The dry mortar consumption calculation automation in the finishing work organization

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Abstract. The use of modern building materials in organizing the production of finishing works makes it possible to avoid shrinkage cracks in the finishing layer, to regulate the humidity conditions indoors, to increase the sound and heat insulation properties of the walls. In this connection, in the process of finishing work, the question about the selection of the necessary dry building mixtures, the diversity of which is also confirmed normatively, arises. The article proposes a method for the automated selection and calculation of the dry building mixtures consumption during the finishing work production organization by creating an algorithm described using the Dynamo visual programming tool. The functionality of the developed software scenario and the interaction of a bunch of Revit and Dynamo programs are presented. The sequence of user work with a software script is described. The proposed script can be used by architects and designers.

Introduction

The dry building mixtures (DBM) consumption calculation and the choice of their specific type when organizing the finishing work production depends on their technical characteristics. Dry building mixes are used for various types of work, so they are usually divided into classes. The technical conditions set forth in GOST 31189-2015. Dry building mixes help to streamline the many varieties of DBMs presented on the modern building materials market.

Classification.

The separation of products is carried out on various grounds. Given that the study was conducted only for the stage of finishing work indoors, the following classification features of DBM were considered:

- the functional purpose of the mixture (masonry (thick, thin); plaster (heavy, light, especially heavy); putty (leveling, finishing); glue (intended for laying: facing materials, sheet materials); grout (suture); floor; repair (surface-restoration, volume-restoration structural, injection); insulating; special (protective, restoration, etc.); for facade heat-insulating composite systems with external plaster layers for the device);

- type of binder used (cement; gypsum; lime; magnesia; polymer; mixed).

An important criterion in selecting the DBM type is also the type of premises in which the construction work is planned. So, for example, cement-based mixtures are used in wet rooms, gypsum or polymer-based mixtures are used in dry rooms, since dry mixtures based on gypsum binders are made according to a different scheme, unlike DBM for general construction works. The difference lies
in the order of loading the components: at the beginning gypsum is poured, then finely ground filler, after the additive is added [1].

Today, the diversity of DBMs and their price range leads to the fact that the customer has to devote the considerable time to choosing the necessary building material. However, the rapid design work automation development thoroughly introduced transformations into the design and construction methods of buildings and structures, which is primarily due to the fact that the use of CAD systems can increase the drawings accuracy, as well as analysis and calculation of structures and materials during design. As a result, it became possible to detect errors in a timely manner, at the stage of automatic calculation of the required material’s volumes, which helps to reduce financial losses at the stage of organizing the interior walls’ decoration.

The purpose of the present study is to develop a software script using a bunch of Revit and Dynamo software products, which allows, at the same time, to simulate the interior decoration of the interior walls and obtain the necessary information about the indoor area selected for finishing work, the type of material and its cost, in the form of automatically filled specifications and statements. To achieve this goal, the following tasks were solved:

- the existing problems that arise when using analogues of a software script for modeling and calculating the costs of interior wall finish material in the Revit program, and also discusses the creation of layers and the calculation of manual consumption of finishing material have been analyzed;
- the requirements for modeling the decoration of the internal walls are identified, which allow to ensure the correct construction of the finishing layer have been determined;
- an architectural model of the object has been created and an accurate automatic cost calculation has been performed with the selection of material used for finishing work.

The relevance of the research

The choice of building material for the decoration of the premises is an important component in ensuring comfortable living conditions for a person. At the same time, the process of modeling wall decoration, with the calculation of material consumption and entering information about the decoration in the specification, requires significant time and labor costs. In addition, possible errors at the stage of calculating the cost of the finishing material required volume can entail significant financial costs for the customer.

At the same time, today, a sufficient number of scientific publications, both in Russia and abroad, are devoted to the development of new energy-efficient types of DBM, the problems of the choice of mixtures in organizing the production of finishing works, the calculation of their volumes and other aspects related to their application. [1-12 and others]. The methods of choosing the finishing material for the walls are presented in detail in [2-4], and the article [5] indicates the importance of visualizing the interior decoration for demonstration to the customer. However, the authors did not take into account that the general finishing parameters, such as the height and thickness of the finishing layers, entail a significant increase or decrease in the required volume of mixtures and the cost of work, as a result.

The importance of the transition from manual modeling of one-time geometries to computer-aided design (CAD) by introducing common high-level geometry patterns and choosing a CAD program to implement automated modeling of the finishing layers of dry building mixes is considered in [6,7]. At the same time, we note that not all programs have functions that allow the automation of modeling and calculation of the dry building mixes consumption.

Methods and Methodology

The design automation task for the modern construction of buildings and structures is relevant, and its solution can lead to the reduction in the design time and calculation of the resources spent, thereby speeding up and simplifying the construction process as a whole.

There are currently several methods and techniques built on the basis of a variety of approaches and criteria that allow avoiding unnecessary time and labor costs in the process of construction and
construction work. So, for example, automation of calculating the DBM consumption during the finishing works production organization is able to provide a reliable and quick way to calculate the financial and material costs of a future project, while visualizing the finishing layer model. To automate the selection and calculation of DBM consumption, the study uses Autodesk Revit and Dynamo software.

Autodesk Revit is a software package for computer-aided design that implements the principle of building information modeling (BIM), provides the ability to three-dimensional modeling of building elements and a flat drawing of design elements, allows to organize a teamwork on a project, starting with the concept and ending with the release of working drawings and specifications.

Dynamo is an add-on for Autodesk Revit that speeds up and automatically performs the functions that cannot be performed in Revit.

An exceptional difficulty in automating the selection and calculation of dry mortar consumption during the finishing work organization is setting up a project template in Autodesk Revit, which consists in correctly filling in the data, creating system families and calculation formulas in the specifications / statements of decoration.

Results

DBM packages are marked and contain information on the consumption of the mixture per 1 square meter at the recommended thickness of the finishing layer. Based on these data, it is possible to calculate the DBM consumption according to the following formula:

\[
\text{Total DBM consumption} = \text{Consumption per 1 sq. m} \times \text{wall area}
\]  

(1)

At the beginning, a DBM analysis of presented on the market in Russia, including a study of their main characteristics aimed at understanding the current market conditions and correct selecting the most popular materials for the finishing layers automated modeling implementation, the selection and calculation of dry building mixes was made. The study used the characteristics of dry gypsum building mixes for plastering internal walls, brands such as Forman, Knauf, Willis.

Then, the project template is set up in Autodesk Revit for the correct operation of the program script: the necessary data is entered, system families are created (Figure 1-2), the calculation formulas are created in the specifications / lists of the indoor areas’ decoration (Figure 3-4).

![Figure 1. Creating a system family of DBM for finishing work](image-url)
Next, a 3D model of the building is created in Autodesk Revit: the building’s body, door and window openings, as well as the main internal structures, are modelled. Based on the results of entering all the necessary parameters, it is possible to create an information model of the object (Figure 5–6).

Figure 2. Filling in the required data on the DBM

Figure 3. Filling in the data for the premises for which the calculation will be implemented

| Unit price | 238.00 |
|------------|--------|
| 10 mm consumption | 11.500000 |
| Kraft bag | 28.000000 |

Figure 4. The decoration sheets

| Type of finish | Finishing Height, m | Area, m² | Thickness, mm | Quantity | Consumption, kg | Total cost, USD |
|----------------|---------------------|----------|---------------|----------|----------------|----------------|
| Plaster "Forman" 10 mm | 8.00 | 72.00 | 10.00 | 30 | 828 | 89.4 |
| Plaster "Forman" 10 mm | 8.00 | 72.00 | 10.00 | 30 | 828 | 89.4 |
| Plaster "Rosband Knauf" 30 mm | 8.00 | 72.00 | 30.00 | 61 | 1836 | 358.3 |
| Plaster "Rosband Knauf" 30 mm | 8.00 | 72.00 | 30.00 | 61 | 1836 | 358.3 |
| Plaster "Walls" 10 mm | 8.00 | 72.00 | 10.00 | 20 | 612 | 78.6 |
| Plaster "Walls" 10 mm | 8.00 | 72.00 | 10.00 | 20 | 612 | 78.6 |

Figure 5. 1-2 floor plan
Next, a software script that implements automation of the DBM consumption selection and calculation and the formation of a report of the decoration material for the premises taking into account window and door openings, as well as all the material and financial expenses sheet is created (Figure 8.)
Figure 8. Implemented script for modeling the finishing layers and calculating the DBM consumption

Next, the results on the selection automation and the designed object’s dry building mixtures consumption calculation are generated. The results of the dry building mixtures finishing layers modelling visualization and the statements of calculation for the object under study are shown in Figure 9 and Figure 10, respectively.

Figure 9. The finishing layers modeling visualization
Figure 10. Sheet for calculating the DBM consumption

Summary
Dynamo visualization program in-built into Autodesk Revit saves time on modeling finishing layers, choosing the dry building mixes’ brand, calculating their consumption in organizing finishing work and financial costs.

In addition, it is possible to simulate the wall decoration in real time, while changing the parameters: thickness and height of the finishing layer. If necessary, the trim sheet also changes automatically and recounting all costs again.

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