Features of BIM-modeling of engineering systems of the construction object

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Abstract. In this article, the possibilities of designing engineering systems of buildings with the use of information modeling tools are considered. In particular, the aspects of the process of designing power supply systems are discussed in detail. The analysis of software products on their adaptability to design problems and the regulatory framework of the Russian Federation is analyzed using the example of calculating the required illumination level for various types of premises (lighting engineering calculation).

The article considers two BIM-oriented programs performing the same process. In the course of the analysis, different approaches to accomplishing the task. In particular, similar program features were revealed, as well as their differences, which allow design engineers to develop project documentation with varying degrees of detail. Including a comparative analysis of the results of automated calculation with manual methods.

1 BIM-modeling

1.1 Concepts

The application of information modeling technologies (BIM) in the problems of engineering and construction design allows to reduce the time and improve the quality of making design decisions, and also to create decision support tools for the tasks of the whole life cycle of the construction object.

With the development of systems of information modeling of buildings and structures, the problem of designing engineering systems can be realized with the involvement of less human and time resources. The process of information modeling allows not only to save time for the development of output documentation, but also to minimize the influence of the human factor on the quality of design solutions.

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1.2 Existing solutions to interaction

Currently, there is a fairly large number of software tools that implement information modeling technologies that allow the development of project documentation for electrical equipment and lighting in the Russian Federation, in accordance with Government Decision No. 87 "On the composition of sections of project documentation". Next, the functionality of these software products allows you to export the developed model into an open data exchange format (supported by the vast majority of software environments) IFC to simplify the interaction between various software tools and to form a common data environment between the stages of the life cycle of the construction site.

2 Adaptation of BIM-modeling programs to the design of engineering systems in the Russian Federation

2.1 Problem

BIM-modeling programs need adaptation to design features in the Russian Federation, especially in engineering systems. This is justified by the various requirements for the implementation of the main sections of the design and working documentation required for the design of engineering systems projects, in particular power supply and electric lighting systems. It is also worth noting different approaches to designing similar sections in different countries. To identify the difference, several programs were compared to perform a work task.

2.2 Approbation

As an example, consider the implementation of the problem of calculating the level of illumination in a room (lighting engineering calculation) in two software products that implement simulation technologies in engineering and construction design and also we will consider manual methods of calculation, for check of correctness of calculations.

Consider the same room in two different programs of information modeling, one of which is the development of domestic specialists, created under the import substitution program. Since the designing will take place on the territory of the Russia, it is necessary to apply the standards of illumination established in the higher normative and technical documents accepted in Russia. Such are the List of the Rules 52.13330.2016 «Daylightning and artificial lightning» and Health Regulations Standarts 2.2.1/2.1.1.1278-03 «Hygienic requirements for natural, artificial and combined lighting of residential and public buildings».

Consider the usual office in the office building, for 2-4 employees.

According to table No.2 of the Health Regulations Standarts 2.2.1/2.1.1.1278-03 [1] this room belongs to the administrative buildings and has a height of the working plane (surface) G-0.8. This means that the visual work is carried out on a horizontal plane, at a distance of 0.8 m from the floor (the standard height of the desktop). In addition, the illumination index on this surface should be 300 lux. Taking these data as standard for the room, we calculate the level of illumination in this room, using the same model of luminaires in two different BIM-oriented programs.

The first type of software used automatically calculates the illumination level using the lighting equipment utilization factor. This software is developed under the import substitution program and has a significant database of normative and technical documents integrated into the program environment, which ensures maximum compliance of project solutions with normative documentation.

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Figure 1 shows the process of automatic selection of fixtures of a certain type and the calculation of the illumination level according to pre-selected types of rooms by Health Regulations Standarts 2.2.1/2.1.1.1278-03.

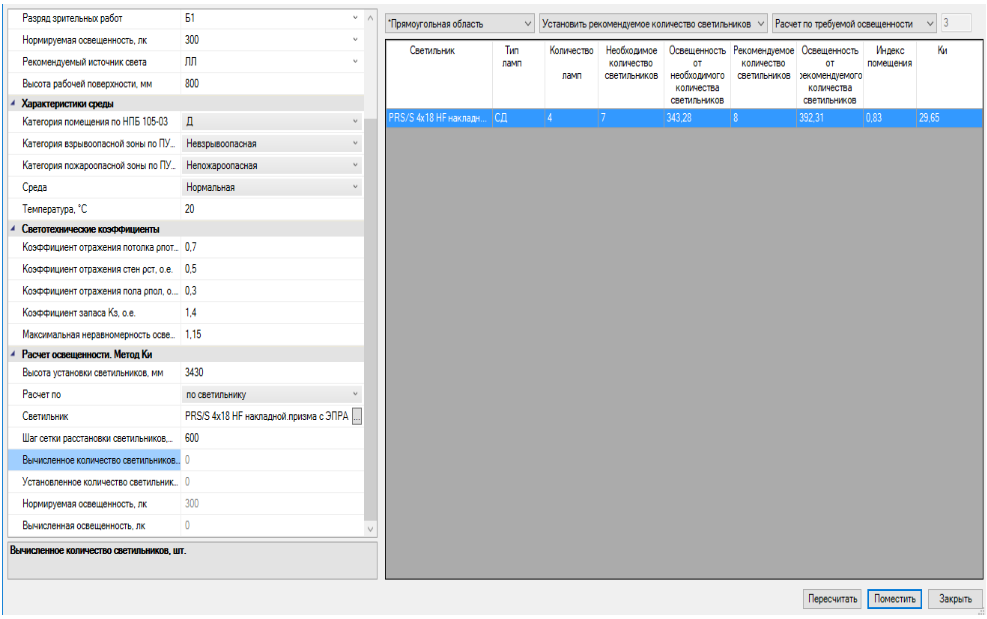

Fig. 1. Selection of parameters and luminaires for automatic calculation of the level of illumination in the room (Software No.1).

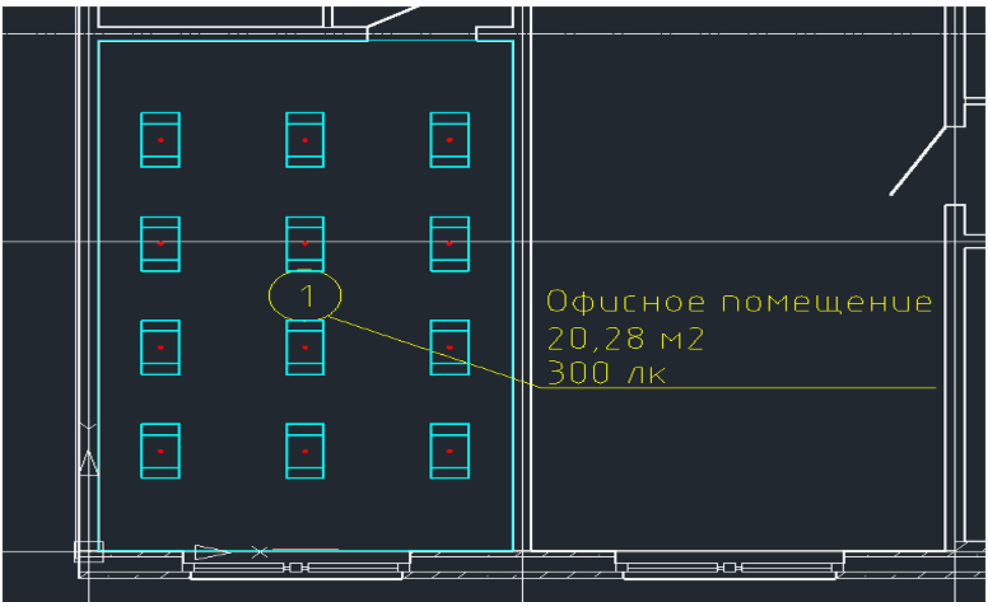

Fig. 2. Presentation of the results of automatic calculation and selection of fixtures (Software No.1).

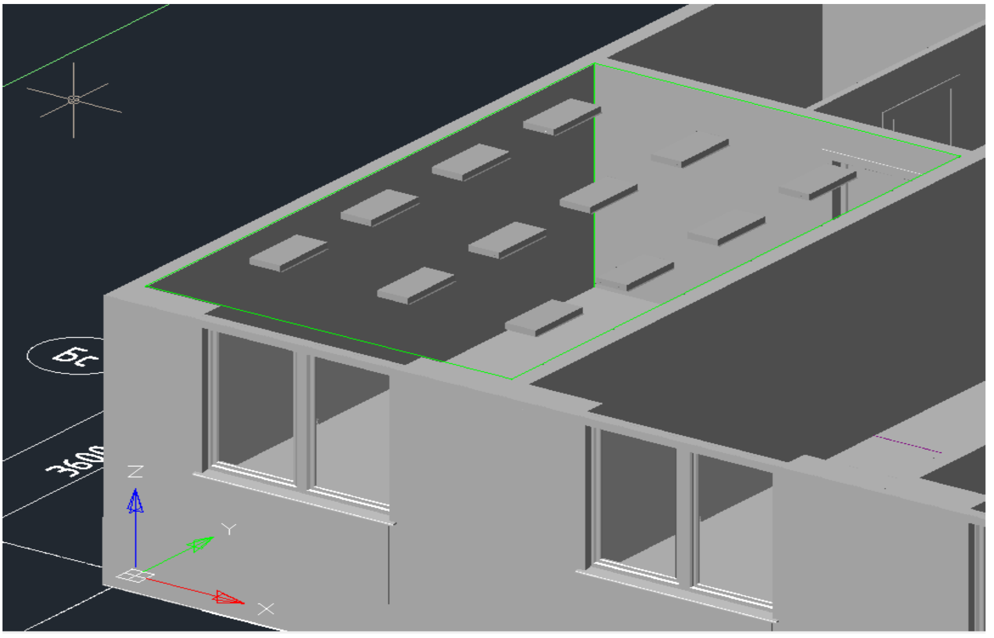

Fig. 3. Representation of the 3D model of the object (Software No.1).

The study of the process of automatic calculation of illumination software No.1, we can conclude that the calculation itself is correct and its presentation to the project. It is worth noting that due to integrated normative-technical documents and their parameterization, the calculation is simplified to the utmost, but still meets the required parameters.

The second type of program also performs automatic calculation of the level of illumination, however, the automatic arrangement of objects in the model space is absent.

Normative and technical documents used in the design in the RF in this program are not integrated, therefore it is not possible to choose the type of the premises according to the document, and however, the illumination level calculation by the coefficient of utilization is realized here. It is worth noting that the program calculates the lighting is not entirely correct (the maximum illumination is indicated).

The positive aspects of the first approach include adaptation to the normative and technical documents of the Russian Federation, because of their integration into the program complex. Including, there is an automatic calculation and arrangement of the lighting elements, according to the required illumination. The disadvantages are weak visualization and the old-fashioned 2D approach to compiling the information model.

To the positive sides of the second approach is a high level of detail, as well as flexible adjustment of the elements of electric lighting. In this case, the disadvantages are the impossibility of automatic arrangement of the elements, according to the level of illumination, an incorrect calculation of the illumination index (in terms of maximum illumination).

Figure 4 shows the automatic calculation of the illumination level on the plan, indicating the peak level of illumination in the selected room.

Fig. 4. The location of equipment and the level of illumination, calculated in automatic mode (Software No.2).

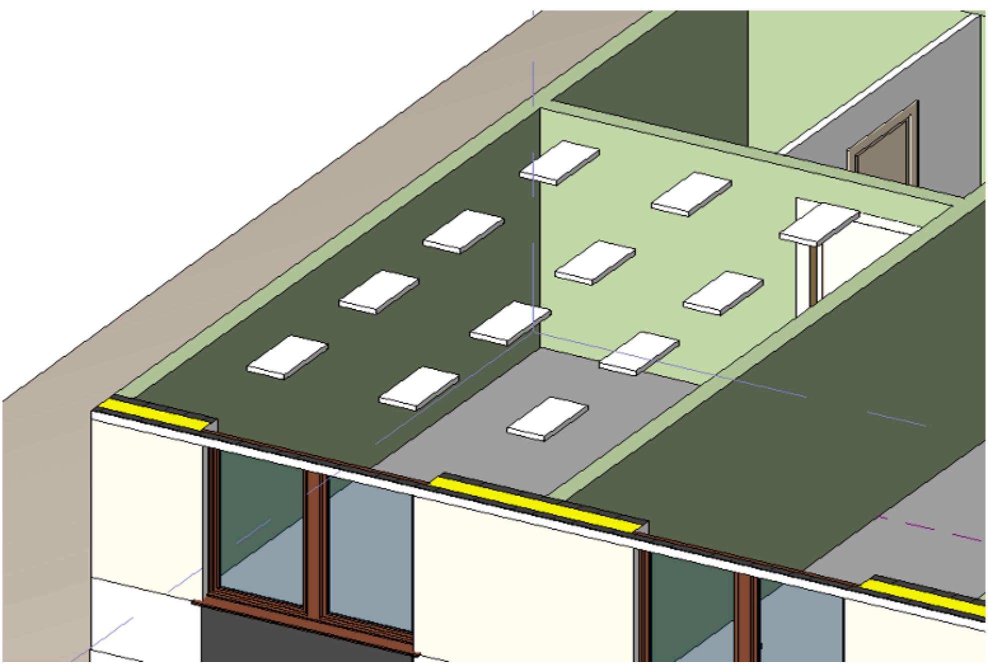

Fig. 5. Representation of the 3D model of the object (Software No.2).

Having the results of the automatic calculation in two BIM-oriented programs, it is necessary to verify the correctness of the calculations of the lighting by the manual method. We use the method of using the luminous flux to determine the required number of lighting equipment for this type of room. Since the type of room and the normalized illumination were previously defined, according to the method, it is necessary to select the required number of luminaires to provide the required level of illumination using equation 1 [2].

$$N=(E_{min} \times k \times S \times Z)/(\varphi_n \times n \times \eta), \quad (1)$$

where:
N – count of lamps;
E_{min} - normalized illumination, lx (in this case is 300 lx);
k – safety factor of illumination (in this case is 1,5);
S – illuminated area, m^2 (in this case is 20,28 m^2) ;
Z - coefficient of minimum illumination (in this case is 1,1);
φ_n – luminions flux of the lamp, lm (part oft he luminaire design);
n – count of lamps (part oft he luminaire design);
η - coefficient of use of the luminous flux in fractions of a unit.

To determine the number of lamps, you must first determine the utilization factor of the using flux η. To do this, it is necessary to determine the index of the room according to the equation 2 [2] and select the desired indicator according to the table of lamps.

$$i=S/(h_1 - h_2) \times (a + b), \quad (2)$$

where:
i – index of the room;
S – illuminated area, m^2 (in this case is 20,28 m^2);
h_1 – heght oft he lamp, m (in this case is 3 m);
h_2 – heght of the working surface, m (in this case is 0,8 m);
a – lengh of the room, m (in this case is 6 m);
b – width of the room, m (in this case is 3,38 m).

Having all the data you can determine the index of the room by the equation2:

$$i=S/((h_1 - h_2) \times (a + b)) = 20{,}28((3 - 0{,}8) \times (6 + 3{,}38)) \approx 1$$

Now, according to the fixture matching table, you can select the using factor of the luminous flux of lighting equipment based on the reflection coefficients:
r_n – ceiling reflectance (for office spaces is 70%);
r_c – wall reflectance (for office spaces is 50%);
r_p – floor reflectance (for office spaces is 10%);

According to the table of conformity: η = 0,43, substitute in formula 1 and calculate the required number of fixtures:

$$N=(300 \times 1{,}5 \times 20{,}28 \times 1{,}1)/(2000 \times 0{,}43) \approx 12$$

According to the calculation, it is necessary to provide for the installation of 12 lamps, which coincides with the automated calculation. This implies the correctness of the lighting calculations performed by BIM-oriented programs, and hence the acceleration of the process of designing electric lighting systems.

3 Conclusion

Thus, practical tests have been carried out on the application of two types of software products and manual calculation for solving the problems of engineering and construction design using information modeling technologies. It is possible to single out such common approaches of the considered software products as the automated calculation of the illumination level based on the lighting files (IES) from the manufacturer. At the same time, the considered software has significant differences: different methods for calculating the level of illumination, different approaches to the organization of data libraries for electric lighting elements. The use of various software tools to solve almost project problems is conditioned by the formulation of the design task and the structure of the initial data. A promising area of work in the subject area under consideration is the development of a methodology for selecting software tools for implementing project procedures, based on known limitations and formulated optimality criteria. In addition, in future work it is planned to consider the influence of methods and means of collective work with information models of construction objects as a tool for the effective distribution of labor.

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