THE ADAPTATION OF SOFTWARE FOR INFORMATION MODELING TO DESIGN OF TRUSSES OF METAL BRIDGES

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Abstract: *This article describes a method to the adaptation of the information-modeling program for the design of metal bridge elements. The variants of the new dialog boxes in the Tekla program were created to illustrate this method with the Tekla Open API program interface.*

Keywords: *Information model, truss, section, metal bridge, Open API interface, adaptation, design.*

Classification number: *2.4*

1. Introduction

Information modeling technology is widely used in many countries. In Russia, this segment is actively developing. High-grade use of information modeling technologies is one of the essential conditions for reducing investment risks, improving the quality and speed of design, reducing the time and cost of construction, reducing operating costs. Information modeling is a higher level of design automation, since it implies the automation of information use - a new stage after CAD, which automated the creation of information. The information model stores any information that may be required in the design process, for example, physical and geometric properties of the element, this allows you to obtain dynamic drawings and specifications that adapt to the changes in the project [1]. In addition, the information model contains a three-dimensional representation of the projected object, this allows you to get a complete picture of the structure and identify emerging collisions and errors.

To create an information model, you need special software. One of the powerful tools is the Tekla Structure software package. With its help, you can quickly assemble an information model of a typical design. However, when designing a unique structure, it is necessary to supplement the program with new elements.

To create a spatial parametric model of an element of a structure, the information model provides the fundamental concept of a "family". Using families makes it possible to make the information model more flexible and quickly transformed when changing the geometry of elements.

The creation of a family does not always solve the problems of information modeling of bridge design elements. More detailed study of the design and its information model can be done only using plug-ins.

In Tekla Structure is possible to extend the functionality through an open software interface Tekla Open API [2], which uses the C # language [3].

2. Method

With the help of the Tekla Open API can perform the following tasks:

- Record and play back actions with the user interface, which allow you to automate routine operations, such as creating daily reports.
- Can create automation tools for the objects, which is often necessary, for example, to create simple designs or to add to the standard detail drawings.
- Integration of Tekla Structures with other software: based on the Tekla Open API and the .NET platform, you can organize the transfer of information between Tekla Structures and other programs, such as software for calculation and design.
- The Tekla Open API allows you to create tools that extend the functionality of Tekla Structures.

Let's see more detail about creation of cross sections of the main truss bridges with through trusses in programming interface Tekla Structure.

When informational modeling of the metal truss bridge during the creation of the lower and upper chord, hip vertical, diagonal and braces the program offers a large selection of typical box and I-sections. Section options are available when selecting a beam, if you select the "Beam Properties" and "Attributes" tab. When you click on the "Select" button in the "Profile" line, a window with the downloaded profiles appears. For the convenience of choice, the section view and its geometric characteristics are displayed.

In most cases, when designing typical metal structures, this list of profiles is sufficient. But when creating designs of non-typical trusses, these cross sections are not suitable. In addition, the task may be to efficiently create different elements on separate layers.

3. Results

To adapt the process of information modeling through the main metal truss bridges, a plug-in was created that tunes the program for modeling such non-typical tasks. In Tekla an open approach to BIM is implemented, thanks to this, writing plug-ins is a convenient way to customize the interface and the necessary functionality for programmers.

3.1. Create built-up section for truss

In addition to the list of profiles, new sections were created and the necessary geometric characteristics were set (Figure 1).

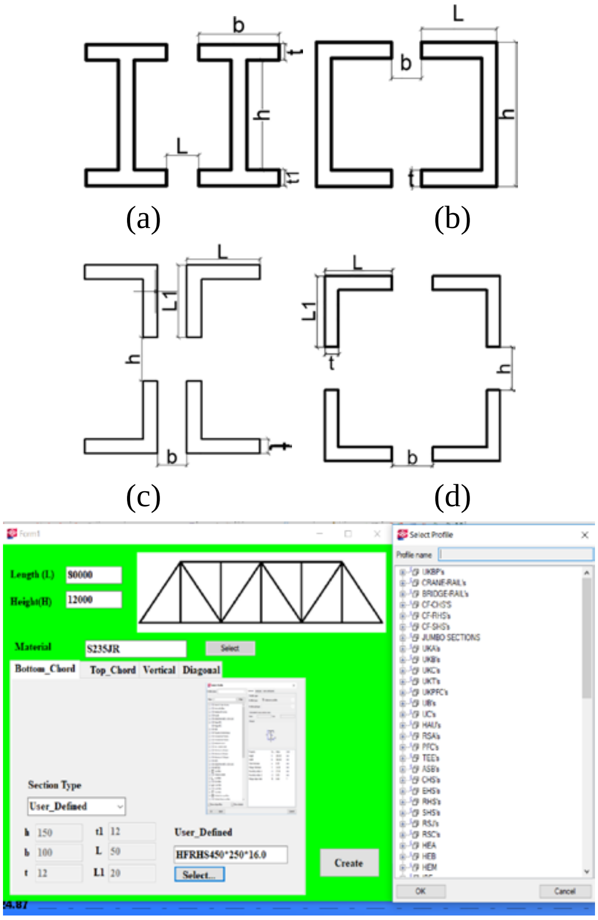

Figure 1. *Select a custom beam section from the list.*

When you select a row in the list, the corresponding section and its geometric characteristics appear. The dialog box allows you to change some parameters when entering numeric values in the marked fields (Figure2).

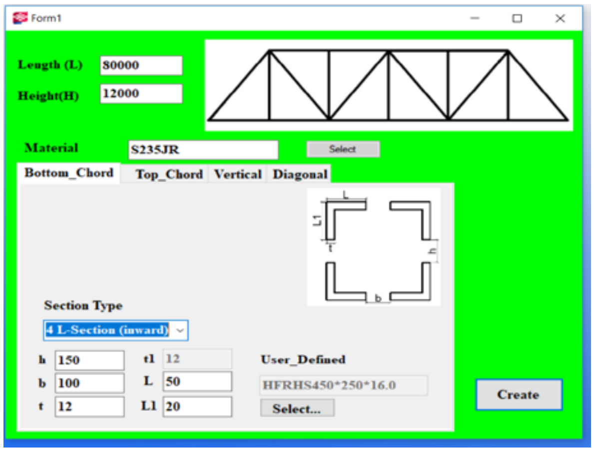

Figure 2. *Custom beam section type.*

In this way, the configuration for each element of the farm is performed, and then when you click on the button "Create" derives three-dimensional truss model is rendered (Figure3).

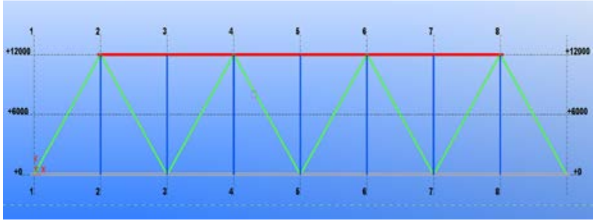

Figure 3. *Whole view of the truss.*

The three-dimensional model of the truss obtained at this step can be imported into the calculation complex [4], [5].

3.2. Create node connection with bolts

When creating an information model of a metal structure, it is necessary to simulate the connections of structural elements with each other (Figure 4). In the work done by the authors, a bolted connection was used. The arrangement of bolts in the designed structure was carried out in accordance with certain requirements.

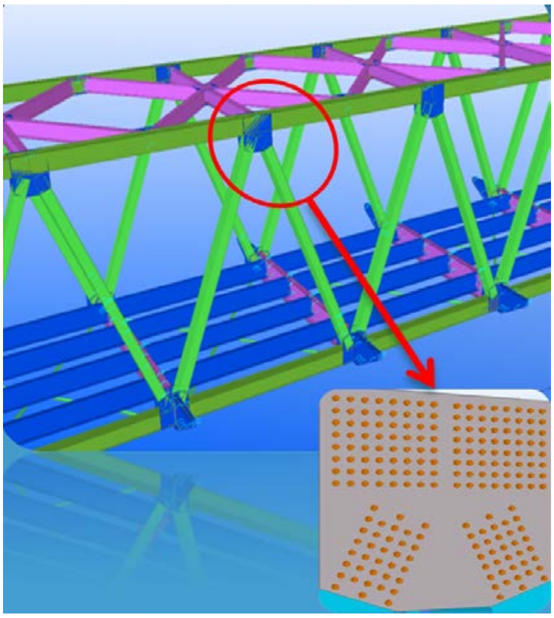

Figure 4. *Node connections of truss elements.*

Standard program functionality offers many different options for placing individual bolts and a group of bolts when selecting the tab "Bolts"[4]. However, in all cases, the designer must first calculate the number of bolts, their location, and the distance between them. The layout of the bolt arrangement takes a certain amount of time, since all the requirements for the number, step and location of the bolts must be taken into account.

The following requirements are imposed on the arrangement of bolts in the nodes of the main truss [6]:

1. The number of longitudinal rows of bolts must be odd;
2. In the first, second and last cross rows of bolts, the maximum number of bolts (in the compressed only the first and last row of bolts) is set in increments of 160 mm;
3. The extreme longitudinal rows are set with a pitch of 80 mm;
4. Bolts are placed symmetrically about the longitudinal axis of the element;
5. Bolted field must be compact.

The minimum pitch for bolting is usually taken to be 80 mm.

An example of the arrangement of the bolts securing the braces of the metal truss at the node in (Figure 5) is made taking into account all requirements: the step between the rows is observed, the number of longitudinal rows is odd, and the bolts are placed symmetrically.

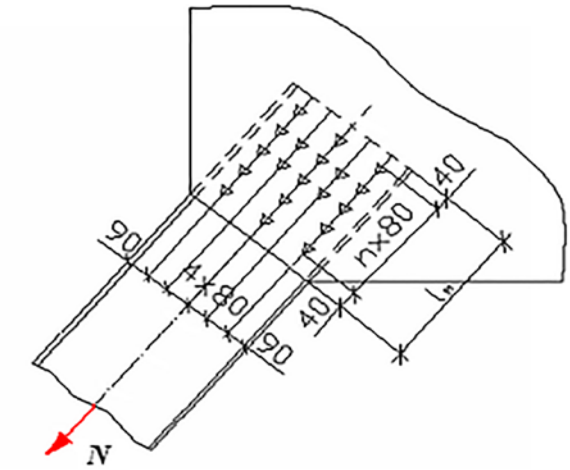

Figure 5. *Diagram of bolt arrangement.*

When using Tekla Structure standard functionality through the tab "Bolts" can be set placement bolt group and carry out the necessary procedure for drawing such a scheme in two passes. Given the number of nodes on the truss, this operation will take a lot of time.

To reduce the time for this operation, the authors proposed an algorithm that allows one-pass arrangement of bolts taking into account all the requirements for their placement. In addition, using this algorithm, the location of each bolt is calculated automatically, and not manually entered.

Input data for the algorithm:

- Width and height of the area for the arrangement of bolts,
- Number of bolts,
- Step of bolting and
- Coordinates of the point, with which start calculation.

To implement the algorithm, a program (plug-in) is written in C #, which performs the alignment of bolts. In Tekla an open approach to BIM is implemented, thanks to this, writing plug-ins is a convenient way to customize the interface and the necessary functionality for programmers.

As an example, to illustrate the operation of the algorithm, it was chosen to fasten the braces to the lower chord of the through main truss (Figure 6). The crosses mark the points from which calculation begins for each area.

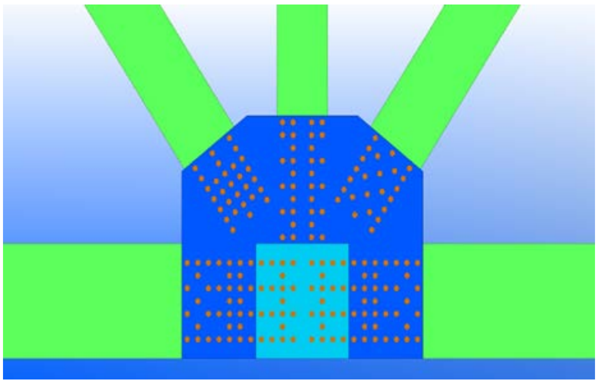

Figure 6. *The lower chord node of the through truss.*

Using the Tekla Open API, a dialog was created for the placement of bolts. The dialog box contains a joint connection and data entry fields. In the corresponding fields of the form, the designer specifies the width, height, step and number of bolts, as well as the starting point of the area in which the bolts are placed (Figure 7). Pressing the "Run" starts the process.

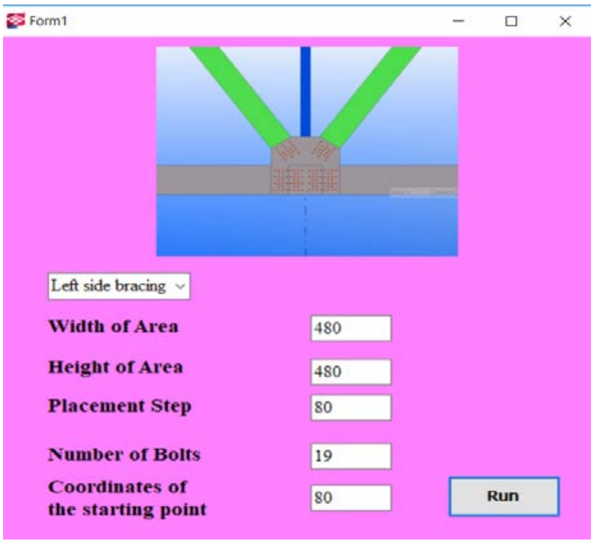

Figure 7. *Dialog box for arranging bolts.*

(Figure 8) shows the result of the program. The bolts are arranged in four areas: fastening the elements of the lower chord, and also fastening of the braces to the lower chord.

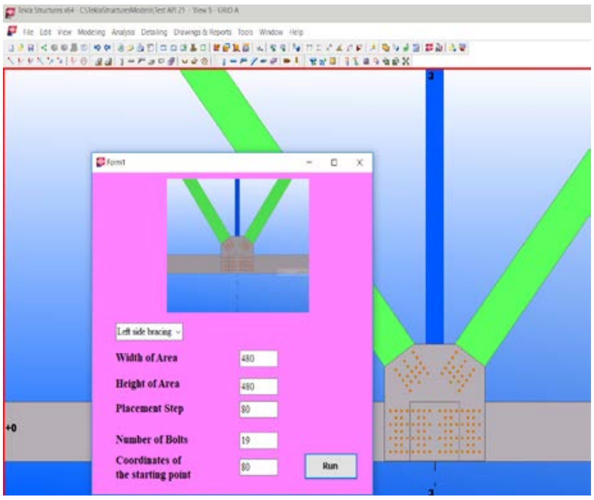

Figure 8. *The result of the plug-in for arranging bolts.*

Using the proposed algorithm allows you to configure a convenient working environment and increase the efficiency of the designer when performing non-standard, but routine tasks. The algorithm can also be useful in the process of training students and postgraduates of construction specialties at the expense of their formalization.

4. Discussion

Modern technologies in the design and construction of transport facilities can speed up the design process and make it more efficient [7]. Expanding the functionality of programs for information modeling using plug-ins allows the designer to set up a comfortable working environment in order to save time and reduce the probability of errors [8]. When using the extended functional adaptation and easier to arrange not only the creation of elements, but also prepare a design for exporting the calculation model to software complexes for structural analysis (SCAD, ANSYS, KATRAN etc.)

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