Application in Autocad to Automate the Calculation of Mechanical Efforts in Fiber Optic Network Projects

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Abstract

The topic addressed in this academic work describes a tool responsible for capturing and extracting data applied to AutoCAD software, using the Autolisp dialect. The tool has the function of automating the calculation of mechanical efforts in fiber optic network projects. With the growing demand after the growth of Fiber to the home (FTTH) networks, there was a need to install new cables on electricity distribution poles. Consequently, the growth of FTTH networks has caused an overcrowding on poles in large urban centers, which in turn, have a limited amount of availability of fixing points. The authorization of shared use of aerial infrastructure is regulated by NBR 15214/2005. Municipal FTTH networks occupy a significant percentage of the total number of poles in a city. As a result, the regulatory process becomes very repetitive, thus leading to the possibility of human error. This work proposes the creation of a plugin that automates a large part of the technical process known as the sharing of poles project to use aerial cables in energy distribution poles. Therefore, a spreadsheet is used as a kind of database. From this worksheet all the attributes necessary for the elaboration of the project are extracted, such as the vector orientation of the effort applied by the cable. The plugin developed in this work performs a georeferenced analysis of the entire plant that involves the network, extracts specific data from each pole and plots all points on the map, automates the process of orienting double T-type poles and creating blocks with the resulting stress values, in addition to calculating all the mechanical stresses in the network. The tool obtained convincing results, certifying the excellent functioning of the application to the projects, both in obtaining and in the implementation of data, thus legitimizing the proposal presented in the work.

1 Introduction

The incentive to the creation of the first telecommunication operators in Brazil emerged with the idea of making the state monopoly of telecommunications systems, conceived to Telebras and Embratel, more flexible. That occurred due to the approval of the General Law of Telecommunications (LGT) in 1995. The law nº9.472 determined the rules that the National Agency of Telecommunications (ANATEL) should follow, like the supervision and regularization of the telecommunications companies (CARVALHO et al.,).

The internet providers, also known as Internet Service Provider (ISP), also emerged in the 90's, more precisely in June 22 of 1995. But the difficulties encountered were enormous when compared to the big operators, once they hadn't the infrastructure to operate and, besides that, the population didn't understand the importance of internet yet (LIGEIRO,2019).

In the past, the rules determined by ANATEL were very harsh to the providers, because there was an excessive bureaucracy, the contribution of the charges were high, the difficulties of investments in infrastructure (like equipment, qualified professionals, etc), and that ended up creating clandestine providers. According to the LGT (art. 183 from the Law 9.472/97) the following crime is foreseen: "To clandestinely performs telecommunication activities", with the penalty its 2 to 4 years of imprisonment, in addition to a fine (ANATEL,2020).

From the second decade of 2000, it was initialized, by the providers, a process of internet services offers, that came out from the countryside to the big urbans centers (BONILHA,2019). That movement had as its idea the opposite displacement that was usually made by the big operators, cause, naturally, they went from the big urbans centers to the countryside. It was saw by the regional providers that, in those far away regions, like city districts and suburbs, it had a great market to be invested. By that time, the internet via radio was predominant with the use of the Wireless Local Area Network (WLAN).

Around 2010, when it was noticed the importance of more data transfer capacity, a deep investiment was made on optic fiber cable internet access networks. By definition, FTTH means Fiber to the house, which derives from the Fiber to the anywhere (FTTx). The 'x' term in the final represents the optic fiber destination.

The growth of the FTTh networks coincided with the growth of the internet providers. Consequently, years later, around 2016, the demand for optical cables increased significantly, causing the cost of equipment related to the infrastructure of wired internet networks to present a sharp drop in price.

Since then, in 2016 the FTTh networks became popular and, due to that, the regional providers started to use this new market trend. That's how started the process of space occupation on the posts of the eletric dealership, which is ENEL in the state of Ceará, by the providers, once those posts were only occupied by the big telecommunications operators.

2 Problem Statement

In 2005, the ABNT NBR 15,214 technical standard was created with the objective of establishing the minimum technical conditions necessary for sharing the infrastructure of aerial and underground electrical energy networks with telecommunications networks. The norm is intended for the occupation of electrical power network infrastructure up to 34.5 kV, in urban and rural regions, by Telecommunications networks.

At the time, the ABNT NBR 15,214 technical standard was intended only for large operators. The ABNT NBR 15,214 technical standard wasn’t popular, the providers were not aware of it and even energy concessionaires did not have well-defined customer clarification sectors. In a short time, the demand for space on power poles increased due to the presence of regional providers that expanded in a short time, reaching dozens in large cities.

In a short time, it was noticed that the excess (crowding) of cables on the poles was causing a risk to people's safety, as they are present on sidewalks, close to avenues, streets, buildings, etc. The poles were not designed to support the load (effort) generated by fiber optic cables, so there were several changes in relation to the types of poles, now being developed to cover a certain number of occupants in addition to the cables of the electrical network.

In order to have control over the integrity of the poles and public safety, currently, energy concessionaires require that infrastructure sharing projects calculate the effort exerted by Telecommunications cables. However, this work of elaborating the calculation carried out by each cable present on the power pole can be considered somewhat exhaustive due to the large amount of necessary information that must be extracted from the technical drawing, in addition the fact that the flow of work is repetitive, that is, it is subject to calculation errors.

Therefore, this work presents a practical, dynamic and efficient solution for the described problem. This solution, developed mostly in AutoCAD software, intends to quickly and automatically calculate the effort resulting from each pole of a fiber optic network project.

3 Solution of the problem

The main goal of this work is to automate the effort calculation of fiber optic cables, aiming at the minimum error in the elaboration of projects and consequently the saving of time. In addition, prove from the results of all the mathematical development that the current standard, (ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS, 2005), is outdated, since it provides a lower number of fixation points (occupants) of fiber optic cables than the pole can support it (currently there are 5 positions), that is, energy concessionaires could assign more points to internet companies, thus solving the problem of overcrowding on poles. Some specific steps will be taken to automate the effort calculation process and are listed below:

- To use a graphic software where the project will be made.;
- The use of a tool to collect and export information from a graphic design;
- To collect the exported data into a table to find the resulting calculation;
- To import the resulting data into the graphic software showing the values resulting from the effort calculation.

4 Related works

The theme of this work has also been explored in other bibliographies, such as (MABJO, 2021), which presents an editable worksheet to insert values such as: height of the pole, type of pole, geographic orientation of the fiber, type of cable, among others, and later returns the effort value and vector orientation of the effort. Something similar can also be seen in (SILVA, 2019). Another bibliography that is also related to stress calculation is (NEXANS,), which details the mathematical concept used to calculate the mechanical stress on poles. The works cited above are quite effective, but do not present a solution that interacts with CAD (Computer Aided Design) software, allowing greater flexibility in the project. However, works that use Lisp language for the purpose of automating projects and performing calculations are discussed in (MORENO; BAZÁN, 2017), (AMIRASLANOVA, 2012), (MUHAMMAD; HASSAN, 2015) and (Kumar; Singh, 2008). Such works are more focused on the area of Civil Engineering due to the vast field of application.

5 Effort Calculation

In this section, the detailed study regarding the parameters that must be followed to perform the calculation will be presented. The following references were considered: (LABEGALINI et al., 1992) and (ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS, 1985).

5.1 Equation used to calculate the efforts of the cables on the poles

The behavior of suspended cables can be presented in two ways, depending on their attachment points, when they are at the same height and when they are at different heights. The second case occurs more often. Despite being different situations, the equation that represents the horizontal traction exerted by the cable in both cases can be seen below, equation 1. The term that changes is the span, represented by the variable "a". In the case of posts with the same height, the common span (distance between two consecutive posts) is considered, and in the case of posts with different heights, the regulating span (distance between posts with anchorage).

$$T_0 = \frac{p \times a^2}{8 \times f} \tag{1}$$

Onde:

- T_0 is the horizontal tension in the anchorages (daN);
- p is the total resultant load exerted by the cable, that is, it is the net weight per meter of cable
- (kg/m);
- a is the distance between poles or also called span (m);
- f is the vertical distance between the line of sight and the lowest point that the cable reaches (m).

6 Methodology

In this chapter, the method that was used to automate the effort calculation process will be addressed, including the programming done in AutoCAD to the spreadsheet in Excel.

6.1 Application of Lisp to calculate mechanical stress in fiber optic network projects

As shown, Autolisp contains very effective tools to guarantee an excellent personalized functioning of a certain process executed in AutoCAD.

To better explain how broad this data extraction process is, it will be presented which elements and situations are mandatory to perform the effort calculation on a pole of the electric utility.

- Situation 1: On a pole where the fiber optic cable is at the end of the FTTh branch;
- Situation 2: On a pole that has an angular orientation between the anchorages of the fiber optic cable less than or equal to 160° (always considering the smallest angle);

- Situation 3: On a pole that has 3 fiber optic cable anchorages;
- Situation 4: On a pole that has 4 fiber optic cable anchorages.

For each situation described above it is necessary to seek the following information:

- Pole identification: In the sharing project, identifiers are placed for each pole to ensure organization and thus allow its location;
- Height and Effort of the pole: During field collection, this information is recorded in order to know what type of pole will be used for the passage of the optical fiber, that is, it is known which electric power network is passing through the pole, low or /and medium voltage, the height of the pole and the total effort it supports;
- Span: You need the value in meters of the span of each fiber optic cable that is anchored on the pole;
- Regulator Span: It is necessary to know the value of the regulatory span in meters for each of the fiber optic cables that is anchored on the pole until the next anchorage;
- Geographic orientation of the fiber: For each fiber optic cable anchored on the pole, it is necessary to know the angle it forms with the reference (zero degrees, hollow face of the pole) which is oriented towards geographic east;
- Location on the plank: For each calculation performed, it is necessary to identify which plank the pole is inserted in the drawing.

In view of this, a task routine was created so that it is possible to capture all the information described, analyzing each situation. Figure 1 shows a summary of the process, which starts with calling the function in AutoCAD until the creation of an "Excel.csv" file.

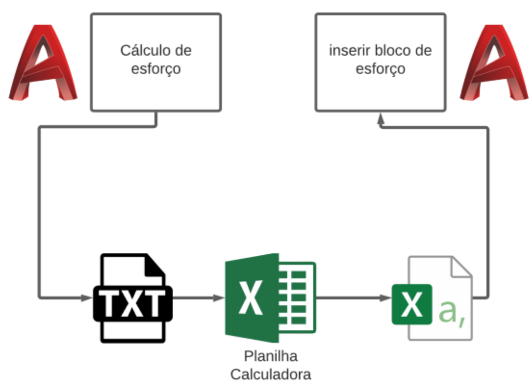


Figure 1 - Summary of the effort calculation process.

As it is necessary to summarize the effort calculation in a table, a Lisp was used to extract the AutoCAD data in txt format and then insert it into an Excel spreadsheet. The tables present in the spreadsheet's calculation model automatically calculate, based on equation 1, the effort and angle resulting from each pole respectively. The second Lisp was also created with a view to saving time, as it automates this procedure of finding the post, inserting the block with effort and angle attributes and writing the values manually, the only action the user needs to perform is to click on the desired location to insert the block.

7 Case study

A small pole-sharing project was made for the case study in order to observe its results, following the order of figure 1. The example project is shown below in figure 2. It has a fiber optic network route passing through 18 electricity utility poles..

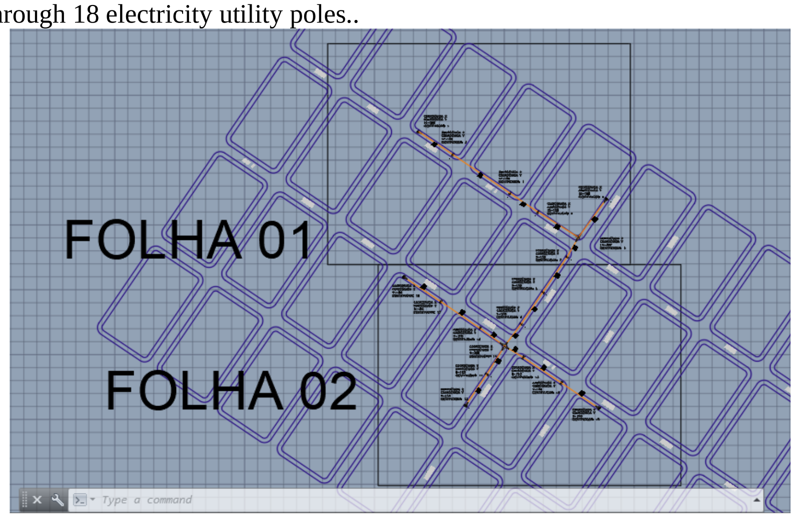
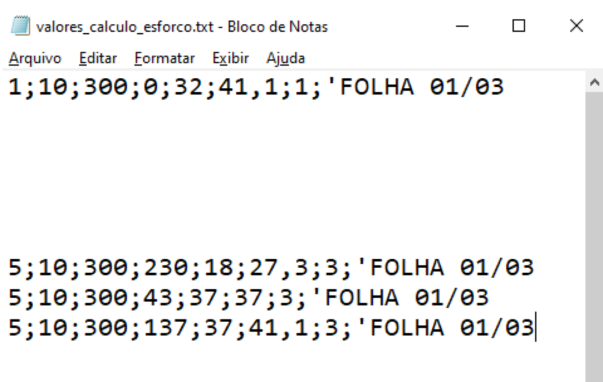


Figure 2 - Sample Project Overview

The purpose of the case study is also to verify the total load exerted by the telecommunication cables on the poles, in order to verify if it is possible to increase the number of points available on the pole, because in this way the problem of capacity on the poles would be solved with its greater availability of points. The total effort exerted by the cable will be compared in relation to the nominal effort of the pole.

8 Results and discussions

The first step is to use Lisp to extract the necessary data to calculate the mechanical stress on the posts. Below in figure 3, part of the information collected is shown at the end of the code execution.




```
1;10;300;0;32;41,1;1;'FOLHA 01/03




5;10;300;230;18;27,3;3;'FOLHA 01/03
5;10;300;43;37;37;3;'FOLHA 01/03
5;10;300;137;37;41,1;3;'FOLHA 01/03
```

Figure 3 - txt file with extracted data

Each data referring to the pole is separated by ";", so the order of organization of the information follows the following configuration: id, effort, height, orientation in degrees, span, regulator span, amount of forces and sheet number. Once inserted in the worksheet, the resulting values are instantly found on the pole. Below is the calculation table for posts 1 and 5.

Table 1 - Calculation of Pole 1

Poste: 1	Altura (m): 10,0			Capacidade do poste (daN): 300			Modelo: DT	Folha: 01/03	Cordoalha NÃO		Caixa de emenda NÃO	
Empresa:	**Força**	**Ângulo**	**Vão regulador**	**Vão**	**Tipo do cabo**	**Nº vias**	**Esforço no ponto de amarração (daN)**	**Carga do vento (daN)**	**Esforço total (daN)**	**Fator de multiplicação (20 cm topo poste)**	**Esforço Refletido Eixo X (daN)**	**Esforço Refletido Eixo Y (daN)**
EMPRESA X	F1	0	41,1	32	CFOA-SM-AS80-12F	1	27,7	3,4	31,1	0,69	21,5	0,0
Esforço resultante (daN):	**21,5**		**Ângulo da força resultante (º):**		**0**	**Carga utilizada no poste (daN):**	**150**		**Trocar poste? NÃO**	**Total de esforço na Face (daN):**	**21,5**	**0,0**

Table 2 - Calculation of Pole 2

Poste: 5	Altura (m): 10,0			Capacidade do poste (daN): 300		Modelo:	DT	Folha: 01/03	Cordoalha	NÃO	Caixa de emenda	NÃO
Empresa:	**Força**	**Ângulo**	**Vão regulador**	**Vão**	**Tipo do cabo**	**Nº vias**	**Esforço no ponto de amarração (daN)**	**Carga do vento (daN)**	**Esforço total (daN)**	**Fator de multiplicação (20 cm topo poste)**	**Esforço Refletido Eixo X (daN)**	**Esforço Refletido Eixo Y (daN)**
EMPRESA X	F1	230	27,3	18	CFOA-SM-AS80-12F	1	21,7	2,3	24,0	0,69	-10,6	-12,7
EMPRESA X	F2	43	37	37	CFOA-SM-AS80-12F	1	19,4	3,1	22,5	0,69	11,3	10,6
EMPRESA X	F3	137	41,1	37	CFOA-SM-AS80-12F	1	24,0	3,4	27,4	0,69	-13,8	12,9
Esforço resultante (daN):	**17,0**		**Ângulo da força resultante (º):**		**141**	**Carga utilizada no poste (daN):**	**216**		**Trocar poste? NÃO**	**Total de esforço na Face (daN):**	**-13,1**	**10,8**

With the worksheet finalized, the values resulting from post 1 (21.5 daN and 0°), post 5 (17.0 daN and 141°) and the others are inserted into the AutoCad Software in block format with their respective values as attributes .

9 Conclusion

In this work, a study was proposed regarding the calculation of mechanical efforts in fiber optic network projects using an application in Autolisp in AutoCAD software, with the aim of automating its elaboration process.

Difficulties were encountered in the AutoCAD platform regarding how the data needed to perform the effort calculation would be automatically extracted, that is, without the need for a designer to search for each piece of data throughout the project. For this, an application of the Lisp language was found on AutoCAD, which adapted to AutoCAD is called Autolisp. It uses the programming language to perform various tasks in AutoCAD and all the information necessary for the effort calculation is exported through it.

Aiming the correct use of the tool, the entire composition of the graphic elements in the AutoCAD software was studied, in which they present everything from geometric data such as points, angle, radius, to information on the classification of an object: line, circle, polyline , rectangle, arc, insert block etc.

To validate the effectiveness of the tool, it was used to make projects at the company Ágil Engenharia de Telecomunicações EIRELI. During the execution of the works, it was validated that this automation improved the tasks performed, reducing the project development time. Before, a project was done in approximately 5 days, now, with the use of the Lisp tool, the time has been reduced to approximately 1 day. Another improvement was to avoid design errors associated with calculations that were once common due to human error. The projects needed to be reviewed after they were finalized, and now, with the use of the tool, it is no longer necessary to review the calculations.

The goals indicated in the work were successfully achieved, obtaining satisfactory results consistent with the idea that was proposed at the beginning of this project.

Finally, it is important to point out that through the results found for effort and orientation resulting from the example project, it is possible to conclude that the load exerted by the fiber optic cables is considered very small in relation to the total nominal effort of the pole. With this, this work serves as a justification for the increase of the number of occupants destined to the telecommunications cables on the poles of the electric power concessionaires, showing that the ABNT NBR 15.214 standard is outdated, once the cables used in the fiber optic networks today are technologically more advanced compared to the time when the standard was written. Therefore, it is necessary to reformulate the norm so that it is possible to minimize the current major problem, which is the large crowding of cables on power poles.

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