Stress Analysis on a "L" shape Truss Optimization

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Abstract—The metal construction market in Brazil has grown significantly over the past few years. The weight reductions and performance increase of mechanical pieces obtained by using optimization techniques are significant to the point that currently its use is critical to define that competitiveness of the metal-mechanical engineering industries, and its undeniable importance in reducing costs. The optimization applied in the mechanical part design consists of using computational methods for dimensions, shape or optimal topology of parts. This study aims to propose a study methodology to analyse the stress distribution thought the use of mathematical software and photoelasticity techniques, to propose a new structural profile, lighter and more efficient, which may be used as solution to overcome the current constructive limitations.

Keywords—Structural optimization, Stress analysis, Equal legs angles, Phoelasticity.

I. INTRODUCTION

The constructive method based on the use of metallic profiles was diffused from the 18th century in Europe, when construction of bridges and buildings based on this technology began. The method has been growing significantly in Brazil over the last few years. The use of metal structures has significant participation in situations where large spans are needed and to achieve advantages such as quickness in project execution time and waste reduction. Sustainable development is an essential theme in our daily lives, and the construction industry has a fundamental role in this field. According to (Grigoletti, [1]) industries have been searching to optimal structures development more than ever, that is, structures with higher structural performance, lower weight and manufacturing cost.

The geometry of the metal profile in which this work focuses is the 'L' angle. Because they are lightweight and have high tensile and compressive strength, the angle profile is used mainly in the construction of electric power towers. This profile is composed of two flaps that form a 90 degree angle between them, and according to (Bonatto, [2]) it is widely used due to its constructive simplicity and versatility.

This paper proposes to make a study about the angle profile "L", seeking to develop a lighter and more efficient structure, through the use of mathematical simulation software and structural optimization techniques.

II. STRESS ANALYSIS

2.1 PHOTOELASTICITY

The Photolasticity Technik is according to (Shiavon, [3]) a method that uses optical effects allowing the stress analysis in a fest and qualitative way. As a necessary instrument is there the polariscopy, composed by 2 polarized lens that by adjusting the phase angle exhibits on the piece, colored lines showing the path made by the stress lines. It is possible to see the change at this lines by modifying the request conditions in which the section is exposed, allowing inclusive the prediction of spots of stress convergence.

At this research work, this method played a significant role to validate the finite element method. The pieces were formed by a blend of resins, which gives them the necessary characteristic to be evaluated throw this method. According to (Shukla and Daylly, [4]) the major discrepancy between the elasticity modulus of the model and prototype does not influences significantly errors through a photoelastic 3D model since the deformations remains small. The results are by two images exposed: The first one is the regular profile available on the industry and the second one is the processed structure, considered optimized.
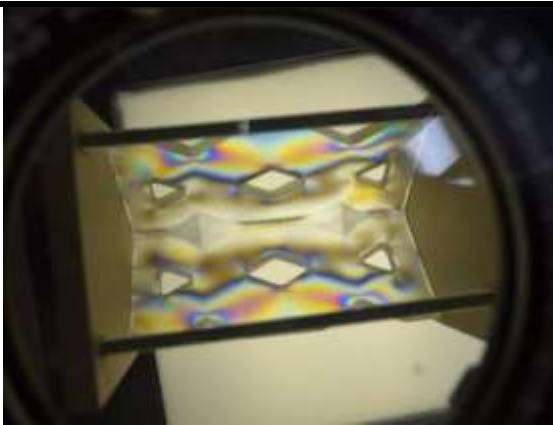

Fig.1: Regular profile

Figure 2: Optimized Profile

III. FINITE ELEMENTS METHODS

The method used for the virtual analysis was made through the finite element software Ansys. The work on the software was done using the Static Structural tool. It is possible to simulate numerous situations with this leading tool, thus predicting the behaviour of tensions, stress, deformation, among others reactions throughout the structure.

In this research, the Ansys was used for the analysis of tension in an angle "L" acting under compression forces at one end, and the other end beam. The aim of this study was to analyze the distribution of stresses under the profile, and do not test it to the limit of its resistance. The forces used for virtual analysis were higher than those used during the photoelastic mode tests. The variation of these forces will not affect the obtained results, because according to the theory of elasticity, the equations of equilibrium tension do not contain elastic constants, in this way, the tensions are independent of the modulus of elasticity E of the model's material, and at most may depend only on the Poisson coefficient.

In Figures 3 and 4below, it is possible to see the initial configuration of the tests, for both angles (optimized angle and base angle).
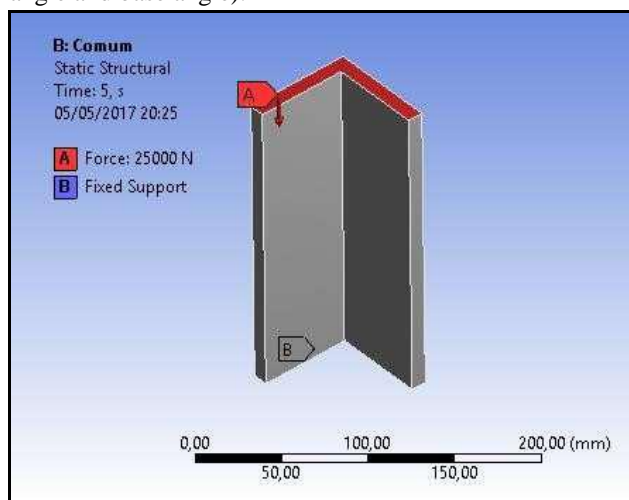

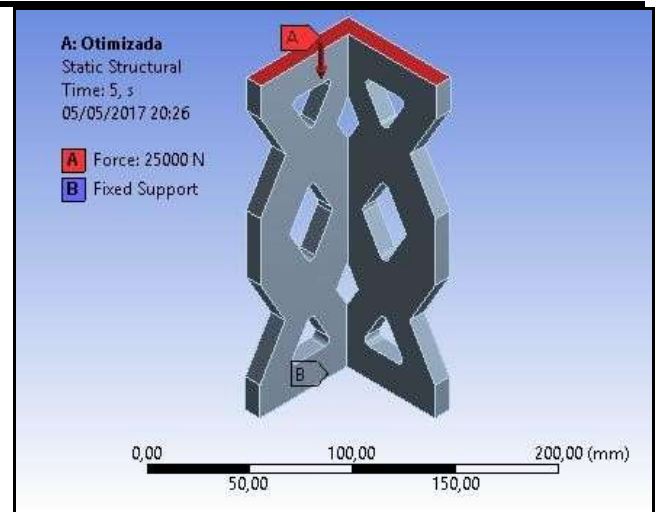*Fig.3: Initial configuration of test for base angle*

Fig.4: Initial configuration of test for optimized angle

Through the simulation performed in the Static Structural tool, they indicated for the base model a maximum equivalent stress (Von-Misses) of 45.7 MPa and a minimum of 8.7 MPa for . The base model angle has a mass of 2,041 kg. The optimized angle had a maximum equivalent stress (Von - misses) of 230,86 MPa and a minimum of 0,09 MPa and a mass of 1,55 kg. The images 5 and 6 below shows the stress distribution as well as the results obtained.
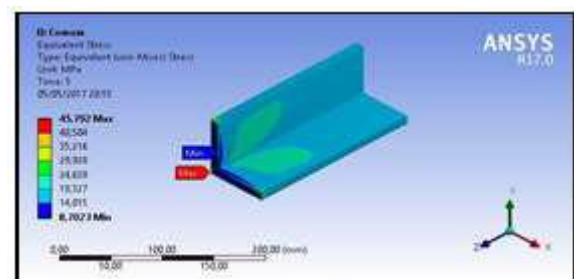

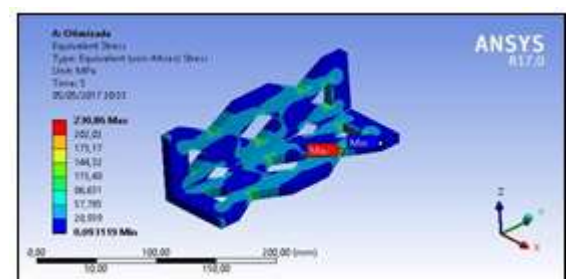*Fig.5: Static stress analysis result for base angle*

Fig.6: Static stress analysis result for optimized angle

It is possible to verify for image 5 that there is concentration of the stresses at the base of the base angle. The angle considered optimized (figure 6) presented a more homogeneous distribution of tensions along the profile.

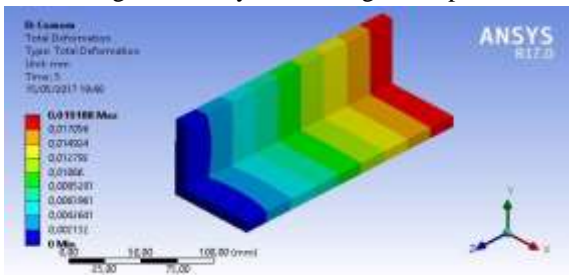The images 7 and 8 below present an analysis of the deformation generated by the loading in the profiles.

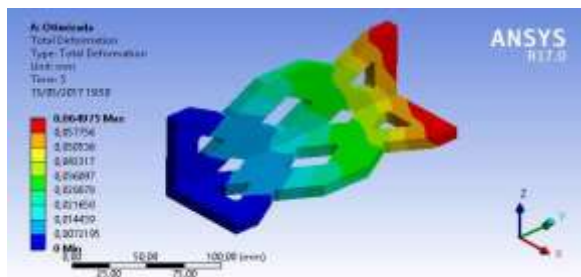*Fig.7: Deformation analysis result for base angle profile when under loading*

Fig.8: Deformation analysis result for base angle profile when under loading

It is possible to verify that the base angle reached a maximum deformation of 1.9 x 10-2 mm, while for the optimized angle, with a maximum deformation of 6 x 102 mm.

The table below shows a summary of the results obtained.

	Base Angle	Optimized angle
Maximum stress (MPA)	45,70	230,86
Minimum stress (MPa)	8,70	0,09
Mean stress (MPA)	20,00	40,00
Max. Deformation (mm)	1,90E-02	6,00E-02
Mass (Kg)	2,04	1,55

IV. CONCLUSION

From the obtained results, it is possible to notice that although the optimized angle has higher stress points compared to the base angle, the mean stress distribution along on its surface was around 40 MPa, whereas for the base angle it obtained an average of 20 MPa. However, there is a greater homogeneity of the stress distribution along the optimized angle, due to the rebated made along the profile. Another important point observed during the simulation was in relation to the deformation, for the base angle, the maximum deformation was 1.90 x 10-2 mm while for the optimum angle the deformation was 6 x 102 mm. Despite the disparity between the results, it is

considered extremely satisfactory, since both tensions remain considerably below the steel flow stress, around 210 MPa, and the mass reduction obtained in the models was approximately 25%. For the deformations, the values are considered insignificant, since maximum deformation was obtained in the studies of 6 hundredths of a millimeter. The results indicated a lighter structure, and as efficient as the base structure studied, reinforcing the need to carry out studies on obtaining optimal structures.

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