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SOFTWARE DEVELOPMENT FOR THE DESIGN OF STRETCH CEILINGS

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Abstract

*Work on the installation of suspended ceilings requires very accurate calculations and precise cutting. When creating the appropriate design systems are based on geometric calculations and key formulas describing the surface. The aim of the work was to develop a subsystem for the design of stretch ceilings, which would minimize the time and material costs that inevitably arise during the organization of production, installation of this type of structures. The classification of approaches related to geometric modeling is carried out. There are two main approaches to geometric modeling of design objects: the approach of structural geometry and the boundary approach. Constructive geometry is to create a library of geometric primitives (elementary objects), on the basis of which by means of regularized Boolean operations (intersection, Union, etc.) is to build a model. The boundary approach is based on the capabilities of piecewise analytical description of the object, description of its boundary elements (faces, edges, vertices of features and contours, nodal point of plane objects) based on algebraic equations. Geometric models have a hierarchical structure that results from the bottom-up construction. An element of a geometric structure can be: a coordinate system, a point, a curve (flat, spatial), a surface, a geometric body. For the two-dimensional case, the objects of modeling are planar contours, which consist of segments of planar curves. The elements of the topological structure of the contours are node points, line segments. The curve can be represented by a set of points, provided that they are close enough to each other. In the scatter method of geometric simulation model is used, the basis of which is the point. The use of mathematical description of the curve complicates the model, but has a number of advantages, for example, there is no need for an interpolation scheme to find intermediate points. The program is designed "Europalace" allows you to quickly build a shape with the specified parameters. There are tools to rotate the selected objects and enable the step-by-step construction mode in order to carefully consider the geometric modeling process and adjust it if necessary. The created system of design of stretch ceilings has the following features: execution of construction on the basis of the table of input data with coordinates and angles; execution of construction of an ellipse; execution of construction of a half-ellipse; execution of construction of a rectangle; execution of construction of a triangle; functions of rotation of the selected edges;
feature construction steps; the function print project.*

Keywords:

Design, stretch ceilings, program.

ACM Computing Classification System

Physical sciences and engineering, Technologies, Management of computing and information systems

Introduction

The work on the installation of suspended ceilings requires very accurate calculations and no less accurate cutting.

And since in the modern world it is very difficult to imagine work without the use of information technology, when installing tension structures can not do without the help of computer programs.

The creation of such a program will significantly simplify the process of installation of ceiling structures, to make competent calculations and cutting, quickly, efficiently and without errors.

The developed system is based on geometric calculations and fundamental formulas, on the basis of which the calculation of the project of the stretch ceiling is made. On the basis of these calculations, experts will be able to mount the ceiling, accurately calculating the amount of material that will be required, and the customer will be able to see the ceiling, how it will look realized desires.

Today stretch ceiling is a popular way of finishing the ceiling. In the Russian Federation today is the development of systems of suspended ceilings, and firms that perform this kind of work, not so much - it is possible to occupy a niche in the market of companies that perform such orders.

The software that helps designers in their work is also a little bit, and these programs miss some points that could help the designer in a particular situation, so I consider the theme chosen for the final qualifying work to be reasonable and in demand, and the product developed is able to compete with existing software products of this line.

The purpose of this paper was to develop a subsystem for the design of stretch ceilings, which would minimize the time and material costs that inevitably arise during the organization of production, installation and sales of this type of structures.

1 Geometric modeling methodology

When creating CAD, we can not do without methods of geometric modeling of objects in two-dimensional and three-dimensional space.

Geometric modeling is a method of studying objects by constructing their geometric models. A geometric model of an object is a system of geometric relations describing the object. The geometric model of the object O is a triple

$$(O)=\{A, F, R\}, \tag{1}$$

where A is the set of geometric elements;
F - set of geometric attributes(characteristics, parameters);
R-set of relationships between elements and attributes.

In this model, A is the mapping of the geometric elements of object A, F is the mapping of the attributes, and R is the mapping of the relationships between the geometric elements and the attributes of object A.

There are two main approaches to geometric modeling of design objects: the approach of structural geometry and the boundary approach [1] (Fig. 1). The approach of structural geometry is to create a library of geometric primitives (elementary objects), on the basis of which the regularized Boolean operations [3, 4] (intersection, Union, etc.) are used to build the model.

The boundary approach is based on the possibility of piecewise analytical description of the object, i.e. description of its boundary elements (faces, edges, vertices of features and contours, nodal points of plane objects) by algebraic equations.

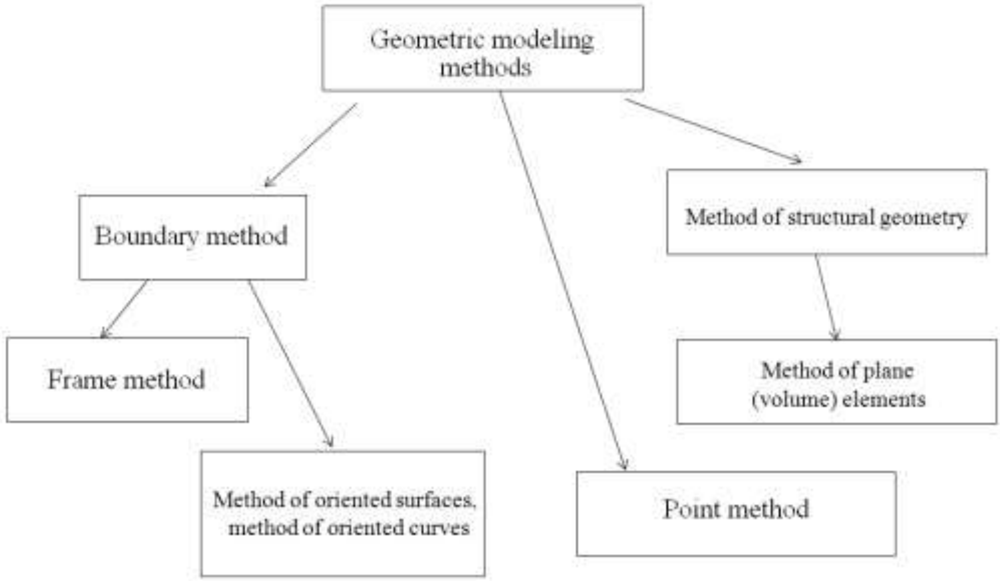

Fig.1. Classification of geometric modeling approaches

A feature of the developed system of geometric modeling, focused on solving the problems of automation of design of engineering objects, is the use of a combination of two approaches to geometric modeling, i.e. the creation of a combined model of the MKOMB object

$$MKOMB=\{MK, BM, F\}, \quad (2)$$

where MKG is an object model using the structural geometry method;
BM – model of the project using the marginal approach;
F – operators convert MKV to BM and BM in MKG.

Geometric models have a hierarchical structure that results from the bottom-up construction. The element of the geometric structure [5, 6] can be: a coordinate system, a point, a curve (flat, spatial), a surface, a geometric body.

A generalized scheme of options for building models of objects is shown in Fig. 2. Arrows indicate how to form geometric elements by using elements of a different dimension.

In the two-dimensional case, the objects of modeling are planar contours consisting of segments of planar curves. The elements of the topological structure of the contours are node points, line segments. The curve can be represented by a set of points, provided that they are close enough to each other.

Point method of geometric modeling uses the model

$$MP=\{P,SA,\}, \quad (3)$$

where P – set of points;
SA – set of attributes $<x_i, y_i.>$, where x_i, y_i – the coordinates of the point;
DIP – display connecting a pair of incidental points.

The MP model is the simplest of the models. It does not use a mathematical description of the curve. The use of mathematical description of the curve complicates the model, but has a number of advantages. In particular:

* mathematical description is accurate, which makes it easy to calculate curve characteristics such as slope, radius of curvature, etc.;

* there is no need for an interpolation scheme to find intermediate points;

* the use of the MP model is difficult if the shape of the curve has to be changed to meet some given criterion.

Mathematically, the curve can be presented in parametric or nonparametric form. The parametric form of the curve description has the form

$$x = f(t),\ y = g(t) \tag{4}$$

where t is the parameter.

A nonparametric curve is described as an explicit or implicit function. The explicit description is $y = f(x)$, implicit $f(x, y) = 0$. A point on an implicit curvilinear segment can be determined by computing the root of an algebraic equation.

An oriented curve is a curve with a specified bypass direction. The orientation of the curve $f(x, y) = 0$ is determined by the direction of the path relative to the area specified by the inequalities $f(x, y) > 0$. Obviously, the curve $-f(x, y) = 0$ coincides with the curve $f(x, y) = 0$, but has the opposite orientation.

The method of oriented curves is to build a geometric model

$$MOC=\{OC, N, SA, DIP\}, \tag{5}$$

where OC-oriented curves;
SA – set of attributes <x_i, y_i.>, where x_i, y_i – the coordinates of the node points;
DIP – display connecting a pair of incidental node points.

The approach of structural geometry on the plane is to construct a two-dimensional object (contour) from a set of specified two-dimensional elementary (base) objects by means of geometric operations of Union, intersection and subtraction taking into account the orientation.

As the basic elements can be used: point, line segment, circle arc, arc parabola, arc hyperbola, arc ellipse, rectangle, parallelogram, circle, etc.

The method of plane elements is to build a geometric model

$$MPE=\{EO, CAP, PAR, PO, GO\}, \tag{6}$$

where EO – set of elementary objects;
CAP – the coordinates of the anchor point; <x, y, φ> – coordinates and angles that define the position of the object in the main coordinate system;
PAR – object parameter;
PO – the transformation of the object on the plane;
GO – geometric union and intersection operations.

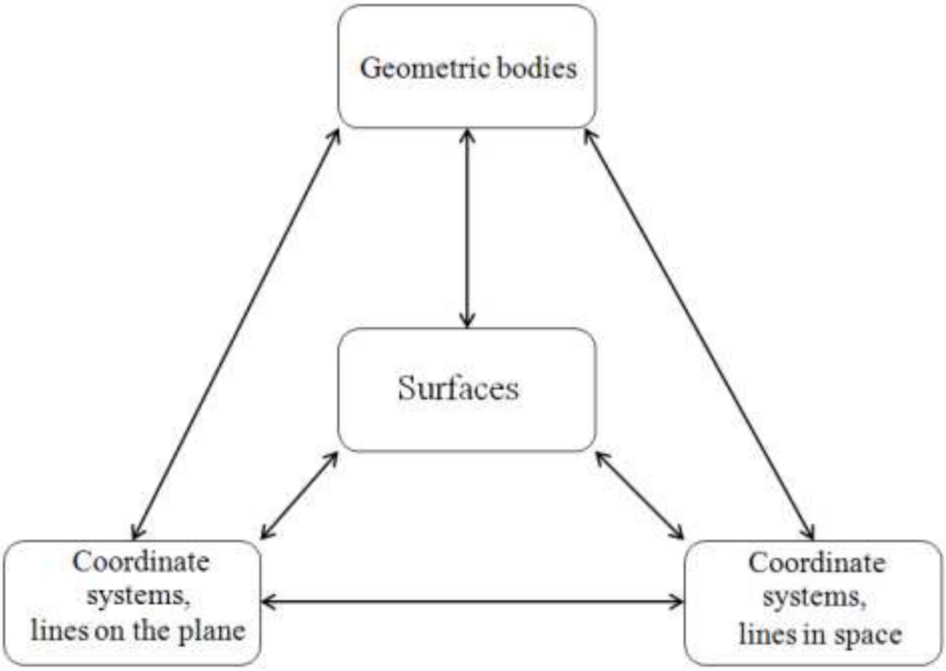

Fig.2. Generalized scheme of options for building object models

Various transformations can be performed on geometric models of objects: transfer, rotation, uniform and non-uniform scaling. Geometric transformations are defined as the objective mapping of a coordinate space into itself. The structure of the object is preserved.

The transformation of objects can be carried out as a transformation of a set of points characterizing the object into another set, provided that these sets are described in the same coordinate system, or as a replacement of the local coordinate system of the object to another coordinate system, which allows to synthesize a set of objects, each of which is described in the local coordinate system, and

The mathematical basis of transformations used in the geometric modeling of objects is the operation of multiplication of matrices that determine the elements of the object and the types of transformation. Transformations of transfer, rotation and scaling in matrix form are written in the form of

$$P' = P + T, \quad P' = PR, \quad P' = PS, \tag{7}$$

where P' is the transformed coordinates of a geometric element;
P - transformable coordinates;
T, R, S – respectively matrix transfer, rotation and scaling.

When modeling objects can be used combinations of the basic types of geometric transformations (translation, rotation, scaling) and various derivatives thereof: mirroring, copying, etc.

Design objects can be modeled interactively in a machine graphics system using a problem-oriented language or a software package. In accordance with the chosen method of modeling modification of objects is carried out by technical devices of the system with the use of embedded software and hardware, language operators and programs of the package.

Modification of objects is carried out with their linguistic models, with internal forms of representation of object models, with images.

Analysis of geometric models of design objects allows to determine their size, area, volume, centers of gravity, moments of inertia, static moments, distances between objects, etc.

One of the main areas of application of standard methods of geometric modeling – computer-aided design and automated control systems of technological processes of design and production of mechanical and Electromechanical systems.

The boundary method of object modeling is appropriate to use in areas where dynamic surfaces are designed, i.e. surfaces interacting with the external environment, or surfaces to which high aesthetic requirements are imposed. Dynamic surfaces are divided into two classes:

* described by the environment
  (external contours of aircraft, ships, cars, turbine blades, etc.));
* tracer-guiding medium
  (air and hydraulic channels, spiral chambers and turbine suction pipes, etc.).

Methods of structural geometry are used in systems focused on the design of machine-building structures, parts obtained in the technology of stamping, cutting, etc. This type of model is most adequate to such processes of designing geometric shapes of parts, when the designer forms a part as a combination of basic elements of shape (cylinder, cone, prism, etc.) or collects it from some functional elements, for example, the shaft section for planting a gear, etc.

For low-performance systems, a method that uses wireframe models is used. Frame models are usually used to define objects representing polyhedra, i.e. closed polyhedra of arbitrary shape bounded by plane faces. Wireframe representation is often used when displaying objects as one of the visualization methods. Feature images of objects represented by a point frame, linear discrete frame and mesh frame.

The efficiency of the use of geometric models of objects in computer-aided design depends on the means of data storage and processing. The composition of the database is determined by taking into account the characteristics of the process and objects of design and current standards and reference data.

Graphic displays are widely used for visual inspection and modification of designed objects. Two types of graphic displays can be distinguished by scanning technology: vector and raster. When displaying object models on a vector display, it is sufficient to use a wire representation; visualization of patterns on a raster display allows you to get the color "deep" images of objects.

Drawing documentation is one of the main results of computer-aided design systems. The complexity of its formation depends on the completeness of the data in the geometric model. For example, a dimensional grid saved during the simulation process allows you to automatically place dimensions in the drawing.

To design a drawing of a part represented as a model of a three-dimensional geometric object, the following tasks are required: to determine the number of projections required to represent the part; to highlight the main view; to build the appropriate projections; to determine the scale of the image in the drawing field; to place dimensions and technological information; to apply technical requirements; to fill in the drawing stamp.

The most common form of application of automated systems of technological preparation of production is programming for machines with numerical control. Based on the generated object model, programs for CNC machines can be created much faster as the object geometry is already defined. In the automated systems of preparation of control information for CNC machines the most convenient way to use a geometric model, formed by the method of oriented surfaces.

2 Geometric modeling examples

De Casteljo algorithm was chosen for the implementation of the planned program for the design of stretch ceilings. The program is designed "Euroceiling" is a window size of 1000 by 600 pixels.

The menu is located at the top:
- Order information
- Drawing
- Print
- Settings
- Help

At the bottom there are quick start buttons that allow you to quickly build a particular shape with the specified parameters.

Also, on the same panel there are buttons "Turn" and "Step by step". The first button allows you to rotate the selected object. The second button allows you to turn on the step-by-step construction mode in order to carefully consider the geometric modeling process and adjust it if necessary.

On the left is the information coordinate panel, where the coordinates of all edges of the drawing are displayed in a table view.

Let's consider the construction based on diagonals. If the construction is done by entering the sides and diagonals, then you must specify the number of angles and press the "Build" button, then a table and a tree of sides will be formed to enter the length of the values in centimeters (figure 3).

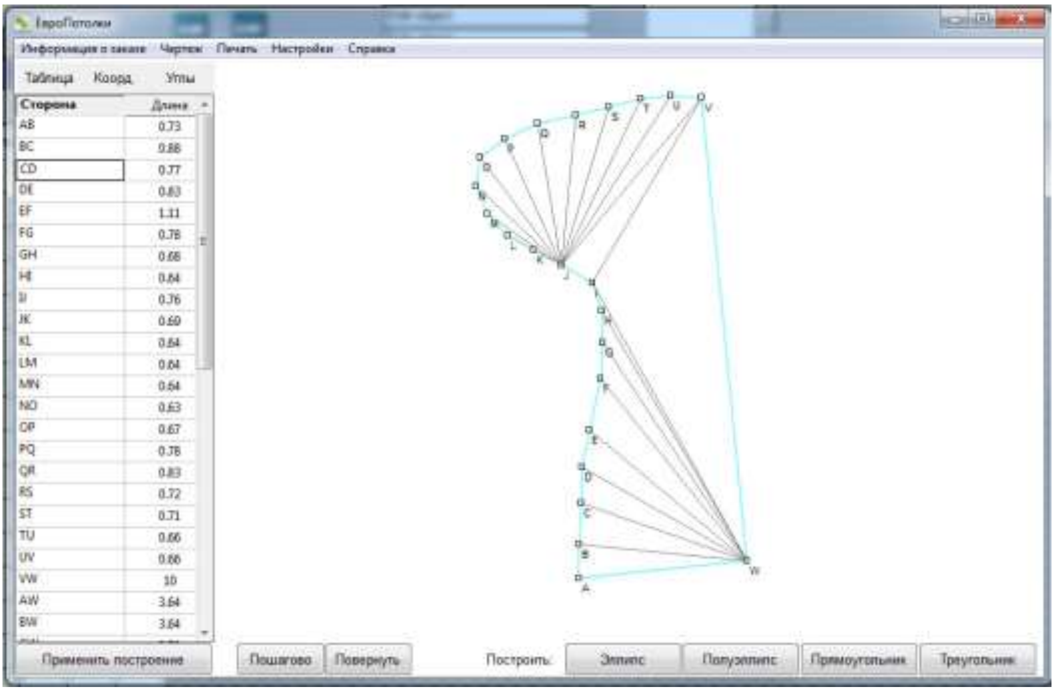

Fig.3. Drawing Based on the sides and diagonals.

In this case, the edges of the constructions are denoted by capital Latin letters, for example, A B (the outer edge between points A and B), AW (the inner edge, which is used to "bind" pieces of the ceiling together).

There are three ways of specifying lengths of sides and diagonals:

Table - the names of the sides are put down automatically, but the name of the diagonals have to be entered manually;

Tree-contains all variants of sides and diagonals, which avoids manual input of the sides and diagonals, also provides automatic transition to the next size in order when you enter the current one and press "Enter" (this applies to both sides and diagonals);

Angles-avoids entering diagonal lengths if known angles (in degrees) between points, for example, there is an ABCD rectangle (AB=300;BC=500;CD=300;DA=500) and it is known that the angle A=90 degrees, hence the diagonal BD=583.1, just note that entering an angle in degrees only automatically calculates the corresponding diagonal.

If you enter an excessive number of diagonals and there are differences in size, an error can be generated, which is displayed on the screen.

The program has a number of support functions:

* Function to "Rotate" - rotates the drawing 90 degrees clockwise;
* The "Build step" - allows you to build a drawing step by step "point by point", thus in difficult situations to assign the responsibility of drawing on the user.

After drawing, you can manually adjust the desired point in the drawing, it is necessary to hold the left mouse button on the changing point and not releasing the move to the desired location. After manual correction of the drawing, an error formed during the construction of the drawing is formed or recalculated.

Consider the construction based on an ellipse. If the construction will be based on an ellipse or circle, you must specify the number of angles and two radii (for the circle radii will be the same and the second radius can not be specified to leave equal to 0), then you must click "Build Ellipse" or "Build half-Ellipse" (Figure 4). The program will automatically build the drawing based on an ellipse.

It is possible to build a half-ellipse, you also need to specify two radii, the number of vertices and click "Build half-Ellipse" (figure 5). If you need to build the right circle, it is enough to specify two of the same radius (figure 6).

Consider manual construction of the drawing. To work with designer ceilings, which are already drawn in special modeling programs with the preservation of all proportions, you can use the "Manual construction" (figure 7). It is possible to enter the data (name of a line and its length) directly in the table. To apply the function, click the «Apply build» button.

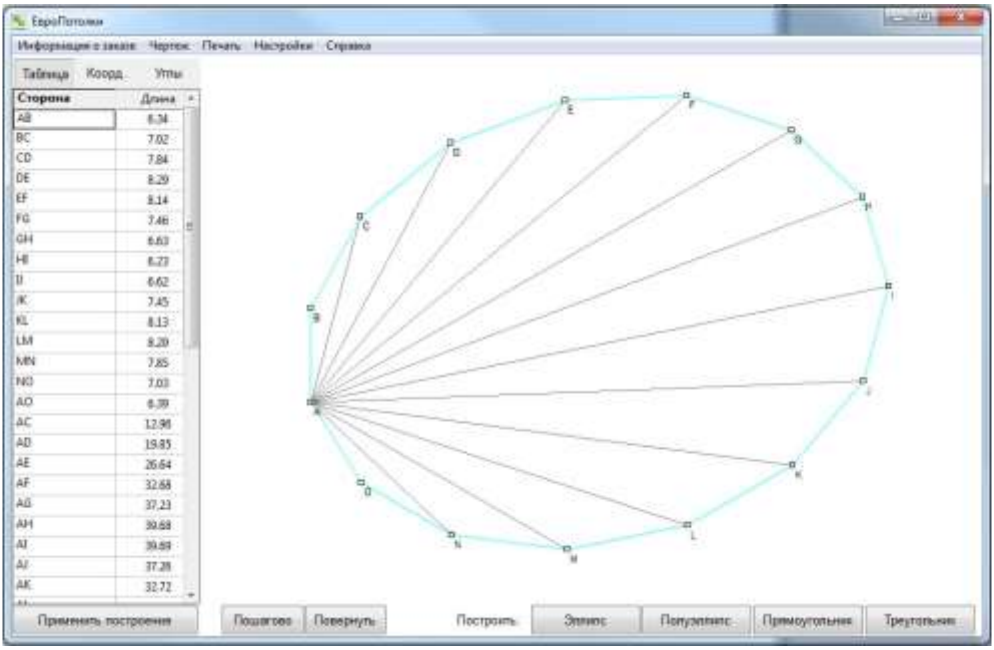

Fig.4. Building an ellipse

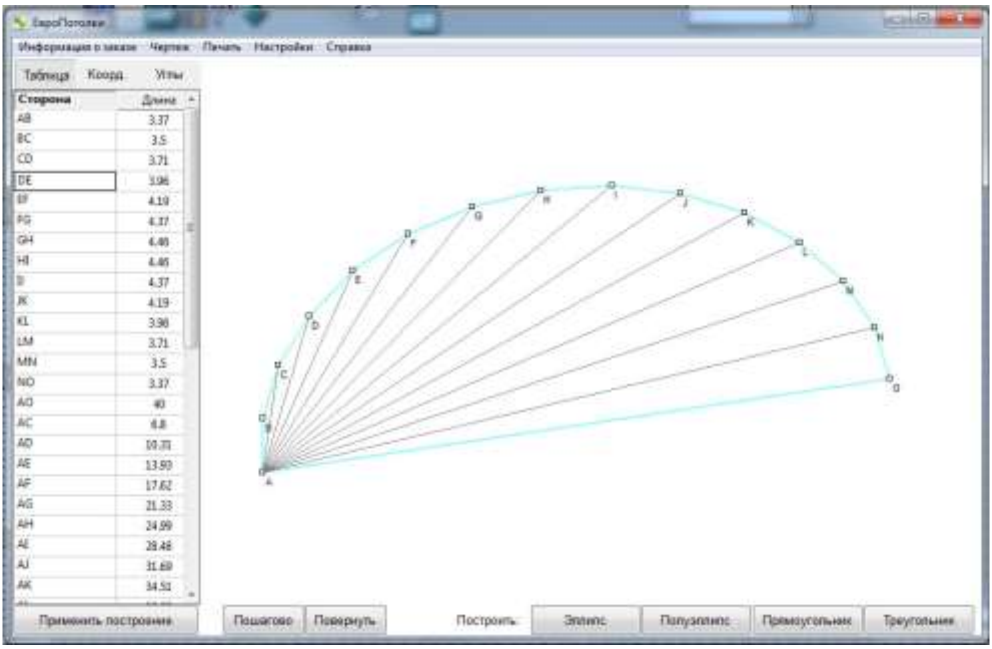

Fig.5. Construction of the half-ellipse

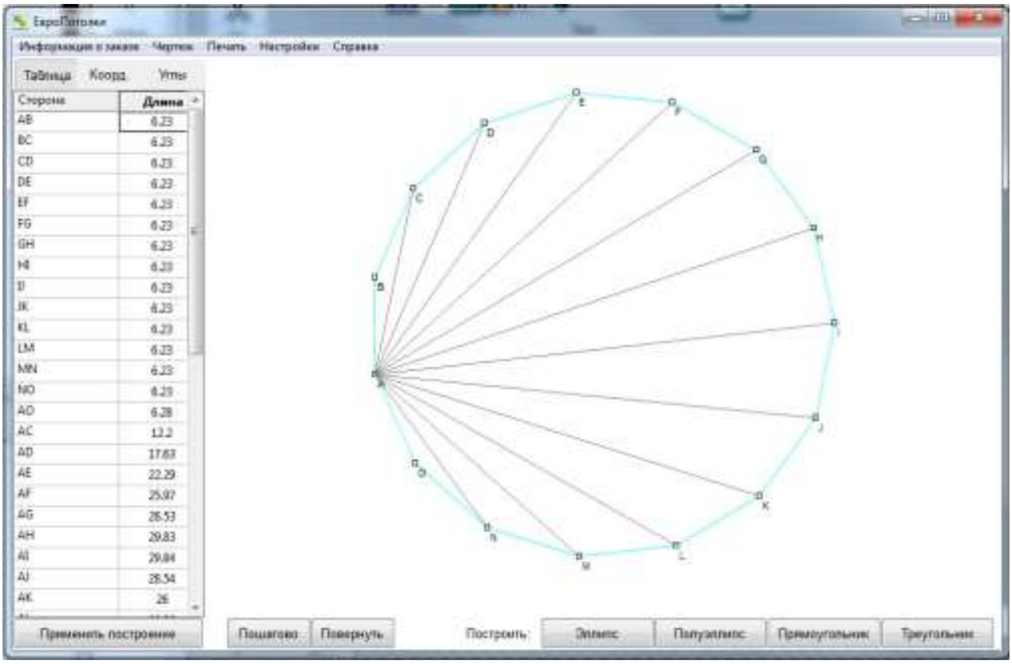

Fig.6. A perfect circle

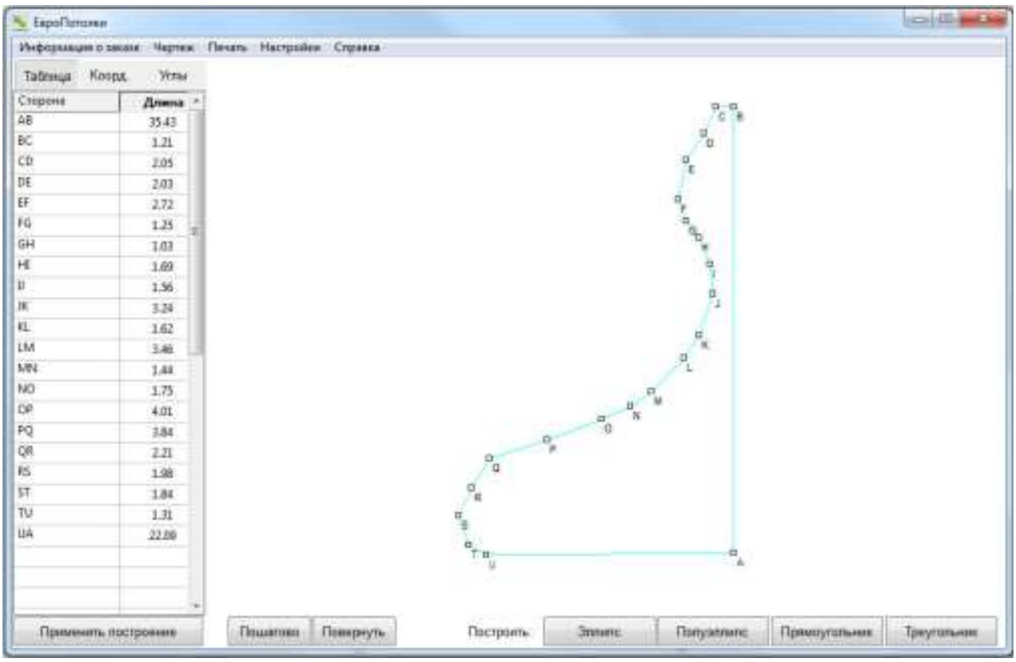

Fig.7. Manual construction mode

Conclusion

As a result, a system of designing stretch ceilings was developed, which has the following features: Perform a construction based on the input data table with coordinates and angles; Execution of construction of an ellipse; Performing a half-ellipse build; The build of the rectangle; The build triangle; Rotation functions of selected edges; Step-by-step build function; roject print function;

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