Parametric modeling in architectural and construction design in AutoCAD

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Abstract. The work introduces modeling in AutoCAD as one of the most adapted CAD for professional designers and architects, as well as for beginners. The creation of associative drawings of a building object in AutoCAD based on its 3D model is considered. When developing a building model, the technology of 2D block parametrization was applied, an associative array was used and both solid and surface modeling were implemented. The article introduces the possibility of creating a 3D dynamic block based on associative surfaces in an environment of flat parameterization of AutoCAD. The great importance of organization of work "on layers", with blocks, was noted. The photorealistic visualization of the building and its section with staging the scene was performed: by creation of light sources, assignment of materials, construction of shadows and insertion of a background. The article familiarizes construction students and design engineers with progressive methods of work in AutoCAD while developing the graphic part of the architectural and construction project, which allows one to speed up the implementation of all design processes.

1. Introduction
Today, when the progress of information technologies is evident in construction, most of the architectural projects are developed with the help of CAD, which solve the main tasks such as creating 3D models, making drawings and documentation.

The main goal of CAD in architecture and construction is to increase the efficiency of engineers' work, by automating work in the design and preparation of production [1-3]. Of great importance in achieving this goal are the knowledge and skills to professionally solve and design solutions using the techniques and technologies incorporated in the programs and allowing to optimize the design work [4-7].

2. Optimization of construction drawing. Working with blocks, arrays, layers, styles
Construction drawings contain a large number of geometric objects, which affects the file size and requires considerable time for their execution and editing.

The advantage of working with blocks is the inheritance of all the changes made to the definition, and the saving of system resources in view of their "reference nature".

Another quick method for creating multiple copies of an object is an array - a group of identical objects located in a certain order and at a certain interval. This work employed a Rectangular array with the insertion of windows on the facade and an Array along the path when creating racks of stair railing.
Objects placed on layers allow to increase the speed of editing their properties, control their visibility, blocking, transparency, printing, ensure the logic of an operation.

Styles (text, dimensional, visual, etc.) are necessary in order to manage the appearance of the object with great efficiency. Changes made to styles are automatically applied to all objects that use them.

3. Creating a 3D object model
At the heart of modern CAD there is creation of a computer model of the object. A designer creates an electronic copy of the projected object and has the opportunity to see the future project in the most realistic form of three-dimensional space [8-11].

The capital walls and partitions of the building are built by Polybody command by marking the coordinate axes, adjusting its width, height and location. A floor is constructed by Extruding a polyline.

It is advisable to build a model of one floor and multiply it by copying to other floors, see Figure 1. Consider constructing some of the main building elements of interest in covering topics.

4. Creation of parametric 3D blocks of windows and doors
To perform laborious work with repeating objects of similar geometry with different sizes - inserting windows and doors into the openings, create their 3D dynamic blocks (DB) [12-14]. Consider constructing a 3D DB window.

The parameterization is flat in AutoCAD. In the basis of the future changing 3D model there will be a 2D dynamic block. Build a window image with polylines and create a 2D block based on it. Apply to it the technology of Parametrization. In the Block Editor, set the geometric constraints (coincidence, verticality, perpendicularity, collinearity, fixation, symmetry) and dimensional dependencies (dimensions of frame and bindings), see Figure 2(a). Obtain a 2D DB with a set of varying sizes. For ease of use, display all dimensions in the Table of Properties, see Figure 2(b) [15-18].

The task is to create a three-dimensional parametric window model [19,20]. As "Solid" support parametrization not fully, apply associative surface modeling. While in the Block Editor, create frames and glasses as associative Extrusion surfaces and Surface Closures. The openings for glass are built by Trimming of surfaces. A 3D parametric block is obtained - a set of associative surfaces subject to the displacement of the polyline [21]. Set the frame and glasses the materials, test the resulting 3D DB, in the absence of errors, save the block description and exit the Block Editor. Now everything is ready to insert the changing parametric models of windows into the wall openings cut by the "box", with the Rectangular array command.

Parametric door models, see Figure 2(c) are created similarly. But in order for a double-winged door to turn into a single-leaf door, it is necessary to set the Visibility operation in the Block Editor.
The ability to work with blocks, create libraries of three-dimensional and two-dimensional parametric blocks allowing to create, edit or modify a project in a short time.

Figure 2. Creating parametric 3D window and door blocks.

5. Creating associative drawings of a building based on the model
The possibility of obtaining associative 2D drawings from 3D models in ACAD accelerates the creation of drawings and provides the opportunity to make changes to the model while working on the project, without losing the finished information of the drawing. A set of commands for working with an associative drawing allows to create images of facades, cuts, including the unfolding secant plane, sections and axonometric projections based on them [8]. When creating images, layers are automatically created. It is possible to customize the styles of the cutting planes.

Automatically generated projections do not always provide a fully correct image: for example, they may contain extra lines at the joints of the walls, not a standard image of window openings and lines that do not fall into the cutting plane, see Figure 3 but are corrected in red. The final completion of the 2D construction tools and the design of the drawing in accordance with the requirements of the standards are carried out after exporting them to another file and discussed in detail in [22].

Figure 3. Creation an associative building drawing.
6. Presentation visualization

Visualization tools of AutoCAD allow to create a photorealistic image of the model, visually immersing the viewer in the real world [23]. If desired, it is possible to create any scene: set up natural or artificial lighting with visualization of shadows, see Fig. 4(a), assign objects with textures, color, transparency, gloss, relief, put the scene into a real background, set the desired point of view, see Figure 4(b). Modern technologies allow to see the interior of the future building, see Figure 4(c).

![Figure 4. Photorealistic visualization in AutoCAD.](image)

7. Conclusion

This work confirms that AutoCAD, while remaining the main graphic package for the beginning designers - construction students, allows to successfully solve complex problems using parametric modeling. Surface associative modeling solves the problem of creating a 3D dynamic block in a medium of planar parametrization. Working with blocks optimizes the design process not only in terms of quickly changing the size and visibility of objects, but also replacing the materials assigned to them. Improving the skills of students in a program with three-dimensional objects allows to remain competitive.

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