Investigation of possibilities of automated design of bolted connections in nanoCAD editor for building structures

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Abstract. The article discusses the use of the Russian editor nanoCAD, replacing foreign editors AutoCAD and Autodesk Inventor, for computer-aided design of bolted connections in building structures. It is shown that there are various means for computer-aided design. These include the Mechanics tab and the Bolted Joint tool from the “Design” group, which after calling and specifying the starting and ending points of the connection, opens the “Fastening Details” dialog box. The latest lists bolts, made according to USDD (Unified system of design documentation) standards. Changing the diameter of the bolt metric thread, the type of washer and nut, the authors carry out a preliminary automated selection of the connection, based on the dimensions of the parts to be joined in building structures. If there are no necessary connection components in the “Fastening details” dialog box, they are selected from the Editor's Element Base in the “Part selection” dialog box. Optimization and refinement of the parameters of pre-designed connections is carried out on the Tab Table parameters of the dialog box “GOST 7796–70 Isp. 1, 3, 4”. For the final check, the Calculation tab and one of the options, the design schemes that are opened in it, are used.

1. Introduction
Bolted connections find a wide circulation in building structures, for example, Figure 1.

Figure 1. Bolted joints in a steel metal truss assembly.

In the era of digital technology, works based on the manual design of bolted connections in building structures and in the design of their drawings [1-8] have lost their relevance. From designing bolted connections in building constructions based on well-known foreign editors AutoCAD [9-14], Autodesk Inventor [15-17], their applications and additional modules, it is necessary to refuse and switch to domestic developments.

The nanoCAD editor [18–20] with the direct support of the USDD standards is currently becoming a direct competitor to the editors noted above.
NanoCAD is a graphic editor of the Russian company Nanosoft (www.nanocad.ru), which has a modern ribbon interface with numerous tool tabs, a large database of 2D drawings and 3D models made according to USDD standards, as well as the built-in information retrieval system NormaCS work with regulatory and technical documentation. The cost of nanoCAD is significantly lower than foreign analogues.

Considering the above, it became necessary to assess the possibilities of using the domestic editor nanoCAD [18-20] for the design of bolted joints in building structures.

2. Research methodology

The research methodology consisted in analyzing the possibilities of computer-aided design of bolted connections in elements of building structures in the nanoCAD editor.

The nanoCAD Mechanic 9.0 editor, build 35, 2018 was chosen as a tool for research.

The studies were conducted as follows. Originally built the contours of the two plates, modeling the site of a real building structure (Figure 1). Later, using an automated approach to the design of bolted joints in nanoCAD, the bolted joints themselves were created with the various components of their component parts and the joints were analyzed.

3. Research results

The study of the capabilities of the nanoCAD editor is discussed below with examples.

Example 1. Preliminary design of connections without a design scheme. Using the “Rectangle by 2 points” tool (click of the left mouse button on the Home tab of the Draw group), the Intersect object snap tool (F3 key), the Copy tool (click of the left mouse button on the Home tab of the Edit group ”) and the "Hatching " tool (click of the left mouse button on the Construction tab from the" Contour objects and fills " group), parts of the two parts in the joints are shown as rectangles according to actual dimensions (Figure 2);

![Figure 2. Walls of connected parts.](image)

Using the Bolt Connection tool (click of the left mouse button on the Mechanics tab from the Design group) and the OPTO mode (F8 key), click the left mouse button to indicate the starting point, move the cursor and click the left mouse button to fix the end point of the future bolted connection - the dialog box “fastening details”.

The construction of the connection is carried out as follows: clicking the left mouse button in the “Fastening Details” dialog box on a line, for example, Bolt GOST 7796–70 (1) - clicking the left mouse button on the selected value of the diameter of a metric thread, for example, 12 mm - clicking the left button mouse click on the Apply button - left-click on the OK button - a bolt connection with a pre-set bolt length is formed (Figure 3);

![Figure 3. An example of building a connection with the thread diameter of the bolt M12.](image)
Example 2. Editing the length of bolts for given thicknesses of the parts to be joined and for a given diameter of a metric thread without taking into account the design scheme.

One of the previously created variants of a bolted connection, for example, with a diameter of metric thread M12 (Figure 3), is taken as the initial one.

Editing the bolt length is performed as follows: double-clicking the left mouse button on the connection axis — the Fastening Details dialog box opens — click the left mouse button on the Select Parameters button automatically — click the left mouse button on the OK button — select the mouse cursor and left-click the mouse buttons fix the bolt length - a bolt joint with the selected bolt length is formed (Figure 4).

Example 3. Editing the diameter of the metric thread for a given thickness of the parts to be joined and a given length of the bolts without taking into account the design scheme.

One of the previously created variants of a bolted connection, for example, with a diameter of metric thread M12 (Figure 3), is taken as the initial one.

Editing the diameter of the metric thread is as follows: double left-click the left mouse button on the connection axis — the Attachment Details dialog box opens — click the left mouse button on the desired diameter of the metric thread, for example, 16 click the left mouse button on the Apply button — click the left button the mouse button on the OK button - a bolted connection is formed with the selected diameter of the metric thread M16 (Figure 5).

To improve the performance of the design of bolted connections, the above two methods (example 2 and example 3) are combined with each other.

Example 4. Design of connections with replacement washers.

In the absence of the required standards for washers in the dialog box “Fastening details”, they are selected as follows:

1) clicking the left mouse button in the “Fastening Details” dialog box in the Washer line on its designation GOST 11371–78 - in the Base of elements of nanoCAD Mechanics 9.0, the “Part selection” dialog box opens - double-clicking the left mouse button on the “Spring” folder - click left-clicking on the line “GOST 6402–70 Spring Washers” - clicking the left mouse button in the viewing window on the image of the washer GOST 6402 - the selected washer appears in the “Fastening Details” dialog box);

2) clicking the left button of the mouse in the “Fastening Details” dialog box on the Apply button — clicking the left button of the mouse on the OK button results in a bolted connection with the selected spring washer GOST 6402–70 (Figure 6).
Example 5. Connection design taking into account design schemes.

When designing building structures and optimizing them (in addition to the above mentioned methods - examples 1, 2 and 3), it is often necessary to check and refine the parameters of previously designed bolted joints, which must comprehensively take into account: 1) the length of the bolts; 2) the diameter of the metric thread; 3) the calculated connection scheme, etc.

Check and refine the parameters as follows:
1) double click with the left mouse button on the bolt contour - the dialog box “GOST 7796–70 App. 1, 3, 4 ” tab Tabular parameters. In the dialog box for given thicknesses of the parts to be connected change the diameter of the metric thread and, accordingly, the length of the bolt;
2) left-click on the Calculation tab of the dialog box “GOST 7796–70 Use. 1, 3, 4 ” - by successive clicks of the left mouse button on the arrow in the viewing window (based on the type of building structure), select the appropriate design scheme (Figure 7);
3) in the rows of the selected design scheme, instead of the preset values, make the necessary changes: a) change the diameter of the metric thread and its pitch; b) set the required number of bolts (Fig. 1); c) change the value of external axial force; g) change the strength class of carbon or alloy steel; e) set the degree of responsibility of the connection; e) alter the safety margin; g) set the custom yield strength of steel; h) set a constant or variable load and other indicators.

The changes made automatically affect the calculation results of the maximum allowable diameter of the metric thread. Control over the changes made in the open dialog box "GOST 7796-70 Isp. 1, 3, 4" according to the inscription "STRENGTH OF THE CONNECTION IS SUFFICIENT";
4) click the left mouse button to return to the Tabular parameters tab, which displays the changes made to the calculation scheme;
5) clicking the left mouse button on the Apply button - clicking the left mouse button on the OK button - the dialog box “GOST 7796–79 Use. 1, 3, 4 ” closes automatically and the final appearance of the bolted joint appears after checking and adjusting its parameters using the design scheme.

The final result of the computer-aided design is a 2D-drawing of the bolted joint, which includes fastened parts, a bolt, a nut and a washer.
When it is necessary to build 3D models of compounds, it is convenient to use the methods described in [20].

4. Conclusion

1. With a wide variety of bolts, nuts and washers, users of the nanoCAD editor are provided with ample opportunities for computer-aided design and editing of riveted joints used in most types of building structures, including instant evaluation of results in the preview windows after changes made in the “Mounting parts”.

2. With the comparability of the results, and also, given the relevance of import substitution, the transition to work in the editor nanoCAD Mechanics [18-20] of the Russian company Nanosoft (www.nanoCAD.ru) allows to completely abandon work in foreign editors AutoCAD [9-14] and Autodesk Inventor [15-17] of the American company Autodesk (www.autodesk.com or www.autodesk.ru).

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