productivity and accuracy that are highly important in the construction of building roofs and any and all constructions. Based on previous knowledge about metallic structures, types of materials and their applications, models and types of trusses, it was decided to design a "Pratt" truss. and a metallic structure, known as a truss, of the Pratt type is needed. For this, the Cype 3d program was used. Applying pre-defined loads, efforts required for the project, such as loads and applied loads, and the requested material, using the program, accurately and with the correct strategy. So that after entering the data, you can reach the quick result in a short time, Allocation of resources necessary for the construction of these structures in an optimized way, as well as the generation of documentation for their manufacture.

Keywords: Metallic Lattice, Cype 3d, Metallic Structure

1. Introduction

This template, known as trusses, these structures have a wide field of application in engineering, being widely used in the construction of bridges as roofing structures, in power transmission towers, and a large number of other uses.

Usually built in steel and also in wood, with light characteristics, they are structures indicated for large spans or that received large loads. Therefore, the trusses become a highly viable economically and practical solution.

Since the loads are applied only at the joints, known as nodes, only normal forces result in the requesting force in the elements, therefore, the axial forces of traction or compression.

In the structural view, trusses can be planar or spatial. With regard to the elements that form them, they can be classified, according to their arrangement in the structure, basically in these categories: flanges (or ropes), diagonals and uprights. Due to the wide range of statically possible solutions to overcome a given span or support a given load, they present a very wide area for the use of customized techniques. Due to the analysis and dimensioning of structures, in general, it constitutes interactive processes, with the use of these techniques it is sought to save the maximum amount of necessary material without compromising the safety of the structure.

2. Trusses

2.1. Definition of Trusses

According to Souza and Rodrigues (2008) [14] trusses are linear structures formed by straight bars that together form triangular panels, whose request is basically due to traction and/or compression.

The elements that make up a truss are: • Rope: also called chord, this element is the set of bars that limit the truss, upper and lower;

1. Upright: vertical bar on a truss;
2. Diagonal: bar with the axis coinciding with the diagonal of a panel;
3. Panel: section between two consecutive mullion alignments,
4. Node: point of union between the ends of the bars.

The first reticulated structural trusses began to be used at the end of the 18th century, coinciding with the beginning of the use of cast iron as a structural material.

According to Souza (2003) [16], between 1942 and 1943, the first industrialized connection system for space trusses, the MERO system, appeared in Germany. This system is formed by a steel sphere where screws are connected to bars with a circular tubular section. This system was widely disseminated around the world, boosting the use of trusses in civil construction works.

According to Souza (2002) [15], the first applications of space trusses were carried out by Graham Bell in 1907, when he developed articulated structural systems formed by prefabricated steel bars. In Brazil, the acceleration in the use of trusses took place in São Paulo, at the end of the 1960s. It was at that time that the Anhembí Exhibition Center was built and, for its construction, a space truss was used, designed by Cedric Marsh (engineer Canadian), composed of 48,000 tubular aluminum bars, covering an area 11 62,500 m^2. To this day, it is one of the largest aluminum structures in the world.

After this construction, countless others emerged in the country, including with international repercussions, as was the case of the spatial truss used on the roof of the Brahma brewery, in the city of Rio de Janeiro. This is the largest space truss in the world, covering an area of around 132,000 m^2 with clear spans of 30m and 60m. Another outstanding construction was the coverage of the Brasília Exhibition and Fair Pavilion, with coverage of approximately 57,000m^2 built in just 100 days (SOUZA, 2003) [16].

Metal trusses, according to Sales, Sousa and Neves (2001)[12], have their own constructive methodology and not knowing this technology leads to the adoption of a solution incompatible with the structural system, so this type of construction requires knowledge of the potentialities and limitations and great attention in planning and interaction from project conception to completion of the work.

Trusses are formed by bars connected at the ends, forming a rigid set. The joining points of the bars, called truss nodes, are admitted labeled, although the connection has some rigidity (SOUSA 2002) [13].

As for their geometric shapes, the trusses have the most varied configurations and the materials most used in their manufacture are: steel, wood and aluminum. According to their geometry, trusses are classified into plane and spatial. (DI PIETRO, 2000) [5].

Steel trusses have a major advantage in construction, Ferraz (2003) [6], states that the properties of steel depend on its chemical composition, the size of the grains and its uniformity, and the heat treatments and mechanical work to which this material is subjected can modify some of these aspects in different intensity, as well as alter the properties of a certain type of steel, giving it specific characteristics, soft or hard, brittle or tenacious, among others. sized correctly.

According to Dias (2006) [4], steel is a metal alloy of iron and carbon obtained by refining pig iron, which may contain other elements according to its purpose, thus steel trusses are a great advantage.

Ferraz (2003) [6] states that the properties of steel depend on its chemical composition, the size of the grains and its uniformity, and the heat treatments and mechanical work to which this material is subjected can modify some of these aspects in different intensity, as well as change the properties of a certain type of steel, giving it 13 specific characteristics, soft or hard, brittle or tenacious, among others, so it becomes imperative that the structure design be dimensioned correctly.

Steel is used because it bonds well with concrete, has a similar coefficient of thermal expansion, and is strong and relatively economical (DALDEGAN, 2017) [3].

For (BRITO and SILVA, 2016) [2] metallic structures in Brazil are a recent technology, compared to other parts of the world, they are used to replace conventional materials used in beams, pillars and conventional slabs, and the choice of the type of steel is made depending on aspects related to the environment where the structures are located; prediction of the structural behavior of its parts, due to the geometry and the requesting efforts; industrial environment with aggressive atmosphere to the structure;

According to Galvaminas (2020) [7], among the main advantages of using trellises, one can highlight: practicality and productivity.

Trusses, according to the distribution of their constituent elements, are classified into plane and spatial.

Flat truss A flat truss is the one whose set of elements are interconnected, with a triangular geometric shape, through pins, welds and screws and which aim to establish a rigid structure, with the aim of resisting normal efforts. Its main characteristic consists in the fact that all the elements that constitute this type of truss belong to the same plane. The main use of these structures is in the construction of bridges and roofs (SOUZA, 2003) [15].

The spatial truss is designed to respond both to localized action and to effectively distribute the efforts among its elements, that is, it requires the interconnection of the constituent elements of the truss. Axial loads are supported by bars and nodes, being distributed in space. According to Souza and Rodrigues (2008) [14], this system works in an integrated way, that is, when a member reaches its maximum capacity, the others support the additional loads. The main advantages of using space trusses are: good ratio between self-weight and span of the structure, ease of construction and transport, low cost compared to other structural elements, in addition to its aesthetics.

A composite truss is one formed by two simple trusses, connected by three bars that are not simultaneously concurrent or parallel, or even formed by a node and a bar, where this bar does not compete with the node (SOUZA; RODRIGUES, 2008) [14].

2.2. Cype 3d

Metálicas 3D is a software for the design of Metallic, Aluminum and Wood Structures that includes the stages of structural calculation and dimensioning of metallic structural elements, aluminum structures and wooden structures.

It has an easy graphical data entry, where the user can draw the structure with a practical dimension command. Just inform the dimensions of the project or import a drawing made in any CAD software (dwg or dxf files) and the lines of the drawing will be transformed into bars, without the need to redraw the entire structure.

The METÁLICAS 3D software contains a wide library of profiles with the main registered Brazilian manufacturers, in addition to allowing the editing and registration of new profiles within existing series.

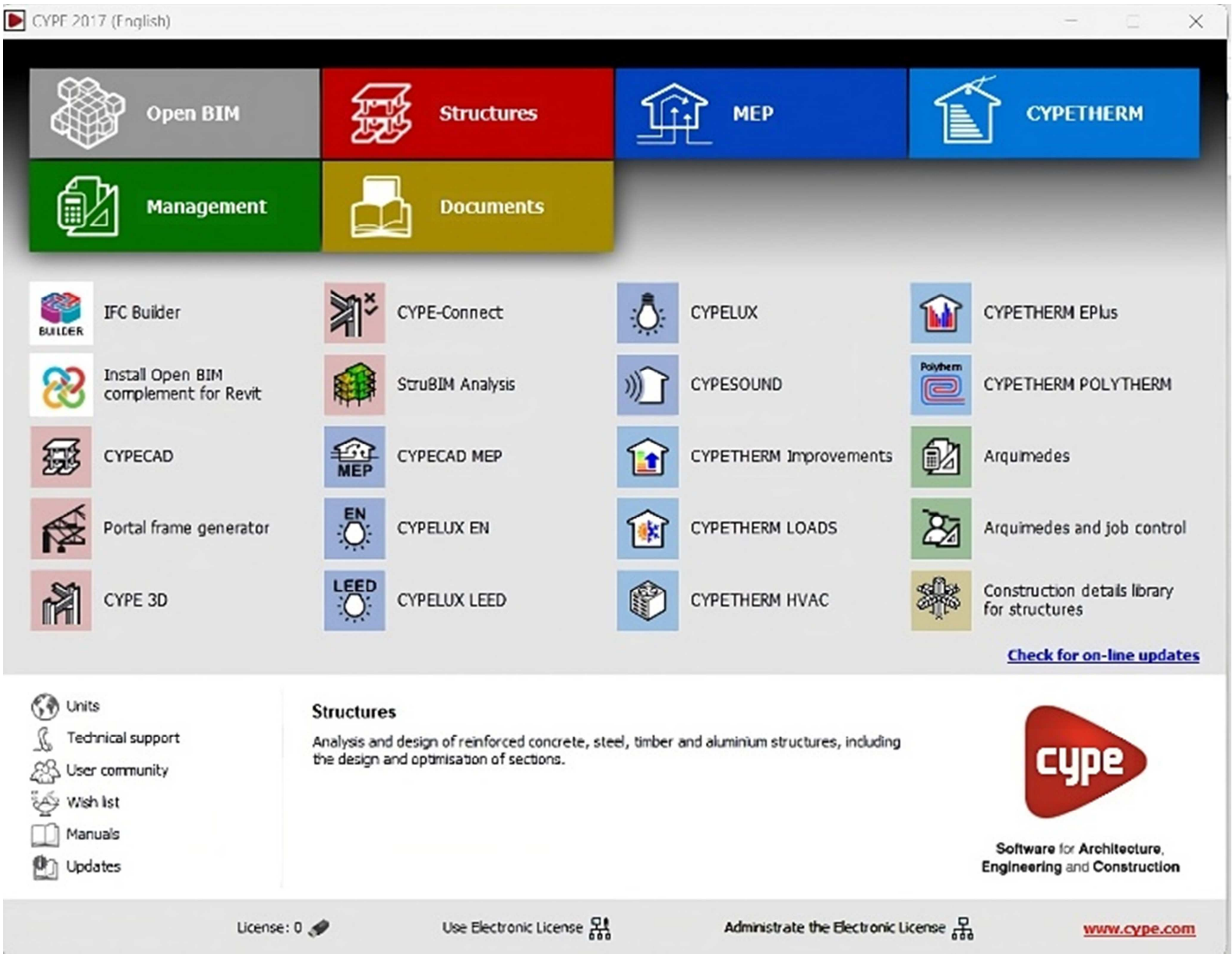
Through the automatic calculation of the buckling coefficients, the software automatically determines, depending on the nodes of the structure, the most appropriate values, even for complex structures, allowing the engineer to adopt the coefficient he deems most appropriate.

After calculating metallic, aluminum and wood structures, the Metálicas 3D software generates a report with all the bars that do not satisfy any verification according to the chosen standard and indicates which profile would be the correct one for that situation. With the resizing resource, the software automatically changes all the bars that are not "passing", thus sizing a structure with the lowest possible weight.

The Metálicas 3D software for calculating and dimensioning metallic, aluminum and wooden structures uses the following Technical Standards: ABNT NBR 7190: 1997 - Design of wooden structures [1], ABNT NBR 14762: 2010 - Steel structures consisting of cold-formed profiles [1], ABNT NBR 8800: 2008 - Design of steel structures and composite structures [1], ABNT NBR 8681: 2003 - Actions and safety in structures - Procedure, ABNT NBR 6120: 1980 - Loads for the calculation of building structures [1], ABNT NBR 6123: 1988 - Wind forces on buildings [1], AISC ASD 89 - American Institute of Steel Construction, AISI 2007 - American Iron and Steel Institute.

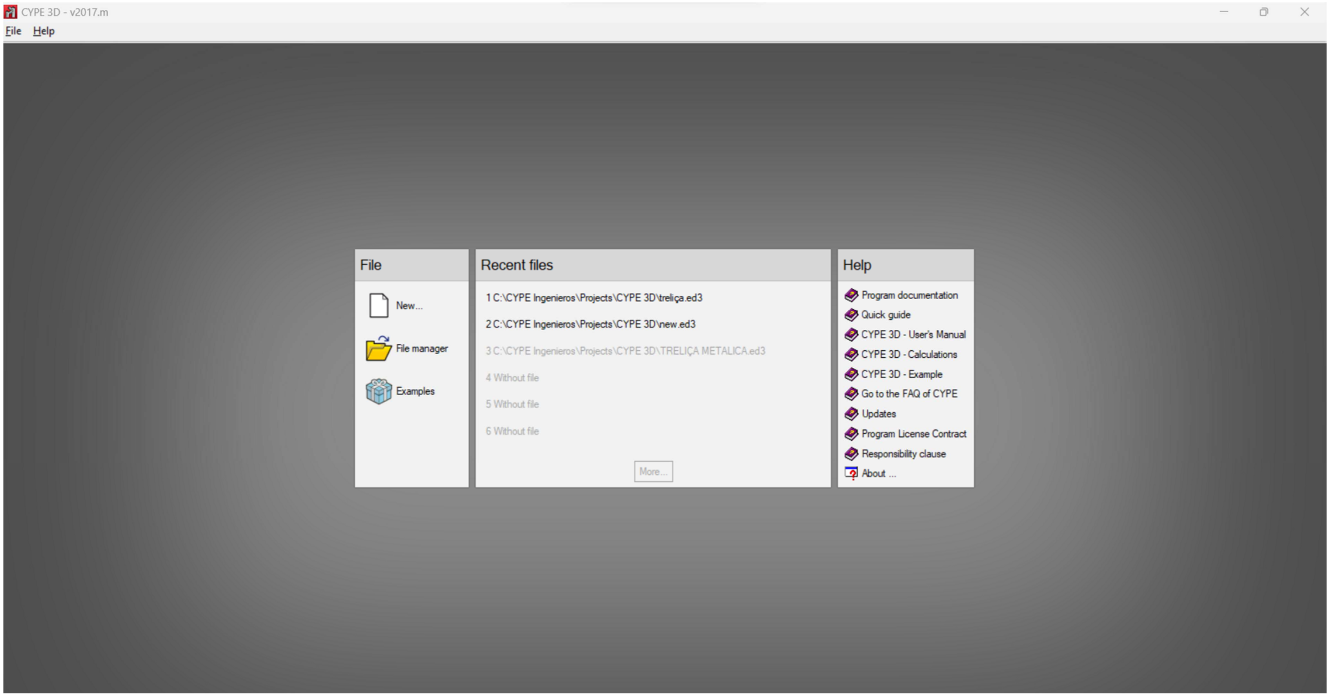
3. Designing the Truss in Cype 3d

Opening the program, the initial screen, in figure 1, shows the icons in an intuitive way, if you click on the cype 3d icon, showing the available options.



Source: Author-2023

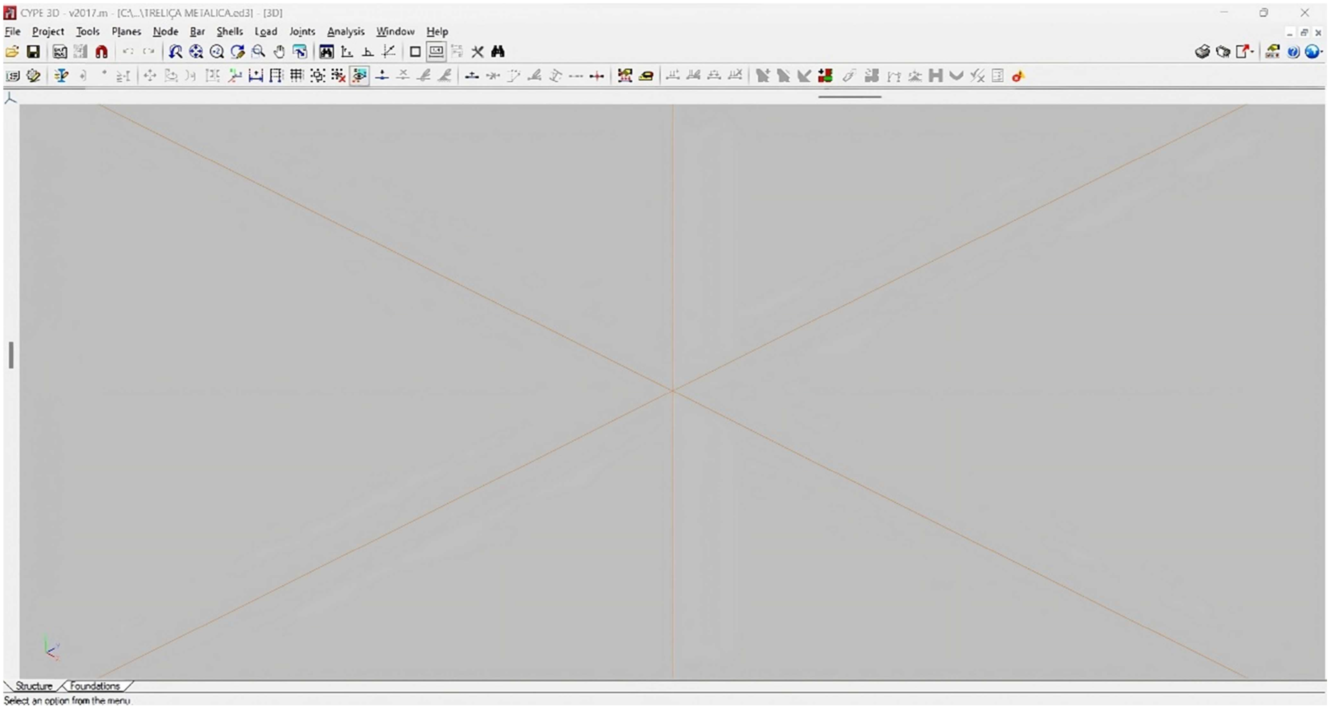
Figure 1. *Cype 3d® Home Screen.*



Source: Author-2023

Figure 2. *Screen New Project Cype 3d®.*

Clicking on cype 3 d, the next window, figure 2, shows the initial page of the project, clicking on new (new project), the program leads to the definition of molds to be used and the materials applied in the project. After these definitions, a window opens, figure 3, where the truss will be modeled and generated from the defined loads.

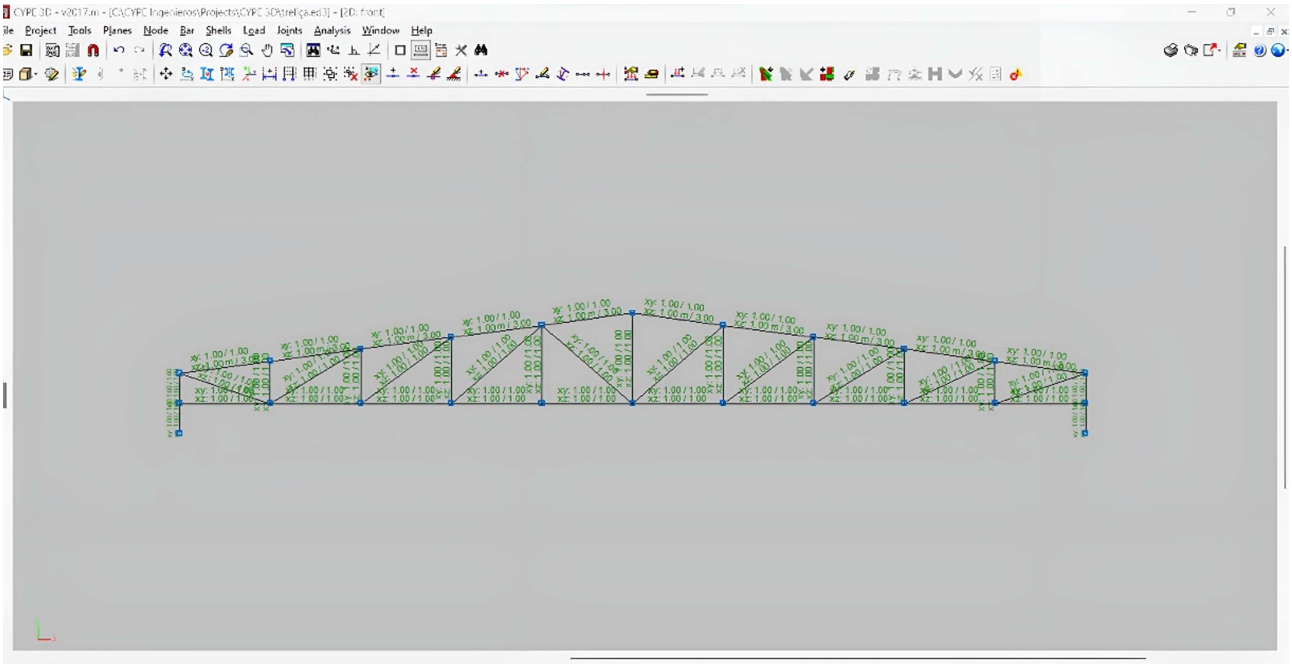


Source: Author-2023

Figure 3. *Cype 3d® Modeling Screen.*

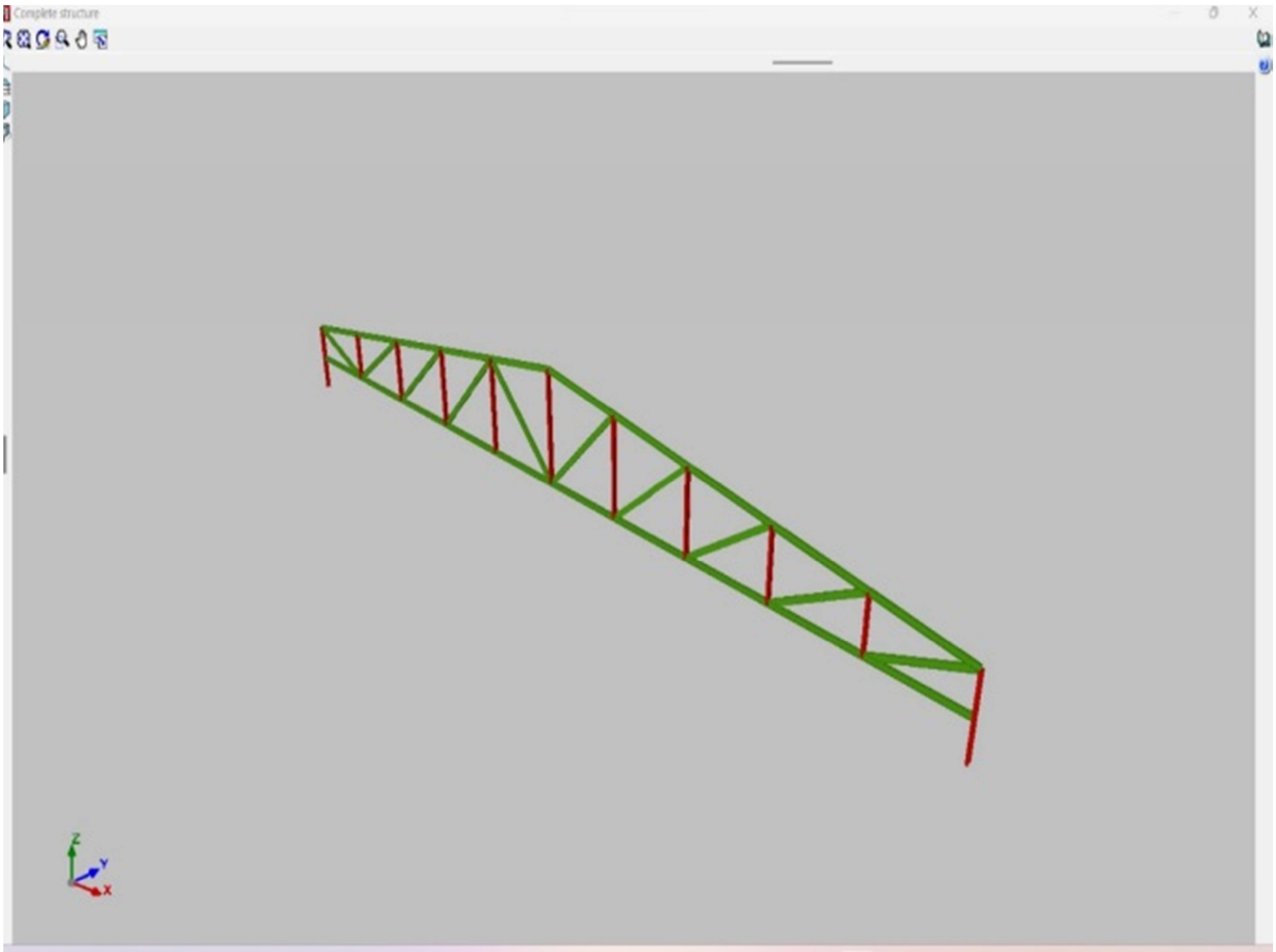
From this screen in the commands, model whether the truss, the defined measures, were 15 meters long with a height of 1.5 m at the ridge.

The geometry is defined, and it already divides the nodes where the loads will be applied, and applies it to lateral arrows.



Source: Author-2023

Figure 4. *Cype 3d® Modeling Screen.*

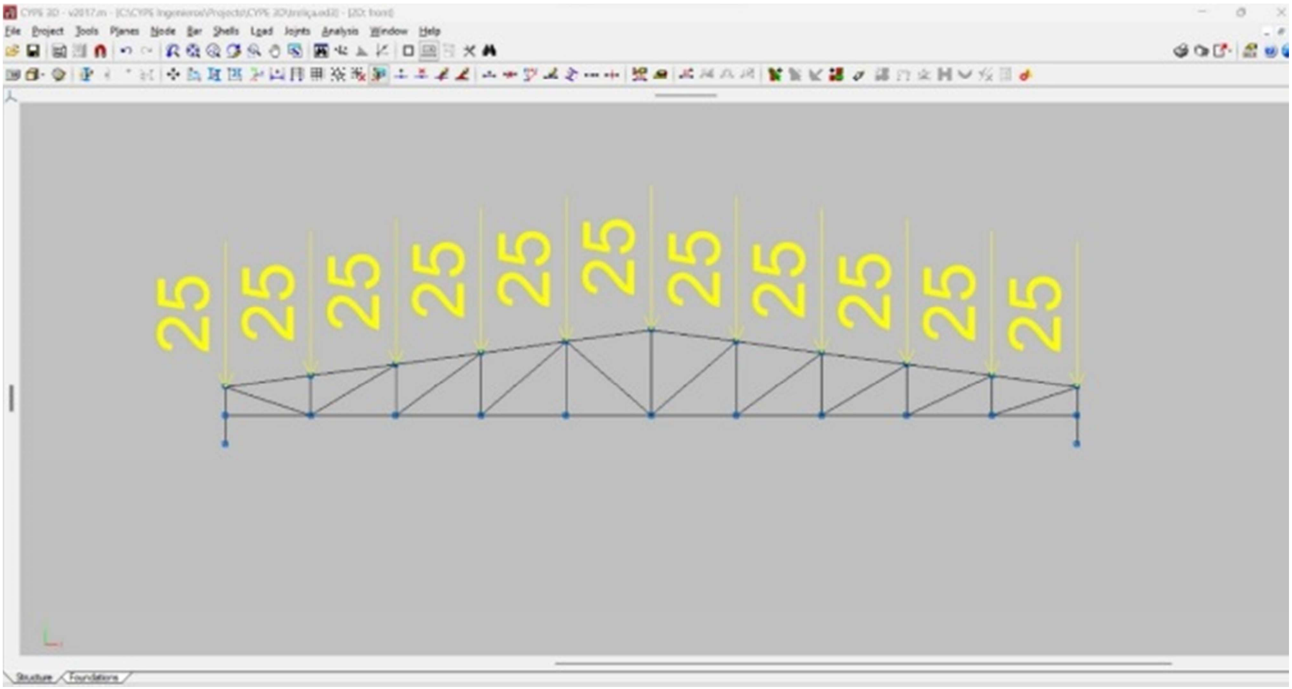


Source: Author-2023

Figure 5. *Model Truss, 3d Projection.*

The applied load, in a didactic way, was 25 kg per node, according to Gesualdo (2003) [8] the loads on a truss are considered as acting on the upper nodes of the structure.

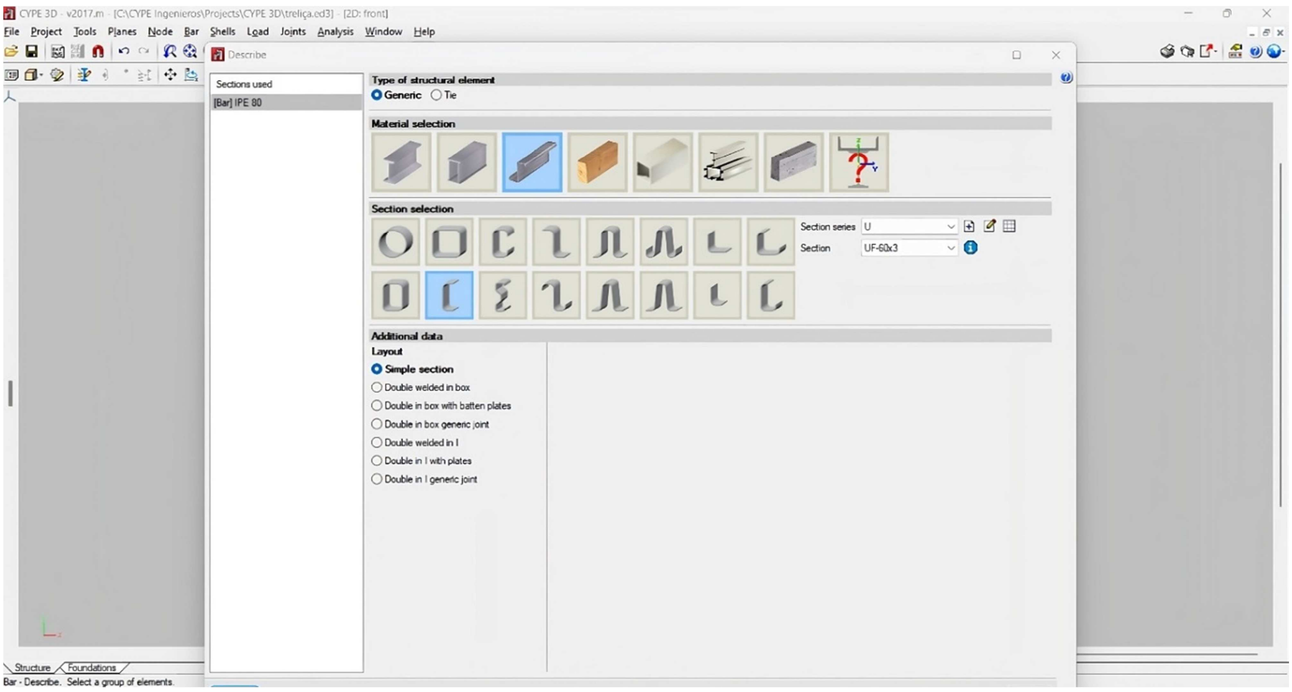
In figure 6, the load applied to all nodes of the truss can be seen, Rigo (1999) [10], states that the rapid evolution of personal computers has served as a motivation for research on new methodologies used in structural projects and without the necessary simplifying assumptions to manual calculation.



Source: Author-2023

Figure 6. *Load Applied to Us.*

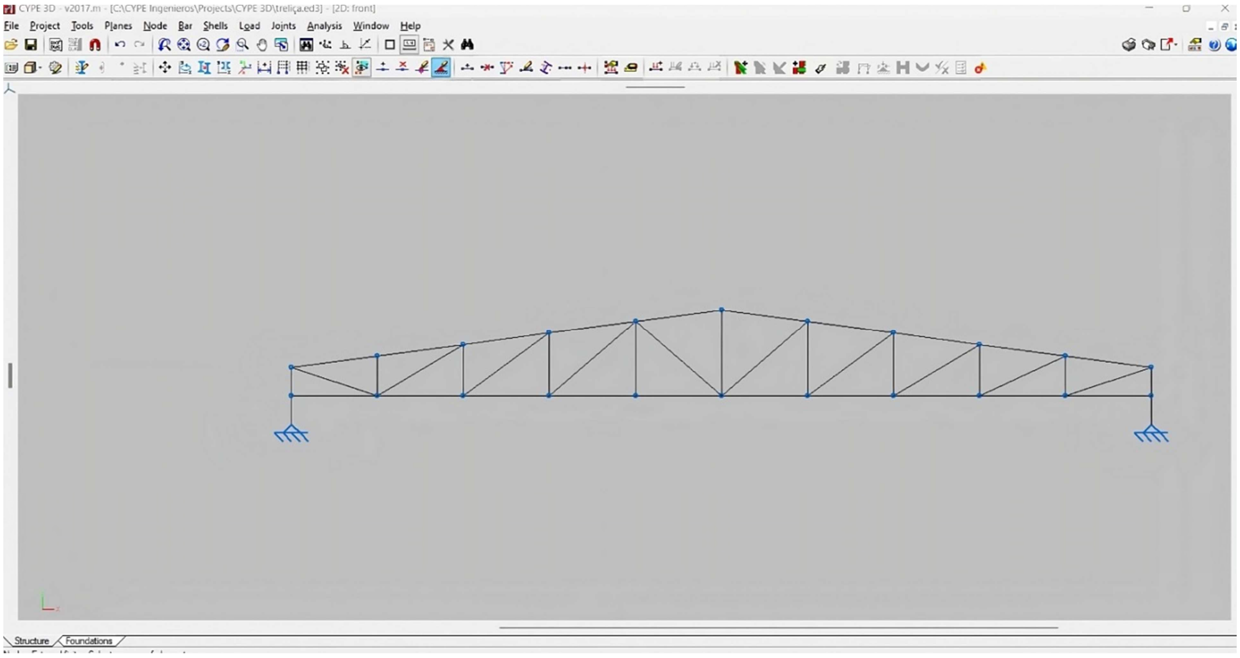
After modeling the truss, it is time to define the material and the type of profile to be used in the truss. The program offers a wide range of materials and profiles, for practical purposes, we chose to use a “u” profile, measuring 100×80×6.3mm.



Source: Author-2023

Figure 7. *Choice of Metallic Profile.*

Right after applying the metallic profile and untying the knots, figure 7, which will allow the program to manage the calculations and check the limits.

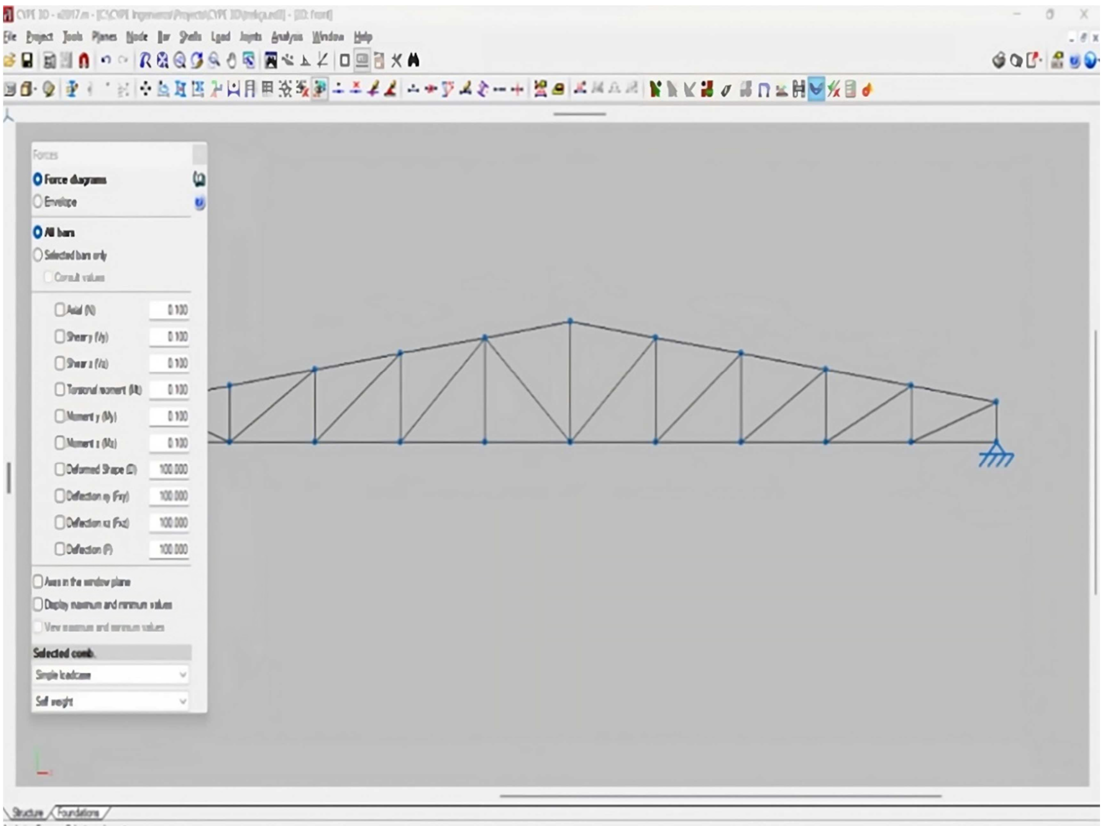


Source: Author-2023

Figure 8. *Untying Us.*

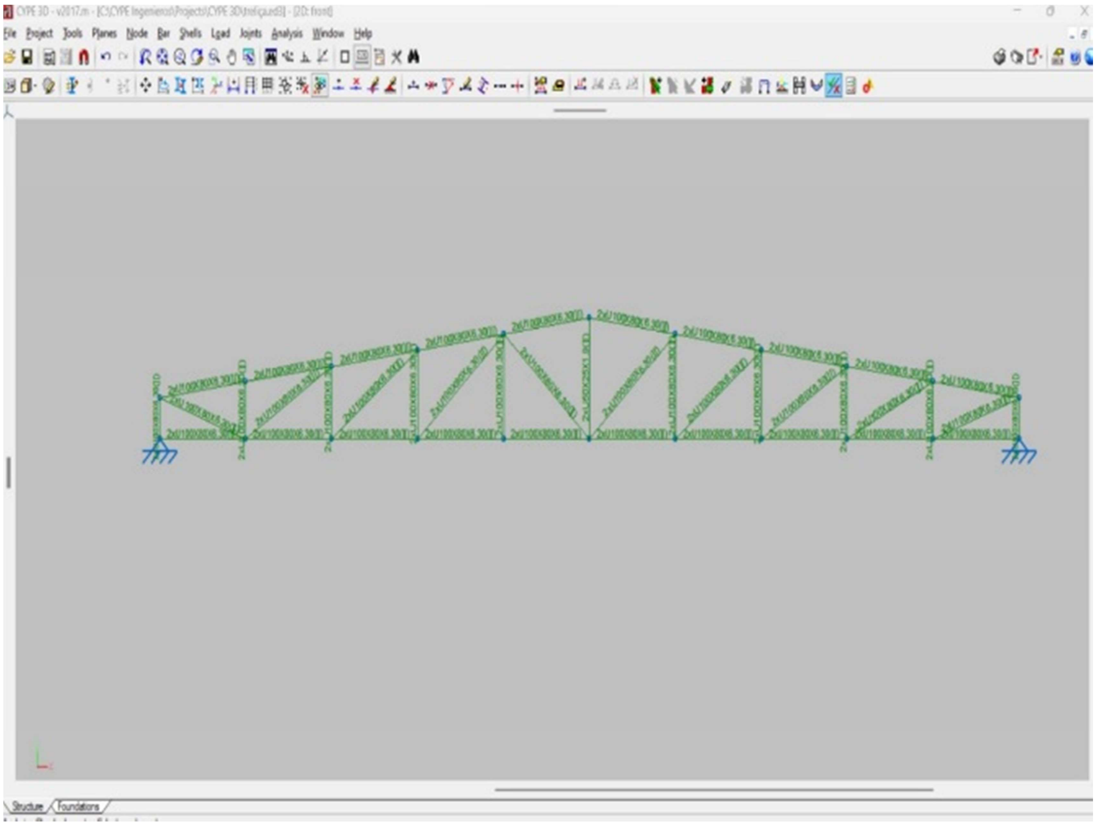
After unlinking, the calculations are processed, figure 8 and the acting forces are shown, as can be seen in figure 8.

If everything happens correctly, the program shows the applied forces and generates a screen showing the displacement, figure 9.



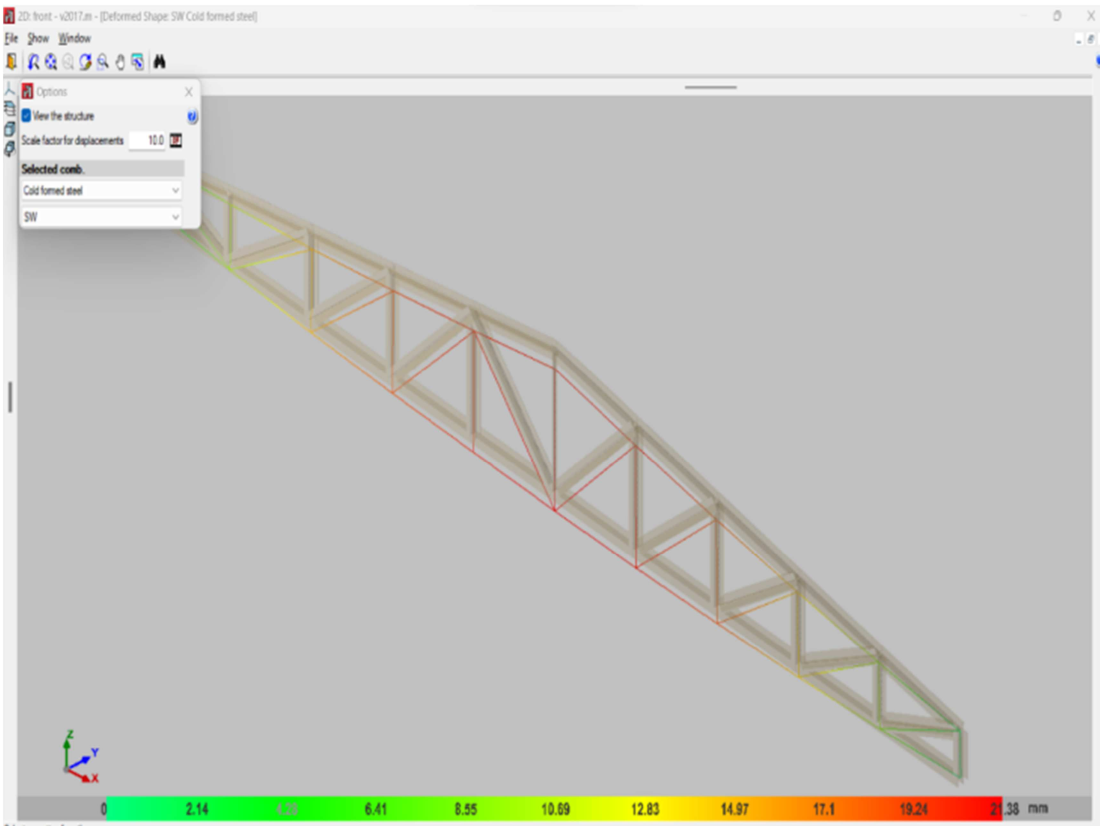
Source: Author-2023

Figure 9. *Truss After Generation of Calculations.*



Source: Author-2023

Figure 10. *Truss After Generation of Calculations.*

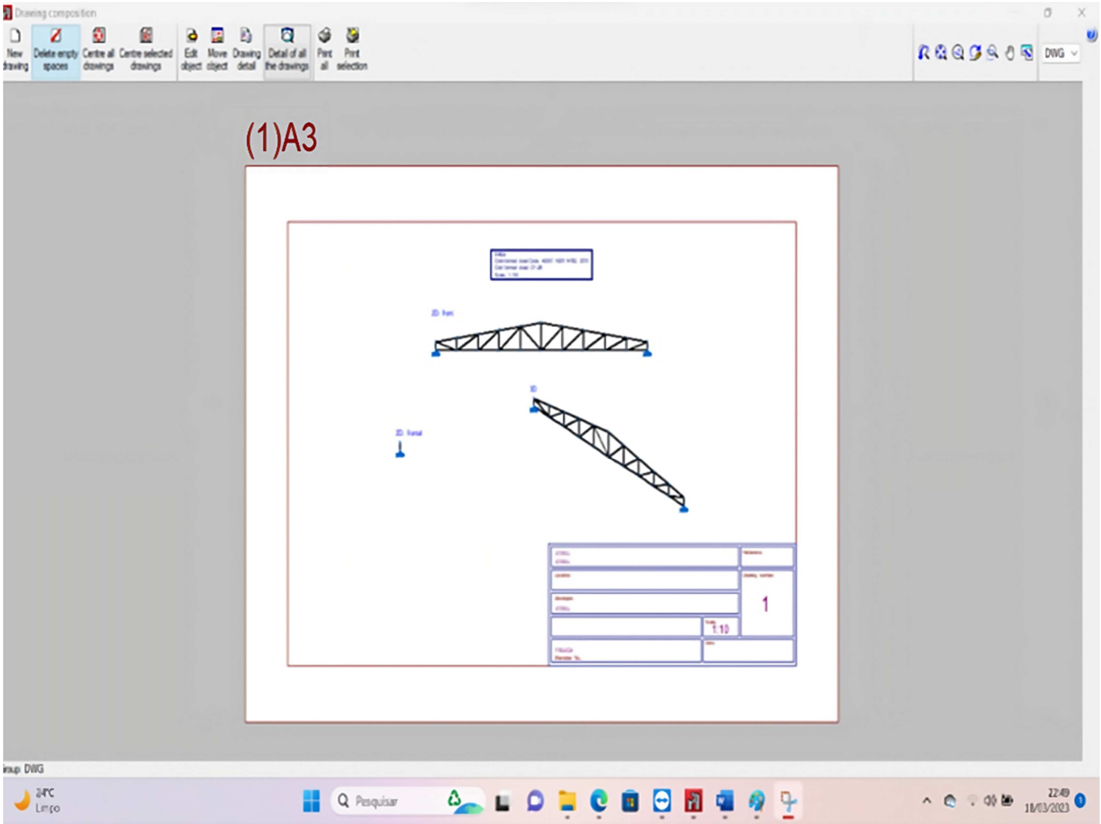


Source: Autor-2023

Figure 11. *Displacements.*

NBR 8800: 2008 [1] (engineering standard in Brazil) classifies structural analyzes according to the effect of displacements in linear or non-linear analyses. While linear analysis (or first-order theory) is based on the unreformed geometry of the structure, non-linear analysis uses deformations to determine new displacements and internal efforts.

For this structure, the maximum displacement observed was 2 cm (21mm), which can be seen in figure 11.



Source: Author-2023

Figure 12. *Generation of Documents.*

The program can generate detailed drawings for manufacturing, figure 12, although simple documents are generated, the possibility of exporting them to DWG format, a format that can be manipulated in other CAD-type programs. According to NASCIMENTO and SANTOS, 2001 [9], CAD, Computer Aided Design. They appeared in 1980 in the information technology (IT) sector.

Romiero, (2011) [11] states that the architecture of the product serves to describe how the components of the product are organized and how they interact with each other, in this way the generation of detailed drawings is another tool that facilitates the design of trusses.

4. Conclusion

Civil construction increasingly needs methods and materials that optimize the issue of quality and total time spent, so the metallic structure with its nuances fills these gaps because it is a simple method of easy application.

The Cype METALLIC 3D program contains a wide library of profiles with the main Brazilian and world manufacturers registered, in addition to allowing the editing and registration of new profiles within existing series.

Through the automatic calculation of the buckling coefficients, the program automatically determines, depending on the nodes of the structure, the most appropriate values, even for complex structures, allowing the engineer to adopt the coefficient he finds most appropriate.

After calculating the structures, the Cype Metálicas 3D program generates a report with all the members that do not satisfy any verification according to the chosen standard and indicates which profile would be the correct one for that situation.

With the resizing feature, the software automatically changes all the bars that are not "passing", thus sizing a structure with the lowest possible weight.

It is concluded that one of the great advantages of using metallic structures in civil construction is the speed and the possibility of overcoming large spans without extrapolating the cross section of the beams. In this way metallic structures can be an excellent constructive method, not only in industrial constructions but also in residential constructions with gains in productivity and manufacturing and execution time.

In view of the practicality, speed and architectural aspect of metallic structures, Brazil is taking short steps towards the adoption of this constructive method, which is so widespread in other countries such as the United States and England, where metallic structures are already present in up to 70% of large buildings.

The economic issue may be the inhibiting paradigm for the growth of construction of metallic structures, in Brazil, perhaps due to cultural issues, this constructive method is still little used due to the simple paradigm that it is an expensive and difficult method to be executed, despite the costs being up to 30% more expensive compared to wood, for example, the metallic structure is compensatory, since this price difference is widely diluted in the manufacturing process.

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