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# 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 for capturing and extracting data applied to AutoCAD software using the Autolisp dialect. The plugin has the function of automating the calculation of mechanical efforts in fiber optic network projects. With the growing demand after the growth of Fiber the home (FTTH) networks, there was a need to install new cables on electricity distribution poles. Consequently, the development of FTTH networks has caused overcrowding on poles in large urban centers with a limited number 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 a city's total poles. 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 getting and in the implementation of data, thus legitimizing the proposal presented in the work.

## 1 Introduction

The incentive for the creation of the first telecommunication operators in Brazil emerged with the idea of making the state monopoly of telecommunications systems, conceived by 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.,).

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Internet providers, also known as Internet Service Providers (ISP), emerged in the '90s, more precisely on June 22, 1995. But the difficulties encountered were enormous compared to the big operators, who needed the infrastructure to operate (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 was 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 Law 9.472/97), the following crime is foreseen: "To clandestinely perform telecommunication activities," with the penalty is 2 to 4 years of imprisonment, in addition to a fine (ANATEL,2020).

In 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 urban centers (BONILHA,2019). That movement had as its idea the opposite displacement usually made by the big operator's cause; naturally, they went from the big urban centers to the countryside. The regional providers saw that it had a great market to invest in those far away regions, like city districts and suburbs.

The growth of FTTH networks coincided with the development of 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 price drop.

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

## 2 Problem Statement

In 2005, the ABNT NBR 15,214 technical standard was created to establish 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 needed to be made aware of it, and even energy concessionaires needed to 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 quickly, 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 the types of poles, now being developed to cover a certain number of occupants in addition to the wires of the electrical network.

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 to 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 mainly in AutoCAD software, intends to quickly and automatically calculate the effort resulting from each fiber optic network project pole.

### 3 Solutions to 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 mathematician's 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 five 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 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 the height of the pole, type of pole, the 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 to automate projects and perform calculations are discussed (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 Methodology

In this section, the method used to automate the effort calculation process will be addressed, including AutoCAD's programming to the Excel spreadsheet.

## 5.1 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 particular process executed in AutoCAD.

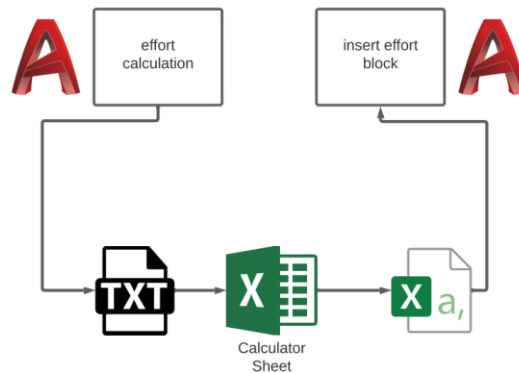
To better explain how broad this data extraction process is, it will be presented which elements and situations are mandatory to perform the effort calculation on a pole of the electric utility.

- 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  $160^\circ$  (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 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 are 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.

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



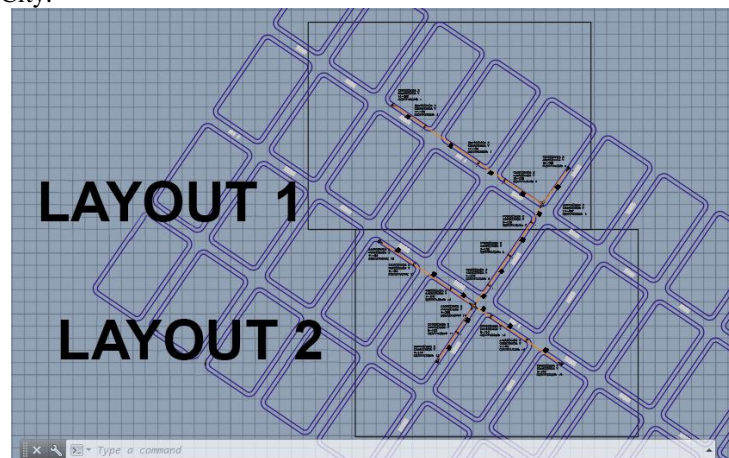
**Figure 1 - Summary of the effort calculation process.**

As it is necessary to summarize the effort calculation in a table, a Lisp was used to extract the AutoCAD data in text 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 to save 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.

## 6 Case study

A small pole-sharing project was made for the case study 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.

The points were chosen randomly, but with accurate data from a conventional project, this choice was made due to data protection from partner companies. It is possible to observe in figure 2 that the project has two layouts and a small number of posts, 18. This choice aims at the easy execution of the codes and presentation of results since, generally, the projects have an average of 500 to 1000 poles depending on the City.



**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 and 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 to the nominal effort of the pole.

## 7 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 shows part of the information collected at the end of the code execution.

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

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

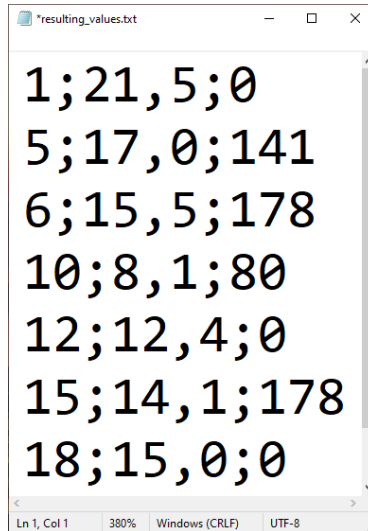
Table 1 - Calculation of Pole 1

Pole:		1	Height (m):		10,0		pole capacity (daN):		300		model:		DT		layout:		01/03		Wire rope		NOT		splice box		NOT	
Company:						Force	Angle	average distance	distance	cable type	N° ways	Effort at the tie point (daN)		wind load (daN)		total effort (daN)		Multiplication factor (20 cm from the top of the pole)		X-Axis Reflected Effort (daN)		Y-Axis Reflected Effort (daN)				
Company X						F1	0	41,1	32	CFOA-SM-AS80-12F	1	27,7		3,4		31,1		0,69		21,5		0,0				
Resulting effort (daN):		21,5		Resultant force angle (°):				0	Load used on the pole (daN):			150		Swap pole?		NOT		Total Effort on Face (daN):		21,5		0,0				

Table 2 - Calculation of Pole 2

Pole:	5	Height (m):	10,0	pole capacity (daN):				300	model:	DT	layout:	01/03	Wire rope	NOT	splice box		NOT	
Company:		Force	Angle	average distance	distance	cable type		N° ways	Effort at the tie point (daN)		wind load (daN)		total effort (daN)		Multiplication factor (20 cm from the top of the pole)		X-Axis Reflected Effort (daN)	Y-Axis Reflected Effort (daN)
Company X		F1	230	27,3	18	CFOA-SM-AS80-12F		1	21,7		2,3		24,0		0,69		-10,6	-12,7
Company X		F2	43	37	37	CFOA-SM-AS80-12F		1	19,4		3,1		22,5		0,69		11,3	10,6
Company X		F3	137	41,1	37	CFOA-SM-AS80-12F		1	24,0		3,4		27,4		0,69		-13,8	12,9
Resulting effort (daN):	17,0	Resultant force angle (°):			141	Load used on the pole (daN):			216	Swap pole?	NOT	Total Effort on 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 in the AutoCAD Software; below are shown in figure 4 with the results of the values.



**Figure 4 - txt file with resulting values**

The file containing the resulting values is used as input for the second AutoLISP code, whose function is to insert the resulting blocks containing the values already filled in, automating the final process of effort calculation. Figure 5 below shows the block resulting from pole 1 (21.5 daN and 0°).



**Figure 5 - Resulting Block on post 1 (Project-example).**

Another significant result found is the relationship between the resulting effort exerted by the fiber optic cables and the nominal effort of the pole. It is possible to notice that the difference is significant; this can be seen below.

The resulting effort on pole 1 is 21.5 daN and represents 7.16% of the nominal effort of the pole, 300 daN. On pole 5, the resulting effort is 17.0 daN, representing 5.6% of the nominal value of the pole, 300 daN. Soon it is seen that it is possible to make more occupants available on the power poles.



## 8 Conclusion

In this work, a study was proposed regarding calculating mechanical efforts in fiber optic network projects using an application in Autolisp in AutoCAD software to automate its elaboration process.

Difficulties were encountered in the AutoCAD platform regarding how the data needed to perform the effort calculation would be automatically extracted without needing a designer to search for each piece of data throughout the project. 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.

The first contact with the Autolisp language was complicated, as its syntax is different from other more common languages in Engineering, such as C or C++. In addition, it is peculiar to the AutoCAD environment, which requires knowledge of AutoCAD itself. To get around this, teaching materials such as videos and handouts were used to study as much content as possible involving AutoCAD and Autolisp. Despite the challenges, it was easy to deal with the language, as it is intuitive and straightforward in its applications.

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, angles, and radius, to information on the classification of an object: lines, circle, polyline, rectangle, arc, insert block.

To validate the tool's effectiveness, it was used to do 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 five days; now, with the in AutoLisp tool, the time has been reduced to approximately one 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 proposed at the beginning of this project.

Finally, it is essential 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 minimal about the total nominal effort of the pole. With this, this work serves as a justification for the increase in 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 considerable crowding of cables on power poles.

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