AUTOMATIC DESIGN OF STEEL CONNECTIONS BY USING CAD PLATFORM: SOFTWARE LIGFLEX

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Abstract.
Considering the large amount of connections in steel structures and the complexity of their design procedures, the use of computational tools become very useful for the productivity increasing and minimization of calculation errors. This work has, as objective, the development of a software named LigFlex, which is able to execute the complete design of simple connections for steel structures, from the calculation steps and connection components verifications to the final detail drawings. The software was implemented based in the AutoLisp and DCL programming languages, and works as an application that is capable of using available resources inside the AutoCAD. The expectation of this work is the offering of a more time-effective way for steel connections design and the improvement in the design of steel-framed buildings, as well as the propagation of steel construction system in Brazil.

Key-words*: Steel Structures, Simple Connections, AutoCAD, VisualLisp*

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INTRODUCTION

The steel structures are pre-manufactured construction systems in which the elements responsible for the structural function are plate-composed bars. The members are joined by means of the so-called steel connections, which must to be specified within the structural design and must comply with the prescriptions in NBR 8800, when it comes to calculation procedures and detailing. In order to ensure the loads transmission, each connection component (welds, bolts, plates, etc.) must be evaluated through calculation routines that involve several formulations specified in the referred code. Finally, the detail drawings elaboration is necessary in order to make it possible the manufacturing and the assembly the structure correctly.

Considering the large amount of existent connections in the buildings, the design procedure becomes laborious and, many times, unfeasible to be done manually. Therefore, the computerization comes as an important resource to project development and time optimization in the execution of the design procedures. This work has, as objective, the development of a software named *LigFlex*, which works as an application within AutoCAD and aims the automatic calculation and detailing of simple connections in steel structures.

METHODOLOGY

The software was developed based in the AutoLisp and DCL programming languages, which can be implemented with the use of Visual Lisp, an IDE (Integrated Development Environment) available internally in AutoCAD. In this context, it was considered the reference from Cesar Jr. (2001), who details all the commands and syntax of the used languages. For the study of pinned connections and improvement of theoretical concepts, recognized bibliographies in the area of steel structures were explored, such as Pfeil (2009), Queiroz (2012) and Fakury (2016), in which the design requirements are based in ABNT NBR 8800/2008.

The software was divided internally into specific routines for the isolated calculation of each connection component in their Ultimate Limit States. Thus, according to the type of connection, these routines are managed by the software's main code, executing the appropriate regulatory verifications. Concomitantly with the calculation procedures, the dialog boxes were also implemented with the use of the DCL language, in order to establish a link between the different parts of the code and to make the software more friendly towards the user experience.

In the following step, a routine that generates, automatically, the Calculation Report in text file format was developed. Such file registers all the calculations and verifications for further consultation. Finally, the code for the design drawings was developed, in which AutoCAD resources and its drawing tools were used through specific commands in AutoLisp.

RESULTS AND DISCUSSIONS

In its most recent version, the *LigFlex* software is ready to make the automatic design and detail drawings of two types of simple connections: Single Plate and Double Angle.

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In order to start the program, the user has to type "*LigFlex*" in AutoCAD command line. Then, a window shows the program initialization and its presentation (figure 1). After that, the user can choose in a menu, created to make an easier interaction, if he wants to create a new project or open an existent project. At this point, the user has to choose, in the window of options (figure 2), the type of connection that will be used.

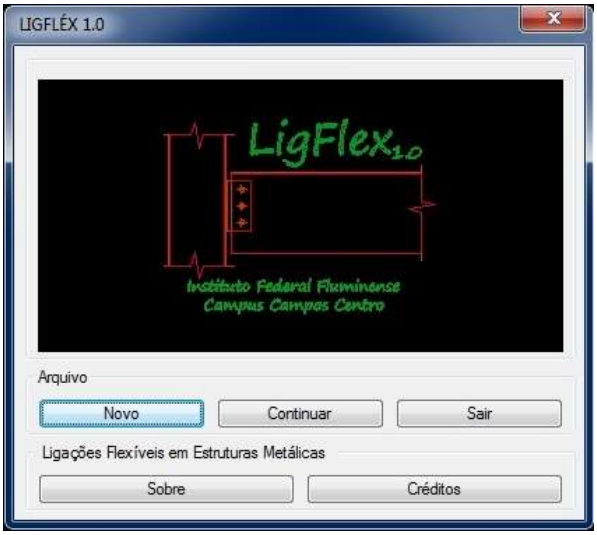

Figure 1 - LigFlex opening window

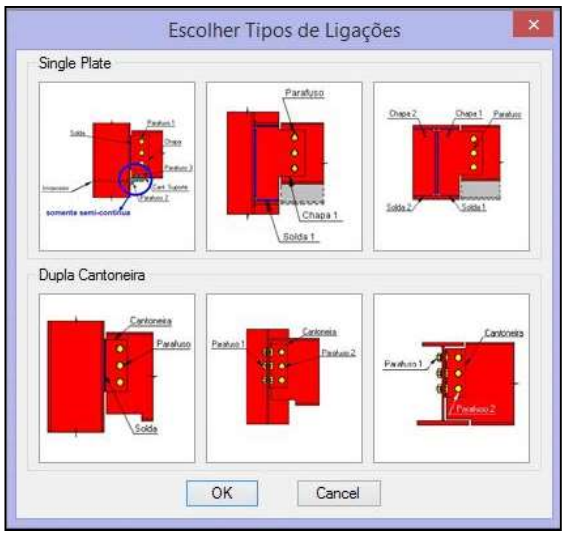

Figure 2 - Types of connections

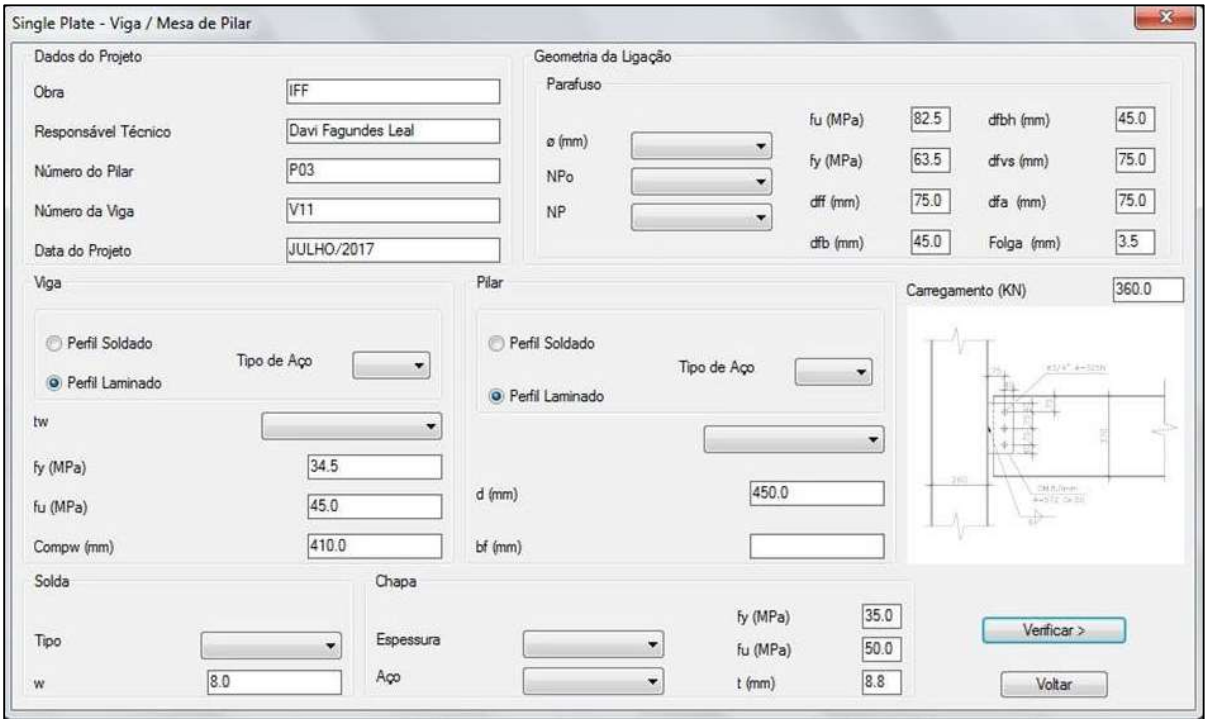

Figure 3 - Data input window

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Afterwards, the main window of the program opens (figure 3), and the user enters the required data for the connection design. When this procedure is done, a new window shows the verifications of each ultimate limit state (figure 4), where the user can verify if the calculations are deficient or conservative and then make adjustments, if necessary. This same window has three buttons: "Mem. de Cálculo" and "Desenhar", which release the command to generate the calculation report and the detail drawing automatically in AutoCAD's workspace, respectively; also "Voltar", if the user wants to change any input data.

In figure 5, an example of detail drawing generated by *LigFlex* for connection of the type Double Angle is shown.

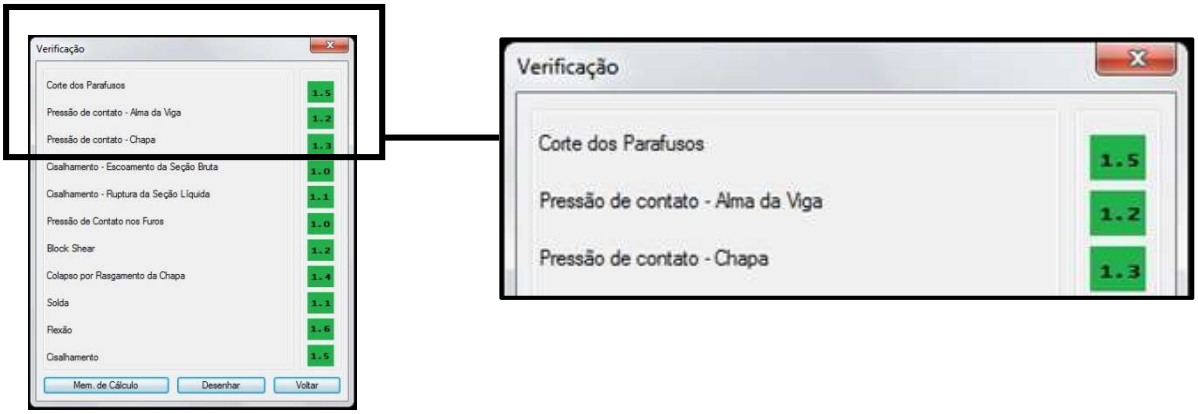

Figure 4 - Ultimate limit states verification window

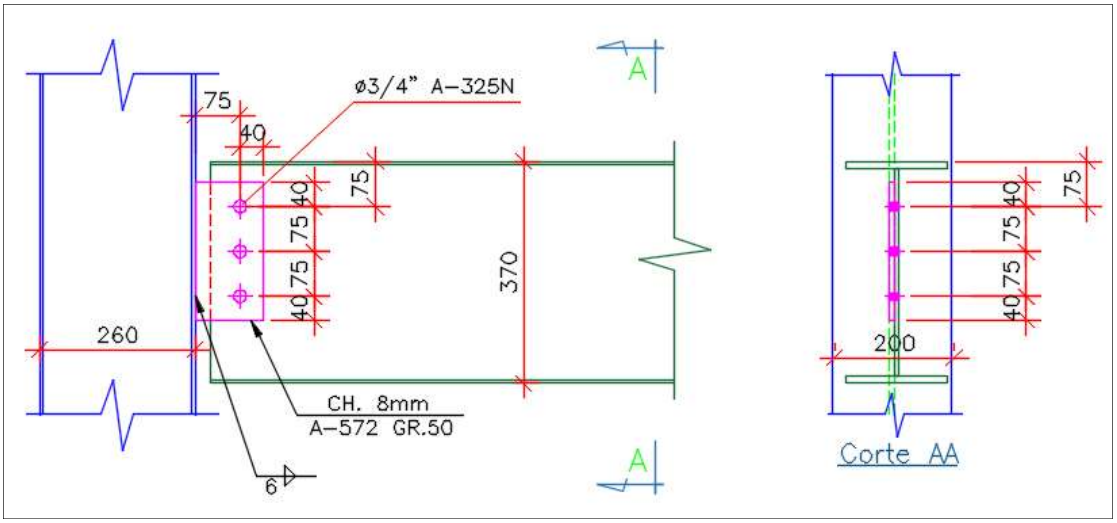

Figure 5 - Example of detailing of the Single Plate connection generated by LigFlex

CONCLUSION

Based in the results, it is possible to conclude that the software *LigFlex* has great potential for application in design of buildings with steel structures, considering that it has

reached compatible results when compared with the references. Based in generic calculations, the software makes it possible to evaluate several configurations of a specific connection in a short time, assisting the designer in choosing the most applicable connection for each situation.

In addition to engineering office use, *LigFlex* can also be used as a support tool for teaching in engineering and architecture courses as a way of encouragement during the classes, increasing their interest.

The importance of the project stands out in the development of softwares that optimize routines that demands time. Besides the easy use and access, *LigFlex* does not demand extra implementation costs, considering that its operation takes place within AutoCAD environment, which is very widespread in civil construction.

The expectation of this work is the offering of a more time-effective way for steel connections design and the improvement in the design of steel-framed buildings, as well as the propagation of steel construction system in Brazil.

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REFERENCES

Associação Brasileira de Normas Técnicas, NBR 8800. *Projeto de estruturas de aço e de estruturas mistas de aço e concreto de edifícios*. Rio de Janeiro:ZABNT, 2008.

CBCA. *Ligações em Estruturas Metálicas Vol. 1 - 4ª Edição revisada e atualizada*. 2011.

Cesar Jr., Kléos M. Lenz. *Visual Lisp: Guia básico de programação para o AutoCAD*. São Paulo: Editora Market Press, 2001.

Fakury, Ricardo Hallal; Ana Lydia Reis de Castro e Silva; Rodrigo Barreto Caldas. *Dimensionamento de elementos estruturais de aço e mistos de aço e concreto.* 1º Edição, Editora Pearson, 2016.

Leal, Davi Fagundes; ALVARENGA, Rita de Cássia S. Sant'Anna. *Modulação automática de edifícios em Alvenaria Estrutural com a utilização da plataforma CAD: Programa AlvMod.* Revista Engenharia Civil UM, v.34, p.27-38. Universidade do Minho,Portugal, 2009.

Pfeil, Walter; Pfeil, Michèle. *Estruturas de aço*. Rio de Janeiro: Editora LTC, 2009.

Queiroz, Gílson; Vilela, Paula Moura Leite. *Ligações, regiões nodais e fadiga de estruturas de aço*. Belo Horizonte: Editora O Lutador, 2012.