RENGA SOFTWARE AS AN OPEN BIM TOOL IN STRUCTURAL ENGINEERING

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Abstract

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Abstract

The main purpose of this work is to collect data about the Renga Software (Renga Architecture, Renga Structure, Renga MEP). All three programs included in the Renga family were studied, and their functionality was compared with each other.

The basic features of modeling in 2D and 3D views, methods of object visualization were considered. The main functions available in the programs and the properties of the elements were analyzed.

As part of the practical part of the work, the following steps were done:

- Renga's work on the design of wooden and metal structures was modeled, and possible problems and drawbacks of the system were fixed;
- the analysis of Renga's interaction with third-party applications for the purposes of exporting and importing data in OpenBIM formats was performed, and the capabilities of Renga for this interaction were evaluated;
- models were made of various materials (concrete, metal) to assess the possible impact on the export and import processes.

A special feature of the work is the lack of practical design of MEP systems. The work is a General research in this area.

The possibilities of data exchange with other Renga users (collaboration), as well as with other information modeling programs, were considered. The analysis of imported models obtained from Revit and Tekla Structure is carried out.

Based on the results of the practical part of the work, it was concluded that the program is suitable for modeling buildings made of metal and concrete, but is not applicable for structures made of wood and lumber.

Keywords

Designing, Renga Structure, Renga Architecture, Renga MEP, BIM, IFC, 3D model, snaps, tools, import, export, collaboration, basic commands, basic operations, Primary Panel Commands, structural model, architectural model, MEP

CONTENT

1 INTRODUCTION

The inevitability of the transition of the design and construction business to information modeling technologies has long been in no doubt. BIM systems have already become the main design tools for many companies.

BIM or Building Information modelling is the technology of information modeling of buildings and structures. BIM is a digital representation of the physical and functional characteristics of an object that covers more than just the geometry of a building. BIM takes into account many factors and information about the object, its elements, geography, design, and other data, including its impact on the environment. All these data, along with technical and economic indicators and other characteristics of the object, form an information model in which changing one parameter leads to an automatic recalculation of all the others.

The term BIM was first mentioned in the 1970s. since that time, two main ways of BIM-interaction of systems that implement different stages of the BIM process have been formed:

- the concept of "Open BIM" – the exchange of information between the disciplinary parts of the model is implemented mainly through the IFC format;
- the second approach — the exchange of such information is primarily based on the proprietary file formats of certain software solutions, and IFC-a a universal complementary exchange format.

The idea of BIM is based on the implementation of the following principles:

- design is carried out in three-dimensional space for a more visual representation of technical solutions and coordination of different disciplinary sections of design among themselves;
- the basic design unit is the object of the subject area;
- the model is saturated with information that can later be used by all participants in the construction process (designers, cost estimators, builders, the customer, regulatory authorities, etc.);
- drawings and construction specifications are generated based on the model and are associated with the model;
- the model is integrated and interacts with calculation systems, it is possible to inventory objects, calculate the necessary materials, stages, and project costs.

Currently, the most widely used software for information modeling is Tekla Structures, Revit, Allplan, and ArchiCAD. However, over the past few years, this list has been supplemented by a new Russian development - a series of programs from Renga Software.

The main goal of this work was to study how to use the Renga software for information modeling of buildings and structures, to get acquainted with the program interface and basic functionality.

As part of the practical part of the work, the following steps were done:

- Renga's work on the design of wooden and metal structures was modeled, and possible problems and drawbacks of the system were fixed;
- the analysis of Renga's interaction with third-party applications for the purposes of exporting and importing data in OpenBIM formats was performed, and the capabilities of Renga for this interaction were evaluated;
- models were made of various materials (concrete, metal) to assess the possible impact on the export and import processes.

A special feature of the work is the lack of practical design of MEP systems. The work is a General research in this area.

2 RENGA SOFTWARE

2.1 General information about the program

Renga Software is a Russian developer of software products for designing buildings and structures following information modelling technology.

The company's mission is to promote the penetration of BIM technology in Russia and neighboring countries so that the design of all civil and industrial construction projects begins with the creation of an information model. At the same time, the complexity of the process would not be higher than the development of projects using two-dimensional drawing, and the transition of design organizations to information modeling of buildings and structures required minimal resource and material investments.

Renga is the first Russian complex BIM system that covers the following stages of the building information modeling process: creation, detailed development of a three-

dimensional model, and obtaining documentation-drawings and schedules. Analysis of the load-bearing capacity and serviceability, assessment and calculation of the estimated cost of construction of the designed object is performed in collaboration with third-party BIM tools to solve these specialized tasks based on the model created in the Renga system. This model can be used at subsequent stages of the BIM process also.

Renga is a series of products for three-dimensional design from the Russian company ASKON. Renga product group includes three programs: Renga Architecture — for architectural design (Figure 1), Range Structure - for structural design, Renga MEP (Mechanical, Electrical, Plumbing) - for the design of internal engineering systems.

Figure 1 The example of 3D model (Renga Software)

The building information model begins to be created at the design stage. In civil construction, first of all, architectural solutions are being worked out. Therefore, Renga Architecture was released in March 2015, and Renga Structure was released in December 2016. In the second half of 2018, in addition to the architectural and design parts, Renga added the Renga MEP system.

Analysis of data from various open sources and available Internet resources allows us to conclude that engineer tasks that the system solves, including interacting with other CAD and BIM tools, are as follows:

1. Organization of the development process for all sections of project documentation and sets of working drawings:
   - creation of explanatory documentation in the model file;

- interaction in a single information environment with structural engineers and internal network engineers, as well as with other design participants;

2. Getting source files for design:
   - reading data from a large number of software systems, including for receiving and processing engineering survey data;
3. Development, adjustment, and approval of the design task:
   - visual 3D representation of the design object;
   - instant receipt of 2D facades and sections from the model, information about materials for matching structures;
4. Design of residential, civil, and industrial buildings:
   - using the archive of 2D drawings;
   - using the database of analogs of BIM models for new projects;
   - storing all data and documentation in a single model file;
   - interaction with calculation systems and complexes;
   - automated structural reinforcement of monolithic reinforced concrete structures according to specified parameters in the form of frames and grids, reinforcement of openings, reinforcement of multi-layer walls and joints;
   - placement of any additional reinforcement strengthening with the use of separate rebar;
   - assignment of rolled metal profiles of any cross-section;
   - import of technical equipment;
5. The ability to export and import files:
   - to OpenBIM formats;
   - regardless of the material that the building structure is made of;
6. Development of project documentation and drawings for reinforced concrete and metal structures:
   - layout of drawings in the graphical editor of the system with automated extraction and updating of views, sections, facades, units from the model, marking of objects;
   - an automated compilation of interactive statements and specifications with data extraction from the model;
   - making changes to the model with automatic recalculation of interactive statements and specifications and reflecting changes in drawings;
7. Transfer of data to justify investments, make estimates, and plan construction dates;
8. Approval of the project in the Supervisory authorities:

- representation of documentation for examination in the form of 2D drawings;
- representation of documentation for examination in the form of a BIM model;

9. Transfer of documentation to the customer:
   - transfer of BIM models, 2D drawings, and PDF documents;
10. Author's supervision of project implementation:
   - use a BIM model for author supervision and visual presentation of solutions to builders.

2.2 System information

The program is available in two languages: English and Russian. The language of the interface is determined when you first log in to the program. Further, the language can be changed in the "Settings" tab during operation.

System lynces is payable and available on the official website of the Renga company: https://rengabim.com/

Renga has a convenient option for teachers and students. It is possible to get a free Renga license for a period of 60 days for educational purposes.

3 3D MODEL

3.1 Basic level and measurement modes

Objects are placed in the model at the current or user-specified level, which is a horizontal plane at the specified elevation. The Basic interface of the programme is shown at the Figure 2.

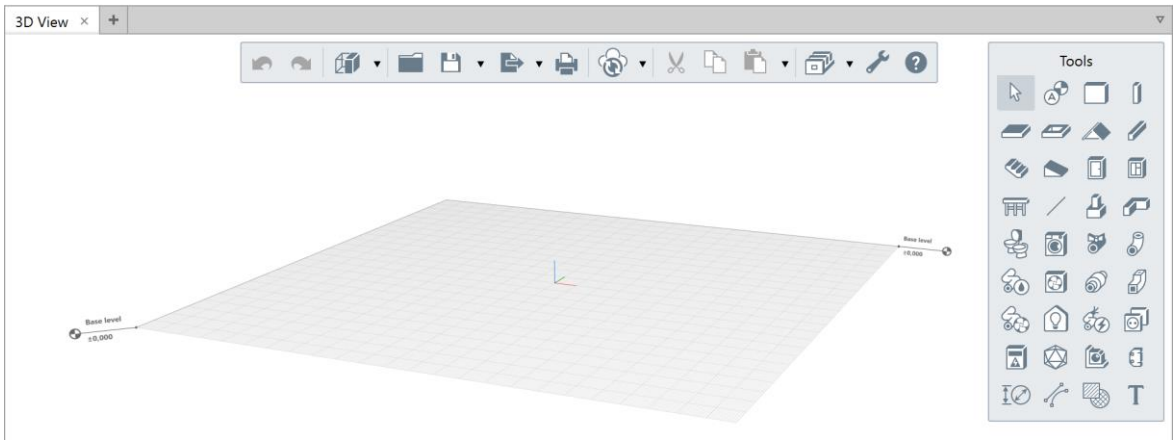

Figure 2 The Basic interface

The Base level, located at 0.000., is default. The level plane is marked with a center of coordinates. The Figure 3 shows how the X, Y, and Z coordinate axes are arranged in the Renga program.

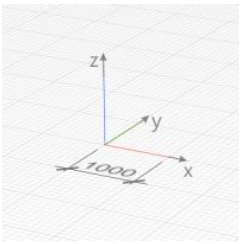

Figure 3 Location of coordinate axes on the plane

The dynamic input field allows the designer to correctly position objects relative to the coordinate axes.

The selected measurement mode determines the data that can be entered in the input fields. The Renga program has two measurement modes, which increases the accuracy of object construction. Initially, by default, the polar mode is selected, in which all distances and rotation angles are calculated relative to the X-axis. In rectangular measurement mode, the position of a point is determined by the distances from the X and Y axes.

Spherical, cylindrical, and cubic modes are used for 3D design. The basic mode is cubic, in which the distance is measured relative to each axis. Cylindrical mode allows you to measure the distance from the object point to the XOY plane and the Z-axis, as well as the angle of rotation relative to the vertical XOZ plane. The third mode, spherical, determines the rotation angle relative to the XOZ plane and the rotation angle and distance in the vertical plane.

3.2 Object snaps

Object snaps are used creating model objects on a 3D view in cubic, cylindrical, and spherical measurement modes. Object snaps allow you to bind model elements to existing objects in the model. The presence of standard object snaps makes it easier for the user to create a model in the system and reduces the design time.

The Renga program implements several types of object snaps that simplify the designer's work:

- a point on the base line;
- the center of a circle;
- the middle;
- a quadrant;
- the intersection of lines, planes or their projections;
- a normal, tangent, and end point.

Graphic images of object snaps are shown in Figure 4.

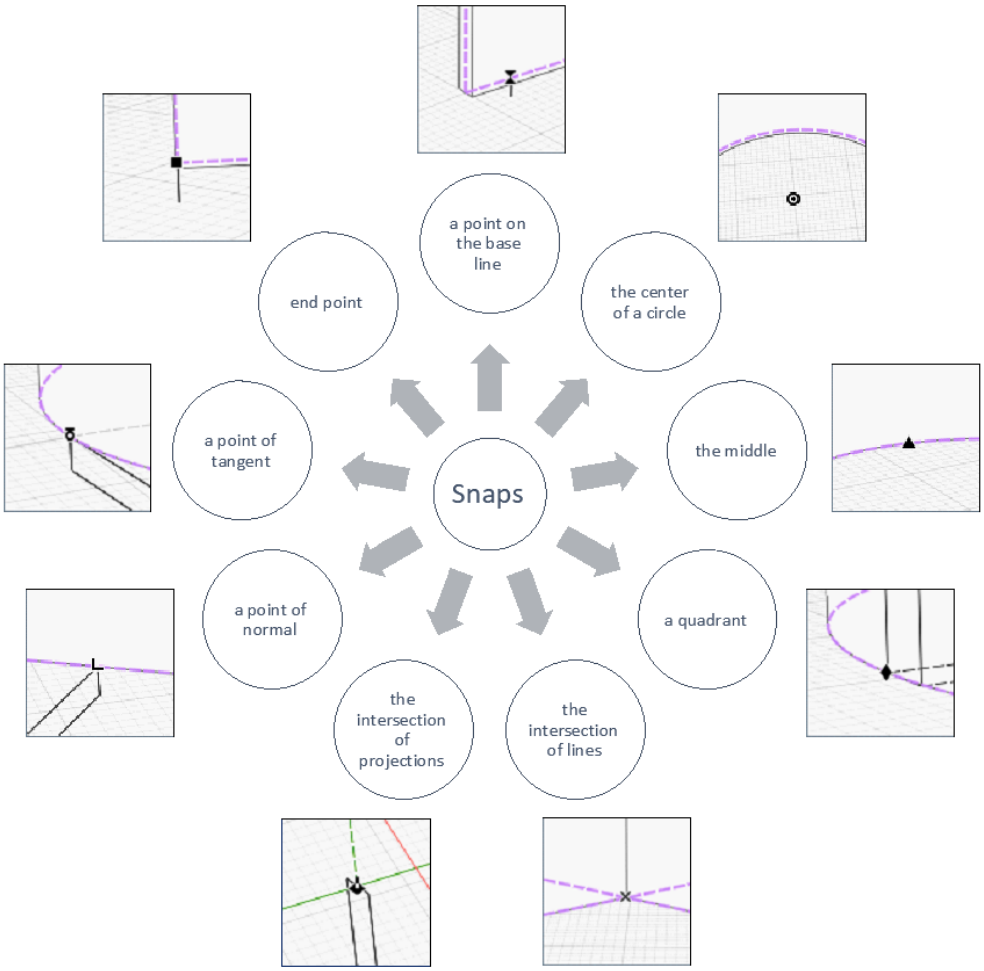

Figure 4 Types of object snaps

Snaps allow you to plot an object parallel or perpendicular to the X, Y, and Z axes (only in 3D mode) or the base lines, as well as relative to the point where two lines intersect (Figure 5). Snaps parallel to the X, Y, and Z axes are triggered automatically during construction. When you edit an item, it automatically snaps to its continuation.

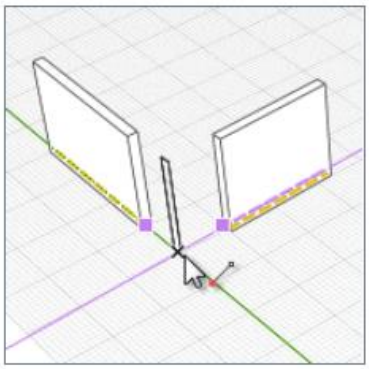

Figure 5 The example of object snap

3.3 Visualization and graphics

To ensure the visual component of the project, the system provides several visual styles applicable for floor plans, facades and sections, and for the 3D model as a whole. All materials and elements can be presented in three different styles, which differ in the degree of drawing and realism. However, the system makes it possible to change the style of the current working window.

Also, there is a function «show connections», which allows user to examine wall connections in detail.

For clarity, the types of styles and their description are presented in Table 1.

Table 1 Styles of visualization

№	Name of style	Level of visualization
1	Wireframe	Only lines of the model
2	Monochrome	Lines and surfaces of the model. Black and white color
3	Colored	All structures and material in color, which depends on defaults of objects

The program interface includes several graphical modes, which include hardware acceleration of graphics, lighting and displaying shadows if necessary, and smoothing roughnesses in lines. However, these options can slow down the program and complicate the design process.

4 BASIC COMMANDS AND OPERATIONS

4.1 Primary Panel Commands

The Primary Panel Commands is located at the top of the working window and provides quick access to perform standard operations of the program (Figure 6). Regardless of which tool is currently active, most commands will be available for selection.

Figure 6 The appearance of the Primary Panel

In this document, the order of user actions to perform these operations is not considered. A description of the main commands of the panel and their limitations is presented in Table 2.

Table 2 Commands of the Primary Panel

№	Command	Symbol	Command options	Limitations
1	Undo/Redo		Cancellation of all actions made since the opening of the project	Functions are not valid in dialog boxes and on MEP objects. The history of each tab's actions is individual, so actions in tabs are canceled regardless of each other.
2	Open project		Opening files that are in Renga format, Renga template or IFC 4 (.rnp, .rnt, .ifc)	The default format is .rnp. Opening projects in IFC formats, objects are not always converted to Renga objects.
3	Save project		All changes made since the opening of the program will be accepted	If the project is not saved on the personal computer (PC), the system will require you to enter a name and indicate the location of the new project on the PC
4	Cut/Copy/Paste		Copying objects is possible from a drawing or from a model. Pasting copied (cut) objects into a drawing is possible	The object will be on the clipboard until another object is placed there

			regardless of the level from which the object was copied, or to another project which is opened in the program. The copied (cut) objects of the model can be pasted onto the model or into another project. Copying, all properties and parameters of the original object remain unchanged. Copying tables and their cells are carried out in the same way as copying objects, The system allows you to insert table cells (table) into another table editor	
5	Visual style		Changing the display of the model's level of detail: realistic drawing and color characteristics of objects	The visual style changes only for objects on the current tab
6	Export		Converting data of project into different formats	-
7	Sync		Allows to collaborate on a document, send and receive model changes	The user who made the changes must sync them themselves, otherwise, the changes will not be saved
8	Manage styles		Changing properties of model objects such as material, hatching, shape, purpose, etc.	-
9	Insert from		The "insert from" function is a subfunction of the "Past" command and allows you to import objects created in other programs for information modeling. It is possible to import 3D models created in the following programs (having the following formats): 3ds Max 3DS (.3ds), LightWave (.lwo), StereoLithography (.stl), Wavefront object (.obj),	All elements inserted from third-party programs and having a different format are automatically converted by the system into the Renga format. Inserting a DWG, DXF, or PDF file as a drawing or substrate in a 3D view, it is possible to need to use the function “zoom”.

			COLLADA (.dae), Autodesk FBX (.fbx), C3D (.c3d), STEP (.stp, .step), IGES (.igs, .iges), Parasolid (.x_t, .x_b), ACIS (.sat), JT (.jt) and VRML (.wrl)	
10	Scale		Change the size of any model elements and text	Scale 100% is automatic in Renga
11	Print		Printing of drawings, sections, facades, individual project elements, tables, specifications of elements, and the view of a 3D model	- tables and specifications will be printed only if located on the drawing; -the print area is determined by the sheet; - all objects beyond the border of the sheet will not be printed; - the sheet parameters specified in the system must match the parameters specified by the printer settings, otherwise, printing will be incorrect; - printing the model, the image is scaled to fit the sheet; - only the part of the model that is in the current print window will be printed.
12	Changing the language		The program allows the user to change the interface language	- the list of languages is limited to the basic package of settings; - a restart of the program is required after changing the language.

4.2 Objects management

Often, objects created in a drawing or model need to be modified. The program allows you to change the parameters of one object or several objects at the same time, as well as perform an extensive list of actions on them.

A description of the main operations and their limitations is presented in Table 3.

Table 3 The main operations in the Renga programs

№	Operation	Operation's description	Limitations
1	Direct array	Copying elements along a line with a specified distance between them. The function is applicable in three-dimensional measurement modes.	-
2	Circular array	Copying elements relative to the center of a circle with a specified angle between elements.	-
3	Offset array (Copy by equidistant)	Copying elements along radially directed lines.	The function is available only for elements such as lines, grid lines, walls, wall foundations, and railings.
4	Rotate	Rotate an object relative to the center by the radius of rotation.	-
5	Move	Moving an object relative to a selected point on the plane. The function is applicable in three-dimensional measurement modes.	-
6	Disassemble	The function allows the user to split the assembly into separate independent objects.	- the command is applicable only to the selected assembly; - there is no way to apply a function to an assembly that has the parameter «Nutation angle».
7	Mirror	Copying and mirroring an element relative to the axis of symmetry.	- asymmetric objects and imported 3D model objects may be reflected with errors; - mirror of several objects at the same time can lead to an error or a program hitch; - the function does not apply to some elements of MEP.
8	Copy	Copying an object relative to a point on the plane in the selected direction, then snapping the object to the specified point. The function is applicable in three-dimensional measurement modes.	-

9	Flip	Flipping an object relative to the baseline. Walls, beams, foundations, windows, and doors mirror flip relative to baseline. Stairs and ramps change direction. MEP objects flip on a route. Sections change the direction of view.	-
10	Hide	Hiding selected objects or hiding all objects except selected (isolating).	If the route is hidden in the 3D view, all objects that are located on it will also be hidden.
11	Route detaching	Detaching objects and route points, which are located on route.	The route itself and all the branch lines connected will be removed.
12	Route rebuilding	Changing the parameters of a part of the road, including existing equipment.	After applying the command, all secondary branches, pipes, and air ducts will be changed according to the previously selected parameters.
13	Placing parts on route	Adding new pipes, ducts, and its fittings to a new place on the route, while the characteristics of the route itself remain the same.	Using the command is allowed on the level's plan, 3D view, Pipe/Duct system tab, and Commands panel of a MEP system.
14	Selecting in system	Displaying objects on the MEP system tab.	The object can be selected on the following tabs: 3D view, level's plan, and schedule.
15	Selecting in model	Displaying objects on the 3D view.	The object can be selected on the following tabs: MEP system tab and schedule.
16	Selecting similar objects	One-time selection of a group of similar objects that have the same parameters.	- using the “With same mark” option on the 3D View tab, all the objects with the specified marks will be selected in the project; - if you select the “With same mark” option on the level tab, all the objects with the specified marks will be selected on the level.
17	Applying filters	Selecting, hiding, and isolating objects that fall under the parameters of the selected filter.	Using the command is allowed on the level's plan, 3D view, and MEP system tab

18	IFC-objects editing	Displaying the IFC model as an IFC object when the program cannot convert the object to a Renga system object.	All the standard operations are available working with IFC objects.
19	Assigning Properties	The appointment of new, and change existing object properties.	If the selected group of objects does not have common properties, the Properties dialog window will be empty

5 MODELING

Construction of a model can be performed both in 3D space and on 2D flat projections in the Range Structure, Renga Architecture, and Range MEP programs. The system and logic for creating a model are similar to other information modeling programs, but Renga focuses on the three-dimensional construction mode.

The Renga model consists of:

- 3D view;
- assemblies (3D view for creating an assembly of objects, which is located as a single object in the main model);
- levels (2D views of horizontal planes that are located at different heights in the model; they contain model objects and allow you to edit the model in the plan, create drawings of plans and their fragments);
- sections and facades (non-editable 2D views formed from the model; used as independent sketches for viewing and printing during the design process, as well as associative views);
- schedules (data sets that are automatically extracted and associated with the model);
- tables (data sets generated in the internal table editor by the user);
- drawings (2D documents that are generated from the views of levels, sections, facades, assemblies, objects, tables, and specifications that are extracted and associated with the model in the internal image editor).

Work with individual levels, sections, facades, assemblies, drawings, tables, and specifications occurs in separate tabs. Tabs open in the main application window and are arranged sequentially in the tab bar. Each tab has its own history of actions. Actions performed in a tab can be canceled only in this tab, without affecting the rest.

It is necessary to consider some limitations that exist in the program working in Renga:

1) There is no possibility to adjust the model on sections.
2) Drawing the dimension lines is available only in the mode of registration of drawings.
3) Fragmentation of the three-dimensional view is not possible. If you need to cut off part of the model, you can only use the "hide" or "isolate" functions.
4) All dimensions of structures (buildings) specified in the program during modeling must be full-size, that is, 1mm of the model must correspond to 1mm of the actual structure (building).
5) Objects on the plans of levels (2D view) are displayed in the form of semi-graphical images.
6) The tool “Level” is available working in three-dimensional model space only.
7) The same types of objects can overlap each other. One object can be built on top of another object, provided their types match.

6 TOOLS

For the convenience of modeling, the program has a set of universal tools with variable parameters. This makes it easier to create elements of any configuration and frees the user from using additional reference literature and element catalogs. All the basic tools are presented in an intuitive context-oriented interface. The panel "Tools" is located on the right side of the program's working area (Figure 7).

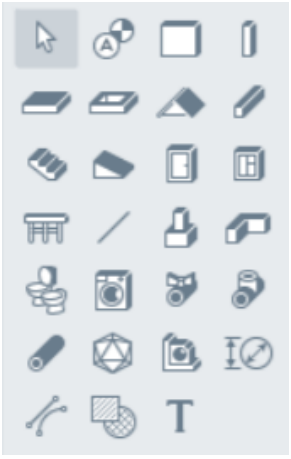

Figure 7 The appearance of the Tools Panel

The principle of operation in 2D and 3D spaces is the same. All tools can be used both on 3D views and on level plans.

The tools are:

- objects that make up the model;
- symbols that are used for annotation when working with the model and drawings.

Elements such as walls, floors, roofs, beams, and openings have several ways to build in the Renga program. The name and concise description of each method are shown in the Table 4. However, some methods have limitations in constructing a particular element. All existing construction limitations for each element will be specified later in the relevant sections.

Table 4 Description of building methods

№	Name of the method	Mark	Short description
1	Automatically by similar		Building a wall using the grid line or snap line of an existing object as a similar object
2	Line by specifying two points		Enter the start and end points, or the start point, direction, and length of the wall (entered in the dynamic input fields)
3	Arc by specifying three points		Enter the start point of the arc wall, the second point (or the value of the length and angle of the chord in the dynamic input fields), and the third point (similar to the second point)
4	Arc by specifying start, center, end points		Enter the starting point, the center of the circular arc that the wall will be built relative to, and the end point
5	Circle by specifying a center point and radius		Sets the center of the circle and the point on it (or the value of the circle radius in the dynamic input fields)

Further the main tools that can be used to create structural or architectural models, as well as elements of MEP systems will be considered.

6.1 Designations

There are tools that allow you to create level plans, images of facades, and sections of a building from a 3D view, as well as place room markers and trace points on the model.

6.1.1 Grid line

The construction of any model often begins with the use of the tool “Grid line”.

You can use any of the methods described in Table 4 to create an axis.

All parameters that an axis can have are listed in Table 5. These parameters can be changed during the element creation process, as well as during its editing later.

Table 5 Parameters of grid line

№	Name of parameter	Mark	Explanation
1	Grid line designation		-
2	Grid Line Extension		The distance from the extreme handle to the grid line name

6.1.2 Level

If you need to place objects at different elevations, use the tool “Level”. It allows you to create horizontal planes and corresponding level plans. The tool is available on a 3D view only.

The level plan has certain characteristics that might be set. All parameters are listed in Table 6. These parameters can be changed during the element creation process, as well as during its editing later.

Table 6 Parameters of level

№	Name of parameter	Mark	Explanation
1	Section plane offset		Value of the elevation at which the section is located relative to the current level is set here. Objects that are contained in the section at a this elevation mark will be shown.
2	View depth level		The level at which the depth of view plane is located is set here.
3	View depth plane offset		The elevation mark of view depth in relation to the view depth level is set here. Projections of objects whose elevation marks above this plane will be shown.

The display of the level view in the drawing depends on the specified parameters.

Levels can overlap each other, take this into account creating a new level.

All actions on a level, such as moving, copying, and hiding, will be applied not only to level but to all objects that belong to that level. When you delete a level, all objects located on it will be deleted.

6.1.3 Section

The tool “Section” allows you to create vertical planes and corresponding views. There are several types of sections. Each type is described in the Table 7.

Table 7 Building methods of section

№	Name of type	Mark	Explanation
1	Section in one plane		One cutting plane is used for creating
2	Section in parallel planes		Two or more parallel planes are used for creating
3	Section in two intersecting planes		Two intersecting planes are used for creating

The section symbol and the working plane are linked. If you change the location of the work plane, the section symbol will remain on it.

The section has certain characteristics that might be set. All parameters are listed in Table 8. These parameters can be changed during the element creation process, as well as during its editing later.
View direction is determined when constructing the section symbol.

Table 8 Parameters of section

№	Name of parameter	Mark	Explanation
1	Section name		-
2	Section line extension		-

6.1.4 Facade

You can use the tool “Elevation” to create an image of the building's facade, as well as add a elevation symbol to the plan.

The facade has the characteristic "Elevation Name". You can assign a name to the facade during construction or editing. The point and angle are necessary for creating

the facade image. The view direction depends on the specified angle value. The elevation symbol and the working plane are linked. If you change the location of the work plane, the elevation symbol will remain on it.

6.1.5 Room

The tool “Room” allows you to determine the characteristics of a room, such as perimeter, volume, and height, assign a room number and name, and display these parameters on the plan, if you need.

The Table 9 shows the main parameters that the room has. The parameters of the room are set creating it, and can be changed at the time of editing.

Table 9 Parameters of room

#	Name of parameter	Mark	Explanation
1	Room number		-
2	Room name		-
3	Room height		-
4	Gross perimeter		This parameter is determined automatically
5	Gross floor area		This parameter is determined automatically
6	Gross volume		-
7	Level		-
8	Vertical offset		The vertical offset of a room relatively to the insertion point

The construction methods described in Table 4 can be used for rooms creating. You can combine these methods.

You can also use the method “Automatically by point”. Room will created automatically if its contour is closed and consists of walls, columns or foundations. Keep in mind that if the lines that are the boundaries of the room intersect each other, the program will not be able to create the room.

6.1.6 Route point

You can use the tool “Route point” to set the points on the working plane that the route can pass through in the future. This tool can be used as a replacement for the model if it is not possible to use the model of the necessary equipment.

The routes depend on the route points. It means that if a route point relocates, the route connected to it will be rebuilt automatically.

The Table 10 shows the main parameters that the route point has. The parameters are set creating it, and can be changed at the time of editing.

Table 10 Parameters of route point

№	Name of parameter	Mark	Explanation
1	Route point name		-
2	System group		-
3	System type		-
4	Level		-
5	Vertical offset		The vertical offset of a room relatively to the insertion point

The Figure 8 shows, which types of utility services the tool can be applied to.

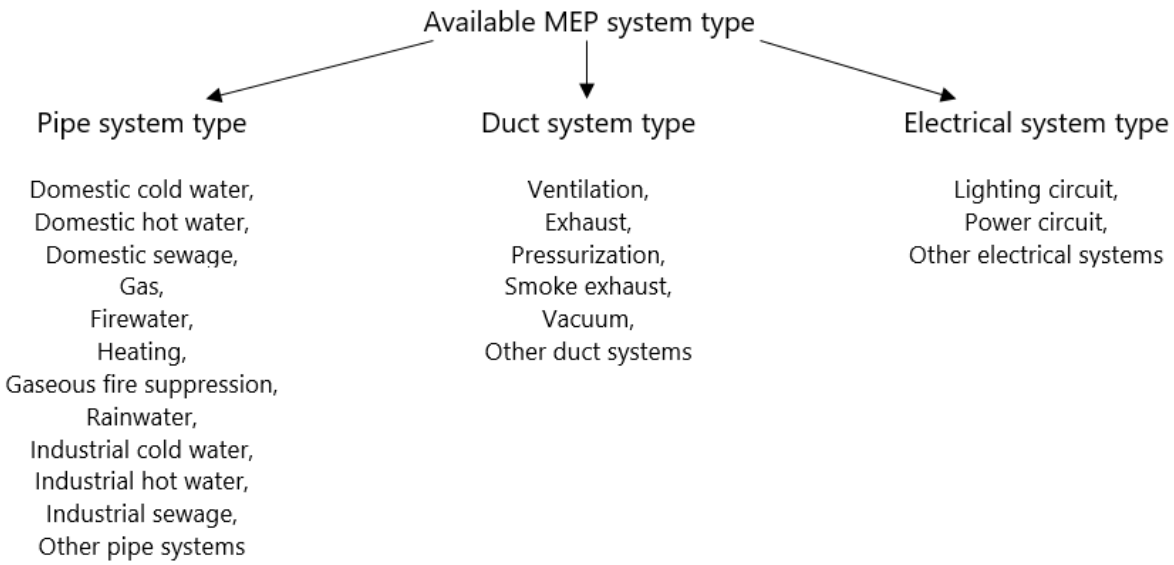

Figure 8 Available MEP system types (Renga. User guide)

6.2 Structural model

6.2.1 Wall

The tool “wall” is applicable for 3D model objects in all measurement modes. Creating a wall, a yellow line appears. This is the base line of the wall, relative to which the wall will be located. Baselines are used to conjoin the walls and can be used to link other objects to the wall. In addition, other objects can be linked to the center of the wall and to its left or right sides. On level plans, the wall is displayed according to the set level of detail. If walls are fallen into the section and their material is determined, they will be displayed as hatched ones on the level's plan.

The Table 11 shows the main parameters that the wall has. The parameters of the wall are set creating it, and can be changed at the time of editing.

Table 11 Parameters of wall

№	Name of parameter	Mark	Explanation
1	Wall position relative to baseline		During work with a wall, the base line is yellow
2	Wall horizontal offset		This parameter can have a negative value
3	Wall Height		This parameter can't have a negative value
4	Wall Thickness		This parameter can't have a negative value
5	Level		-
6	Vertical offset		Vertical offset of the wall relative to the baseline. This parameter can have a negative value
7	Layered materials		-
8	Reinforcement style		Only the base layer of the wall material can have a reinforcement style
9	Mark		This parameter required for the drawing

All construction methods were described in more detail earlier in Table 4. The main limitations, which every building method has for walls, are described in the Table 12.

Table 12 Limitations for wall building methods

№	Name of the method	Mark	Limitations
1	Automatically by similar		Point objects cannot be similarity objects. The similarity objects must come in contact with the current work plane.
2	Line by specifying two points		-
3	Arc by specifying three points		The value of the chord angle is set relative to the OX axis
4	Arc by specifying start, center, end points		-
5	Circle by specifying a center point and radius		-

6.2.2 Floor

The tool “floor” allows creating a slab of any shape which can have linear or curved faces. All floor parameters are shown in the Table 13. The floor parameters are set at the time of its creation, and can be changed later during editing the object.

Table 13 Parameters of floor

№	Name of parameter	Mark	Explanation
1	Floor thickness		-
2	Level		-
3	Vertical offset		The vertical offset of text relatively to the level. A floor is being built downwards from the level.
4	Layered materials		-
5	Floor angle of reinforcement		The angle of the reinforcement layout in the floor relative to the Ox axis.
6	Reinforcement style		Only the base layer of the floor material can have a reinforcement style
7	Mark		This parameter required for the drawing

All construction methods were described in more detail earlier in the Table 4. If the floor has a complex shape, the program allows you to use several construction methods at the same time (such as “Line by specifying two points”, “Arc by specifying three points” and “Arc by specifying start, center, end points”).

Keep in mind that if the lines that are the boundaries of the slab intersect each other, the program will not be able to create the floor correctly and will give the user an error.

6.2.3 Column

The tool “column” allows you to create columns of the desired cross-section on a plan or in a 3D view in any of the three measurement modes. The base line of the column is highlighted in yellow. Linking to a baseline allows to build a column exactly above an existing one.

The column parameters are set at the time of its creation, and can be changed later during editing the object. All column parameters are shown in the Table 14. If the "material" parameter is defined and the column falls within the section, then it will be displayed as hatched one on the level plan.

Table 14 Parameters of column

№	Name of parameter	Mark	Explanation
1	Column profile position relative to axis		During work with a wall, the base line is yellow
2	Horizontal offset of column profile		X-axis offset relative to the column insertion point. This parameter can have a negative value
3	Vertical offset of column profile		Y-axis offset relative to the column insertion point. This parameter can have a negative value
4	Column style		The column shape, width, and depth are set here.
5	Column Height		This parameter can't have a negative value
6	Column rotation angle		Defines the angle of rotation of the column relative to the specified coordinates’ axis
7	Level		-
8	Vertical offset		Vertical offset of the wall relative to the insertion point. This parameter can have a negative value
9	Material		-
10	Reinforcement style		-
11	Mark		This parameter required for the drawing

6.2.4 Roof

You can use the tool “Roof” to create sloped or flat roofs of various shapes in a 2D view on a level plan or in a 3D view. 3D object bindings are used for building a roof in all measurement modes. Each roof structure has General parameters, as well as parameters of the roof slope, which are set separately. All parameters are shown in the Table 15. Each roof segment has its own parameters. Segments can have the "slope" or "gable" shapes. If you need to build a flat roof, assign a "gable" shape type to each segment. Segment parameters are set before starting the build. General roof parameters are set at the time of its creation, and can be changed later during editing the object.

Table 15 Parameters of roof

№	Name of parameter	Mark	Explanation
General parameters			
1	Roof thickness		-
2	Level		-
3	Vertical offset		The vertical offset of the roof relative to the baseline. This parameter can have a negative value
4	Materials		-
5	Mark		This parameter required for the drawing
Parameters of the slope			
6	Edge shapes		There are “slope” and “gables” types. One edge of Single-slope roof is always “slope” and the rest are “gables”.
7	Slope		-
8	Slope level		This parameter is determined in relation to level on which the roof is located
9	Overhang		The value of the overhang width is assumed to be equal to the value of the overhang projection on the working plane

All construction methods were described in more detail earlier in the Table 4. You can combine these methods creating segments.

All objects that are located under the roof and touch it will be cut off. If the roof is higher than the object or only partially intersects it, the object will remain unchanged.

6.2.5 Beam

The tool "Beam" allows building a beam of any profile and shape

All parameters that the beam has are described in the Table 16. The beam parameters are set at the time of its creation, and can be changed later during editing the object.

Table 16 Parameters of beam

№	Name of parameter	Mark	Explanation
1	Beam profile position relative to axis		-
2	Horizontal offset of beam profile		Horizontal offset of beam profile relative to beam axis. This parameter can have a negative value
3	Vertical offset of beam profile		Vertical offset of beam profile relative to beam axis. This parameter can have a negative value
4	Beam style		The beam shape, width, and height are set here.
5	Beam rotation angle		Beam rotation angle in relation to the axis
6	Beam start		The shape of beam end face at the start of the beam
7	Beam end		The shape of beam end face at the end of the beam
8	Level		-
9	Vertical offset		The vertical offset of a beam relatively to the baseline
10	Material		-
11	Reinforcement style		-
12	Mark		This parameter required for the drawing

All construction methods were described in more detail earlier in the Table 4. The main limitations, which every building method has for beams, are described in the Table 17.

The base line, which is highlighted in yellow working with a beam, allows to pair beams and serves to link the beam to the column. The yellow line indicates the actual location of the beam baseline in 3D measurement mode, in polar and rectangular modes - the projection of the baseline on the working plane.

Table 17 Limitations for beam building methods

№	Name of the method	Mark	Limitations
1	Automatically by similar		Point objects cannot be similarity objects. The similarity objects must come in contact with the current work plane.
2	Line by specifying two points		Pay attention to the parameters “beam start” and “beam end” building a beam that has a slope
3	Arc by specifying three points		The method allows to build in the three-dimensional measure mode in the 3D View. Pay attention to the parameters “beam start” and “beam end” building a beam that has a slope
4	Arc by specifying start, center, end points		This method allows to build only a horizontal beam
5	Circle by specifying a center point and radius		This method allows to build only a horizontal beam

6.2.6 Opening

The tool "opening" is used for creating openings of the desired shape in roofs and floors.

All parameters for openings are shown in the Table 18. The parameters are set at the time of its creation, and can be changed later during editing the object.

Table 18 Parameters of opening

№	Name of parameter	Mark	Explanation
1	Opening depth		-
2	Level		-
3	Vertical offset		The vertical offset of opening relatively to the level. An opening is being built downwards from the level.
4	Reinforcement style		If the floor requires reinforcement at the opening location, this parameter is applied
5	Mark		This parameter required for the drawing

All construction methods were described in more detail earlier in the Table 4. If the opening has a complex shape, the program allows to use several construction methods at the same time (such as “Line by specifying two points”, “Arc by specifying three points” and “Arc by specifying start, center, end points”). However, if the lines that are

the boundaries of the opening intersect each other, the program will not be able to create it correctly and will give the user an error. To get an opening in the roof, set the parameters of the opening such that its faces crossed the slope.

6.2.7 Object reinforcement

The Renga program allows you to reinforce elements such as walls, columns, floors, openings, doors and windows. Reinforcement of openings, doors and windows involves the reinforcement of sections of walls or floors, to strengthen these structures in the places of openings. In addition, the program allows you to reinforce wall connections (internal and external corners) if it is necessary. However, this function works if the baselines of the walls intersect each other.

There are two different methods of reinforcement: parametric reinforcement (reinforcement of the individual rebars) and ready-to-use reinforcing meshes and cages. The Table 19 shows dependence of the reinforcement method on the selected object.

Table 19 Reinforcement methods (Renga. User guide)

№	Object	Reinforcement method			
		Parametric reinforcement	Place a reinforcing meshes	Place a reinforcing cages	Place a reinforcing meshes and cages
1	Wall	+	+	+	
2	Column	+		+	
3	Floor	+	+		
4	Opening	+		+	
5	Beam	+		+	
6	Wall opening	+		+	
7	Foundation	+			+

The rebar that make up the reinforcing meshes and cages should be prepared in advance by setting their parameters and properties.

6.2.8 Rebar

Using the tool “Rebar”, it is possible to create straight or arc reinforcement bar.

All rebar parameters are shown in the Table 20. The stair parameters are set at the time of its creation or during editing the object.

Table 20 Parameters of rebar

№	Name of parameter	Mark	Explanation
Rebar parameters			
1	Rebar		Characteristics such as rebar diameter, grade, and material are determined
2	Level		-
3	Vertical offset		The vertical offset of a rebar relatively to the level
4	Mark		This parameter required for the drawing
Point parameters			
5	Bend radius		This parameter defines the bend radius of the rebar with the center at the selected point
6	Offset point in the plane		-

There are several ways to build stairs: “Line by specifying two points”, “Arc by specifying three points” and “Arc by specifying start, center, end points”. The program allows to use several construction methods at the same time.

If the construction of rebar is not interrupted, the rounded rebar part will be creating automatically.

6.3 Architectural model

6.3.1 Isolated foundation

The tool “Isolated foundation” gives the opportunity to create isolated foundation, which has rectangular or trapezoidal form. Generally, isolated foundation are located under the columns or other point objects.

All parameters for this type of foundation are shown in the Table 21. The parameters are set at the time of its creation or during editing the object.

Table 21 Parameters of isolated foundation

№	Name of parameter	Mark	Explanation
1	Foundation height		-
2	Foundation width top		-
3	Foundation depth top		-
4	Foundation width		-
5	Foundation depth		-
6	Foundation rotation angle		The rotation angle of foundation in relation to the coordinates' axis
7	Level		-
8	Vertical offset		The vertical offset of a foundation relatively to the level
9	Material		-
10	Reinforcement style		-
11	Mark		This parameter required for the drawing

6.3.2 Wall foundation

The tool “wall foundation” gives the opportunity to create a foundation under extended objects such as walls. The program allows you create rectangular or trapezoidal foundation.

All parameters for this type of foundation are shown in the Table 22. The parameters are set at the time of its creation or during editing the object.

Table 22 Parameters of wall foundation

№	Name of parameter	Mark	Explanation
1	Wall foundation position relative to baseline		During work with a wall, the base line is yellow
2	Wall foundation horizontal offset		This parameter can have a negative value
3	Wall foundation height		-
4	Wall foundation thickness top		-
5	Wall foundation thickness		-
6	Level		-
7	Vertical offset		The vertical offset of a wall foundation relatively to the baseline
8	Material		-
9	Mark		This parameter required for the drawing

All construction methods which were described in more detail earlier in the Table 6, may be used for creating of wall foundations.

If a snap to the baseline is used when a foundation is constructed, then foundations will automatically be mated.

6.3.3 Stairs

Using the tool “Stair”, it is possible to create straight or arc stairs, with intermediate floor or not.
All stair parameters are shown in the Table 23. The stair parameters are set at the time of its creation or during editing the object.

Table 23 Parameters of stairs

№	Name of parameter	Mark	Explanation
1	Stair position relative to axis		-
2	Stair horizontal		This parameter can have a negative value
3	Stair height		-
4	Stair width		-
5	Number of steps		-
6	Tread depth		This parameter is automatic and is calculated depending on the set values for the length and height of the stairs, as well as the number of steps and flights of stairs
7	Riser height		This parameter is automatic and is calculated depending on the set values for the length and height of the stairs, as well as the number of steps and flights of stairs
8	Slope		This parameter is automatic and is calculated depending on the set values for the length and height of the stairs, as well as the number of steps and flights of stairs
9	Stair shape		Defines contour, thickened or solid staircase
10	Stair thickness		Defines the thickness of risers and steps for contour stairs, the thickness of solid stairs, the thickness of steps for open staircase
11	Level		-
12	Vertical offset		The elevation mark of stair in relation to the level
13	Material		-
14	Reinforcement style		-
15	Mark		This parameter required for the drawing

There are several ways to build stairs: “Line by specifying two points”, “Arc by specifying three points” and “Arc by specifying start, center, end points”. The program allows to use several construction methods at the same time. If the construction of stair runs is not interrupted, the stair winders will be creating automatically. If you need to change the direction of the stairs, use the function “flip” from the shortcut menu.

6.3.4 Ramp

The tool "Ramp" allows you to build a straight or arc ramp using the next construction methods: “Line by specifying two points”, “Arc by specifying three points” and “Arc by specifying start, center, end points”.

All ramp parameters are shown in the Table 24. The ramp parameters are set at the time of its creation or during editing the object.

If you need to change the direction of the ramp, use the function “flip” from the shortcut menu.

Table 24 Parameters of ramp

№	Name of parameter	Mark	Explanation
1	Ramp position relative to baseline		-
2	Ramp horizontal offset		This parameter can have a negative value
3	Ramp height		-
4	Ramp width		-
5	Ramp slope		This parameter is automatic and is calculated depending on the set values for the length and height
6	Ramp shape		-
7	Ramp thickness		This parameter is user for reinforced ramps.
8	Level		-
9	Vertical offset		The vertical offset of a ramp relatively to the level
10	Material		-
11	Mark		This parameter required for the drawing

6.3.5 Door

The tool “Door” allows creating doorways of various shapes in existing building walls, which are automatically filled with door panels. There are several possible types of door apertures: rectangular, arch, trapezoidal, semi-trapezoidal and semi-arch forms. The door parameters are set during construction, and can be changed in edit mode. All door parameters are shown in the Table 25.

Parameters such as "Door orientation " and " Door depth "are set if the parameter "Door style " is defined. The "Door style" parameter defines the element's properties and appearance. You can manage the panel, lining, threshold, casing and transom parameters with the door style. The program also allows you to create your own door style, if the list of suggested styles does not include one that meets your requirements. Pay attention, after editing/deleting styles in the editor, by clicking OK, all the performed changes will be applied to the related objects permanently.

Graphical visualization of doors in 3D views, facades, and drawings depends on the previously set parameter values.

Table 25 Parameters of door

№	Name of parameter	Mark	Explanation
1	Door height		-
2	Door width		-
3	Door arc/trapezium height		-
4	Level		-
5	Vertical offset		The vertical offset of a door relatively to the insertion point
6	Door style		-
7	Location of the doorway		The opening follows the wall shape and enables radius doors to be created.
8	Reinforcement style		If the wall requires reinforcement at the door aperture location, this parameter is applied
9	Mark		This parameter required for the drawing
10	Door orientation		-
11	Door depth		-

6.3.6 Window

With the tool “Window” it is possible to create window opening of various shapes in existing walls, which are automatically filled with windows. There are several possible types of window apertures: rectangular, arch, trapezoidal, oval, semi-trapezoidal and semi-arch forms.
The window parameters are set during construction, and can be changed in edit mode. All window parameters are shown in the Table 26.

Parameters such as "Presence of a window sill", “Presence of a window outward sill”, “Window orientation” and "Window depth" are set if the parameter "Window style" is defined. The "Window style" parameter defines the element's properties and appearance. The program also allows you to create your own window style, if the list of suggested styles does not include one that meets your requirements. Pay attention, after editing/deleting styles in the editor, by clicking OK, all the performed changes will be applied to the related objects permanently.

Graphical visualization of windows in 3D views, facades, and drawings depends on the previously set parameter values.

Table 26 Parameters of window

№	Name of parameter	Mark	Explanation
1	Window height		-
2	Window width		-
3	Window arc/trapezium height		-
4	Level		-
5	Vertical offset		The vertical offset of a window relatively to the insertion point
6	Window style		-
7	Window position		The window aperture follows the wall shape and enables radius windows to be created.
8	Reinforcement style		If the wall requires reinforcement at the window aperture location, this parameter is applied
9	Mark		This parameter required for the drawing
10	Presence of a window sill		-
11	Presence of a window outward sill		-
12	Window orientation		-
13	Window depth		-

6.3.7 Railing

The tool “Railing” is intended to create railings for balconies, terraces, etc.
The railing parameters are set during construction, and can be changed in edit mode. All railing parameters are shown in the Table 27.

Table 27 Parameters of railing

№	Name of parameter	Mark	Explanation
1	Railing height		-
2	Space between the balusters		-
3	Level		-
4	Vertical offset		The vertical offset of a railing relatively to the insertion point
5	Mark		This parameter required for the drawing

All construction methods were described in more detail earlier in the Table 4.

6.3.8 Stair and ramp railing

If you need to design railing along the stairs or ramp, use the tool “Railing” and construction mode “Stair Railing” or “Ramp railing”. Note that those construction modes are available in Polar and Rectangular measure modes only.

The parameters for stair (or ramp) railing are set during construction, and can be changed in edit mode. All parameters are shown in the Table 28.

Table 28 Parameters of stair and ramp railing

№	Name of parameter	Mark	Explanation
1	Railing height		-
2	Number of steps per baluster or Space between the balusters		-
3	Railing offset		-
4	Mark		This parameter required for the drawing

The railing changes automatically if the stair or ramp on which it is located are edited.

6.3.9 Element

If you have the goal not only to develop the scheme of the project but provide the design of the object also, you can use the tool “Element”. Using the tool, it is possible to add to the Renga model different objects such as elements of the interior and decor of the room, equipment and standard elements, the parameters of which you can find in the manufacturer's catalogs.

The objects can be imported form the next programs with relevant formats: 3ds Max (.3ds), LightWave (.Rengalwo), StereoLithography (.stl), Wavefront object (.obj), COLLADA (.dae), Autodesk FBX (.fbx), C3D (.c3d), STEP (.stp, .step), IGES (.igs, .iges), Parasolid (.x_t, .x_b), ACIS (.sat), JT (.jt) or VRML (.wrl).

All parameters for imported elements are shown in the Table 29. The parameters are set at the time of its creation or during editing the object.

Table 29 Parameters of element

№	Name of parameter	Mark	Explanation
1	Element position relative to axis		-
2	Element horizontal offset		X-axis offset relative to the insertion point. This parameter can have a negative value
3	Element vertical offset		Y-axis offset relative to the insertion point. This parameter can have a negative value
4	Element style		The properties and parameters of element are set here.
5	Element width		-
6	Element depth		-
7	Element height		-
8	Precession		-
9	Nutation		-
10	Spin angle		-
11	Level		-
12	Vertical offset		The vertical offset of an element relatively to the insertion point
13	Mark		This parameter required for the drawing

Parameters such as “Procession”, “Nutation” and “Spin angle” allows you to modify the position of an object in the 3D view space.

The initial orientation of the element depends on the program from which it was exported. All dimensions of imported elements are set in millimeters by default.

There are several limitations that define the graphical representation of objects on level plans, depending on their primary format:

1) Elements based on imported objects from programs 3ds Max, LightWave, StereoLithography, OBJ, COLLADA and VRML will be displayed as bounding boxes;
2) Elements based on imported objects from programs C3D, STEP, IGES, Parasolid and ACIS will display their projections on the level plane;
3) The display of an element based on a JT format object will depend on the parameters and properties set in the object's source file.

The "Element style" parameter defines the element's properties and appearance. This parameter gives the possibility to set material, overall dimensions and orientation relative to the working plane. The program also allows you to create your own equipment style, if the list of suggested styles does not include one that meets your requirements.

Pay attention, after editing/deleting styles in the editor, by clicking OK, all the performed changes will be applied to the related objects permanently.

6.3.10 Assembly

Using the tool “Assembly”, it is possible to add to the model different objects which were created on the Assembly tab. It is necessary to choose the “Create New assembly” function in the project explorer if you want to create new assembly.

All parameters for assembly are shown in the Table 30. The parameters are set at the time of its creation or during editing the object.

The assembly will be located relative to the axis on the working plane in the same way as it is relative to the origin in the assembly tab. Parameters such as “Procession”, “Nutation” and “Spin angle” allows you to modify the position of an object in the 3D view space.

Table 30 Parameters of assembly

№	Name of parameter	Mark	Explanation
1	Assembly position relative to axis		-
2	Assembly horizontal offset		X-axis offset relative to the insertion point. This parameter can have a negative value
3	Assembly vertical offset		Y-axis offset relative to the insertion point. This parameter can have a negative value
4	Assembly name		-
5	Precession		-
6	Nutation		-
7	Spin angle		-
8	Level		-
9	Vertical offset		The vertical offset of an element relatively to the insertion point
10	Mark		This parameter required for the drawing

If you change the assembly parameters, all assemblies with the same name will be automatically modified. The graphical representation of the Assembly on facades and 3D views depends on the previously set parameters of the elements that it consists of.

6.3.11 Plate

The tool “Plate” allows you to add elements to the model that connect load-bearing structures to each other. The plate is a flat sheet element.

All parameters for plates are shown in the Table 31. The parameters are set at the time of its creation or during editing the object.

Parameters such as “Procession”, “Nutation” and “Spin angle” allows you to modify the position of an object in the 3D view space.

The "Plate style" parameter defines the element's properties and appearance. This parameter gives the possibility to set shape, width and length. The program also allows you to create your own plate style, if the list of suggested styles does not include one that meets your requirements. Pay attention, after editing/deleting styles in the editor, by clicking OK, all the performed changes will be applied to the related objects permanently.

Table 31 Parameters of plate

№	Name of parameter	Mark	Explanation
1	Plate position relative to axis		-
2	Plate horizontal offset		X-axis offset relative to the insertion point. This parameter can have a negative value
3	Plate vertical offset		Y-axis offset relative to the insertion point. This parameter can have a negative value
4	Plate style		The properties and parameters of plate are set here.
5	Plate thickness		-
6	Precession		-
7	Nutation		-
8	Spin angle		-
9	Level		-
10	Vertical offset		The vertical offset of an element relatively to the insertion point
11	Material		-
12	Mark		This parameter required for the drawing

6.4 MEP systems

Systems of water supply, heating, duct and electrical systems might be designed using the tools of Renga program. Special tools allow you to create pipes, ducts and its connections, to place the necessary equipment, lighting devices and elements of electrical systems.

6.4.1 Plumbing fixture

The tool "Plumbing fixture" allows you to place the required bathroom-and-lavatory equipment that will be part of the internal water supply and sewage system.

You can see the types of plumbing fixture that can be used in Renga, as well as the corresponding types of pipeline systems in the Table 32.

Table 32 Types of plumbing fixture

№	Plumbing fixture	Mark	Pipeline system
1	Toilet		Domestic sewage, domestic cold water
2	Bathtub		Domestic sewage
3	Shower tray		Domestic sewage
4	Sink		Domestic sewage, industrial sewage
5	Washbasin		Domestic sewage
6	Bidet		Domestic sewage, domestic cold water
7	Urinal		Domestic sewage, domestic cold water
8	Floor drain		Domestic sewage, industrial sewage, rain water
9	Roof drain		Rain water

All parameters for bathroom-and-lavatory equipment are shown in the Table 33. The parameters are set at the time of its creation or during editing the object.

Table 33 Parameters of plumbing fixture

№	Name of parameter	Mark	Explanation
1	Plumbing fixture position relative to axis		-
2	Plumbing fixture horizontal offset		X-axis offset relative to the insertion point. This parameter can have a negative value
3	Plumbing fixture vertical offset		Y-axis offset relative to the insertion point. This parameter can have a negative value
4	Plumbing fixture style		The appearance, overall dimensions and connection points parameters are set here.
5	System type		The plumbing fixture system type is set here. Can be changed if the plumbing fixture is not connected with a route
6	Precession		-
7	Nutation		-
8	Spin angle		-
9	Level		-
10	Vertical offset		The vertical offset of plumbing fixture relatively to the insertion point
11	Mark		This parameter required for the drawing

Parameters such as “Procession”, “Nutation” and “Spin angle” allows you to modify the position of an object in the 3D view space.

If you change the parameters of plumbing fixture equipment connected with a route, the route will be removed

The "Plumbing fixture style" parameter defines the element's properties and appearance. The program also allows you to create your own plumbing fixture style, if the list of suggested styles does not include one that meets your requirements. Pay attention, after editing/deleting styles in the editor, by clicking OK, all the performed changes will be applied to the related objects permanently.

6.4.2 Mechanical equipment

The tool "Mechanical equipment" allows you to place the required equipment such as faucets, pumps, radiators, etc., that will be part of the internal heating, water supply and sewage system.

You can see the types of mechanical equipment that can be used, as well as the corresponding types of pipeline systems in the Table 34.

Table 34 Types of mechanical equipment

№	Plumbing fixture	Mark	Pipeline system
1	Faucet		Domestic cold water, domestic hot water
2	Pump		Domestic cold water, domestic hot water, domestic sewage, firewater, heating, gaseous fire suppression, rainwater, industrial cold water, industrial hot water, industrial sewage, other pipe systems
3	Air terminal		Domestic cold water, domestic hot water, domestic sewage, firewater, heating, gaseous fire suppression, rainwater, industrial cold water, industrial hot water, industrial sewage, other pipe systems
4	Rangehood		Domestic cold water, domestic hot water, domestic sewage, industrial sewage
5	Radiator		Vent cowl cap
6	Towel radiator		Vent cowl cap, domestic hot water
7	Fan		Domestic cold water, domestic hot water, domestic sewage, firewater, heating, gaseous fire suppression, rainwater, industrial cold water, industrial hot water, industrial sewage, rainwater, other pipe systems
8	Anti-downdraft cowl		Domestic cold water, domestic hot water, domestic sewage, gas, other pipe systems
9	Plate heat exchanger		Domestic cold water, domestic hot water, vent cowl cap

All parameters for bathroom-and-lavatory equipment are shown in the Table 35. The parameters are set at the time of its creation or during editing the object.

Table 35 Parameters of mechanical equipment

№	Name of parameter	Mark	Explanation
1	Mechanical equipment position relative to axis		-
2	Mechanical equipment horizontal offset		X-axis offset relative to the insertion point. This parameter can have a negative value
3	Mechanical equipment vertical offset		Y-axis offset relative to the insertion point. This parameter can have a negative value
4	Mechanical equipment style		The appearance, overall dimensions and connection points parameters are set here.
5	System type		The plumbing fixture system type is set here. Can be changed if the mechanical equipment is not connected with a route
6	Precession		-
7	Nutation		-
8	Spin angle		-
9	Level		-
10	Vertical offset		The vertical offset of plumbing fixture relatively to the insertion point
11	Mark		This parameter required for the drawing

Parameters such as “Procession”, “Nutation” and “Spin angle” allows you to modify the position of an object in the 3D view space.

If you change a style of connected to route object and the style specifies an object type with different amount of connection points, the route will be detached. The route that the equipment is attached to will be moved automatically if the location of the equipment is changed.

The "Mechanical equipment style" parameter defines the element's properties and appearance. The program also allows you to create your own equipment style, if the list of suggested styles does not include one that meets your requirements. Pay attention, after editing/deleting styles in the editor, by clicking OK, all the performed changes will be applied to the related objects permanently.

6.4.3 Pipe

Elements of a building's pipeline systems can be connected to each other using the tool “Pipe”, which creates a pipe between specified points. Please note that to use this tool, the elements must be located on the same route.

All pipe parameters are shown in the Table 36. The parameters are set at the time of its creation or during editing the object.

Table 36 Parameters of pipe

№	Name of parameter	Mark	Explanation
1	Pipe style		The pipe properties are set here.
2	Mark		This parameter required for the drawing

The "Pipe style" parameter defines the element's properties and appearance. This parameter gives the possibility to set material, connection style, minimum pipe length and bending radius of pipe. The program also allows you to create your own pipe style, if the list of suggested styles does not include one that meets your requirements.
Pay attention, after editing/deleting styles in the editor, by clicking OK, all the performed changes will be applied to the related objects permanently.

Before you start building, make sure that there is no a pipe, because the pipes may overlap. This may cause a misconnection.

6.4.4 Pipe accessory and pipe fitting

When designing internal water supply and sewage system, it may be necessary to install fittings and accessories of pipeline valves. It is possible to use the tools “Pipe accessory” and “Pipe fitting” for this purpose.
All parameters, which fittings or accessories may have, are shown in the Table 37. The parameters are set at the time of its creation or during editing the object.

The “Pipe accessory style” and “Pipe fitting style” parameters define the element's properties and appearance. Those parameters give the possibility to set overall dimensions and connection points.

Table 37 Parameters of pipe accessory and pipe fitting

№	Name of parameter	Mark	Explanation
1	Pipe accessory style or Pipe fitting style		The accessory and fitting properties are set here.
2	Rotation angle in relation to the coordinates' axis		-
3	Mark		This parameter required for the drawing

Accessory "cuts" a pipe. After placing an accessory on a pipe, the pipe pieces before and after the accessory will be available for editing separately

Pipe accessories and fittings can be overlapped when you insert them on one another. Delete the previous object before putting a new one in the same place.

6.4.5 Duct

Elements of a building's duct system can be connected to each other using the tool “Duct”, which creates a duct between specified points. Please note that to use this tool, the elements must be located on the same route.

All duct parameters are shown in the Table 38. The parameters are set at the time of its creation or during editing the object.

Table 38 Parameters of duct

№	Name of parameter	Mark	Explanation
1	Duct style		The duct properties are set here.
2	Duct rotation angle		Rotation angle in relation to the coordinates' axis
3	Mark		This parameter required for the drawing

The "Duct style" parameter defines the element's properties and appearance. This parameter gives the possibility to set overall dimensions and connection points. The program also allows you to create your own pipe style, if the list of suggested styles does not include one that meets your requirements. Pay attention, after editing/deleting styles in the editor, by clicking OK, all the performed changes will be applied to the related objects permanently.

Before you start building, make sure that there is no a pipe, because the pipes may overlap. This may cause a misconnection.

6.4.6 Duct accessory and duct fitting

Tools “Duct accessory” and “Duct fitting” allow installing parts ventilation system such as accessories and fittings.

All parameters, which fittings or accessories may have, are shown in the Table 39. The parameters are set at the time of its creation or during editing the object.

Table 39 Parameters of duct accessory and duct fitting

№	Name of parameter	Mark	Explanation
1	Duct accessory style or Duct fitting style		The accessory and fitting properties are set here.
2	Rotation angle in relation to the coordinates' axis		-
3	Mark		This parameter required for the drawing

The “Duct accessory style” and “Duct fitting style” parameters define the element's properties and appearance. Those parameters give the possibility to set overall dimensions and connection points.

Duct accessories and fittings can be overlapped when you insert them on one another. Delete the previous object before putting a new one in the same place.

6.4.7 Ventilation equipment

The tool "Ventilation equipment" allows you to place the required equipment such as air terminals, fans, rangehoods, etc., that will be part of the internal ventilation system.

There are the types of ventilation equipment that can be used, as well as the corresponding types of duct systems in the Table 40.

Table 40 Types of ventilation equipment

№	Equipment	Mark	Duct system
1	Air handling unit		Ventilation, exhaust
2	Air terminal		Ventilation, exhaust
3	Rangehood		Ventilation
4	Vent cowl cap		Ventilation, exhaust
5	Fan		Ventilation, exhaust, pressurization, smoke exhaust, vacuum, other duct systems
6	Anti-downdraft cowl		Ventilation, exhaust

All parameters for ventilation equipment are shown in the Table 41. The parameters are set at the time of its creation or during editing the object.

Table 41 Parameters of ventilation equipment

№	Name of parameter	Mark	Explanation
1	Ventilation equipment position relative to axis		-
2	Ventilation equipment horizontal offset		X-axis offset relative to the insertion point. This parameter can have a negative value
3	Ventilation equipment vertical offset		Y-axis offset relative to the insertion point. This parameter can have a negative value
4	Ventilation equipment style		The appearance, overall dimensions and connection points parameters are set here.
5	System type		The plumbing fixture system type is set here. Can be changed if the ventilation equipment is not connected with a route
6	Precession		-
7	Nutation		-
8	Spin angle		-
9	Level		-
10	Vertical offset		The vertical offset of plumbing fixture relatively to the insertion point
11	Mark		This parameter required for the drawing

Parameters such as “Procession”, “Nutation” and “Spin angle” allows you to modify the position of an object in the 3D view space.

If you change a style of connected to route object and the style specifies an object type with different amount of connection points, the route will be detached. The route that

the equipment is attached to will be moved automatically if the location of the equipment is changed.

The "Equipment style" parameter defines the element's properties and appearance. This parameter gives the possibility to set material, overall dimensions and connection points. The program also allows you to create your own equipment style, if the list of suggested styles does not include one that meets your requirements. Pay attention, after editing/deleting styles in the editor, by clicking OK, all the performed changes will be applied to the related objects permanently

6.4.8 Lighting fixture

Designing a building's lighting system it is possible to use tool “Lighting fixture”, which allows you to place lighting equipment such as lamps, spotlights, and so on. Lighting fixture can be placed on walls, ceilings, beams or columns.

There are two types of lighting system in the program: lighting circuit and power circuit. All lighting fixture that can be designed belong to these two types.

All parameters, which lighting equipment may have, are shown in the Table 42. The parameters are set at the time of its creation or during editing the object.

Table 42 Parameters of lighting fixture

№	Name of parameter	Mark	Explanation
1	Lighting fixture position relative to axis		-
2	Lighting fixture horizontal offset		X-axis offset relative to the insertion point. This parameter can have a negative value
3	Lighting fixture vertical offset		Y-axis offset relative to the insertion point. This parameter can have a negative value
4	Lighting fixture style		The appearance, overall dimensions and properties are set here.
5	System type		The plumbing fixture system type is set here.
6	Light fixture angle		Rotation angle in relation to the coordinates' axis
7	Mark		This parameter required for the drawing

If you change the parameters of plumbing fixture equipment connected with a route, the route will be removed. The route that the equipment is attached to will be moved automatically if the location of the equipment is changed.

The "Lighting fixture style" parameter defines the element's properties and appearance. The program also allows you to create your own equipment style, if the list of suggested styles does not include one that meets your requirements. Pay attention, after editing/deleting styles in the editor, by clicking OK, all the performed changes will be applied to the related objects permanently.

6.4.9 Electrical circuit line

Elements of a building's electrical system can be connected to each other using the tool “Electrical circuit line”, which creates an electrical cable between specified points. Note that to use this tool, the elements must be located on the same route.

All Electrical circuit line parameters are shown in the Table 43. The parameters are set at the time of its creation or during editing the object.

Table 43 Parameters of electrical circuit line

№	Name of parameter	Mark	Explanation
1	Electrical circuit line Styles		-
2	Mark		This parameter required for the drawing

The " Electrical circuit line Styles" parameter defines amount of conductors and their style. The program also allows you to create your own pipe style, if the list of suggested styles does not include one that meets your requirements. Pay attention, after editing/deleting styles in the editor, by clicking OK, all the performed changes will be applied to the related objects permanently.

6.4.10 Wiring accessory

Designing a building's electrical system it is possible to use tool “Wiring accessory”, which allows you to place wiring equipment such as sockets and switches, junction

boxes and so on. All wiring accessories that can be designed belong to the lighting type electrical circuit.

All parameters, which wiring equipment may have, are shown in the Table 44. The parameters are set at the time of its creation or during editing the object.

Table 44 Parameters of wiring accessory

№	Name of parameter	Mark	Explanation
1	Position of wiring accessory relative to axis		-
2	Wiring accessory horizontal offset		X-axis offset relative to the insertion point. This parameter can have a negative value
3	Wiring accessory vertical offset		Y-axis offset relative to the insertion point. This parameter can have a negative value
4	Wiring accessory style		The appearance, overall dimensions and properties are set here.
5	System type		-
6	Wiring accessory angle		Rotation angle in relation to the coordinates' axis
7	Mark		This parameter required for the drawing

If you change the parameters of wiring accessory connected with a route, the route will be removed. The route that the equipment is attached to will be moved automatically if the location of the equipment is changed.

The " Wiring accessory style" parameter defines the element's properties and appearance. The program also allows you to create your own equipment style, if the list of suggested styles does not include one that meets your requirements. Pay attention, after editing/deleting styles in the editor, by clicking OK, all the performed changes will be applied to the related objects permanently.

6.4.11 Electric distribution board

The tool "Electric distribution board" allows you to place the distribution boards, that will be part of the electrical system.
All distribution boards that can be designed belong to the power circuit.

All parameters, which distribution boards may have, are shown in the Table 45. The parameters are set at the time of its creation or during editing the object.

Table 45 Parameters of electric distribution board

№	Name of parameter	Mark	Explanation
1	Position of distribution board relative to axis		-
2	Distribution board horizontal offset		X-axis offset relative to the insertion point. This parameter can have a negative value
3	Distribution board vertical offset		Y-axis offset relative to the insertion point. This parameter can have a negative value
4	Electric distribution board style		The appearance, overall dimensions and properties are set here.
5	System type		-
6	Distribution board rotation angle		Rotation angle in relation to the coordinates' axis
7	Mark		This parameter required for the drawing

If you change the parameters of distribution board connected with a route, the route will be removed. The route that the equipment is attached to will be moved automatically if the location of the equipment is changed.

The " Electric distribution board style" parameter defines the element's properties and appearance. The program also allows you to create your own equipment style, if the list of suggested styles does not include one that meets your requirements. Pay attention, after editing/deleting styles in the editor, by clicking OK, all the performed changes will be applied to the related objects permanently.

6.5 Auxiliary elements of the model

6.5.1 Dimension

The tool “Dimension” allows setting a linear dimension, as well as measure the radius, diameter and angle. The linear dimension can occupy different positions relative to the element: parallel to the line which passes through the selected points, vertically or horizontally. The values of diameter or radius dimensions can be located both inside the circle or arc and outside on the extension line.

The dimensions have parameters, which are shown in the Table 46. The parameters are set at the time of creation or during editing.

Table 46 Parameters of dimension

№	Name of parameter	Mark	Explanation
1	Dimension value type		There are two options: the dimension value and text. The text option is manual.
2	Value		This parameter is automatic if the dimension value option is selected
3	Text style		-

6.5.2 Model line

The tool "model line" is used to creating auxiliary lines in the model space.

All parameters for lines are shown in the Table 47. The parameters are set at the time of its creation, and can be changed later during editing.

Table 47 Parameters of model line

№	Name of parameter	Mark	Explanation
1	Line thickness		-
2	Line type		-
3	Line color		-
4	Vertical offset		The vertical offset of a line relatively to the level.
5	Level		-

All construction methods, which is possible to use creating lines, were described in more detail earlier in the Table 4.

6.5.3 Model hatch

The tool “Model hatch” allows you to create hatches and fills in the horizontal planes of the model.

All hatch parameters are shown in the Table 48. The parameters are set at the time of its creation, and can be changed later during editing the object.

Table 48 Parameters of model hatch

№	Name of parameter	Mark	Explanation
1	Hatch type		The styles of hatches and flood color filling are set here.
2	Hatch (Fill) color		-
3	Hatch angle		It changes the hatch texture inclination ready-made value by a preset angle
4	Hatch scale		-
5	Vertical offset		The vertical offset of hatching relatively to the level.
6	Level		-

All construction methods, which is possible to use creating hatch, were described in more detail earlier in the Table 4.

Pay attention that if the lines that are the boundaries intersect each other crosswise, the program will not be able to create the hatch correctly.

6.5.4 Model text

The tool "Model text" allows you to place a text on the level plan or 3D view.

All parameters for model text are shown in the Table 49. The parameters are set at the time of its creation, and can be changed later during editing the object.

Table 49 Parameters of model text

№	Name of parameter	Mark	Explanation
1	Vertical offset		The vertical offset of text relatively to the level.
2	Level		-

The text properties such as fonts and alignment settings might be modified in the text editor tab. Required symbols can be insert also.

7 DOCUMENTATION

7.1 The general page parameters

The embedded Renga graphic editor allows the user to arrange the required project documentation – to compose and edit annotated drawings using primitives.

Drawings are compiled as separate pages in the project file. Each page is edited separately from the others. Landscape orientation of the page and A3 format are set by default. The user can choose any standard page format or create a custom format with any custom dimensions. The edge of the page defines the boundaries of print.

The model and drawings are linked associatively, which means that all changes made to the model will be displayed in the drawing.

7.2 Display style

The parameter "Display Style" allows you to configure how each view is displayed in the drawing. It also allows inserting a specific list of model objects into the drawing. Any display style can be applied to any view or object. The program allows you to create your own display style if there is no one in the list of existing ones that would meet the user's requirements. You can also edit existing styles.

All symbols created in the model will not be displayed in the drawing, regardless of the style that was selected.

For visible objects, it is possible to set different levels of detail that determine how the object is displayed in the drawing. The Table 50 shows the existing levels of detail and their brief description.

The following parameters can also be defined for visible objects: the display of section lines and projection of the object, set parameters for hatching the projection and section of the object. Pay attention, after editing/deleting styles in the editor, by clicking OK, all the performed changes will be applied to the related objects permanently.

Table 50 Levels of detail

№	Level of detail	Description
1	Symbol	Plumbing fixture and fittings are displayed at this level of detail
2	Detail	All object lines are displayed at this level of detail
3	Simplified	The object is displayed in a simplified view at this level of detail
4	Symbolic	The object is displayed in a symbolic view at this level of detail.

7.3 Plans of levels, sections, facades and other elements

Plans of levels and their fragments, facades, sections, elements, and axonometric views can be located in the drawing. Visibility borders define the part of the view that will be displayed on the page, which allows adding fragments and drawings of individual structural components. Standard functions such as moving, displaying, and so on can be applied to each view in the drawing.

For plans and sections, the standard monochrome visualization style is used, for color facades - colored, and for visibility of reinforcement in Renga Structure-wireframe.
You can place in the drawing the view of an individual object, assembly, and each of its parts using the tool "Object". Mark and direction of view are indicated for each object.

The axonometric view is an axonometric projection of a 3D model. The axonometric view parameters are shown in the Table 51.The parameters are set at the time of its creation, and can be changed later during editing the object.

Table 51 The axonometric view parameters

№	Name of parameter	Mark	Explanation
1	View name		-
2	Projection type		The display and rotation angle are set here.
3	Model view		Direction of the observed rotation of the axes (clockwise or counter clockwise)
4	Orientation axonometric axes		-
5	View scale		The vertical offset of hatching relatively to the level.
6	Visual style		The frame is monochrome or colored
7	Display style		-
8	Filter		Displaying objects that meet the specified parameters

7.4 Designations

Lines, hatches, text, dimensions, section designations, tags, and callouts can be inserted into the drawing. If it is necessary, these tools are used for the final design of components, fragments, and other views from the model.

Lines in the drawing have the following characteristics: thickness, line type and color, and line caps. All lines are applied to the drawing at the drawing scale, i.e. if the drawing has a scale of 1: 100, printing, the line will have the same scale.

Text parameters, such as font and alignment settings, can be changed using the text editor. You can also use the text editor to insert symbols, such as the diameter of the rebar.
The command ”Arrange” lets changing the order of lines, hatches, and text by placing an element in the background.

You can also use the "Dimension" tool to set linear dimensions, circle or arc dimensions, angle values, and elevation marks if it is necessary. Elevation marks are linked with sections and facades of the model, so when the model changes, the elevation value will change automatically. In this case, the condition is that the elevation mark should be linked to the end or middle points of the object.

You can use the tool "Marker" to display any custom property in the drawing, such as the mark, name, type, design characteristics, dimensions of the marked object, and so on. The output value will be linked with the object in the 3D model, and when its properties change, the marker will also change. For the marker, it is possible to set up a set of styles that will allow displaying the appropriate marks of doors, windows, columns, etc.

Using the tool "Callout" , you may add the necessary clarifying information to the drawing, for example, add the composition of a multi-layer material to the drawing, indicating the thickness of the layers.

7.5 Tables and specifications

An existing table or specification of the project can be placed in the drawing, specifying its parameters.

The specification is a list of uniform items or materials, which are necessary for construction of the building. For example, you can create a specification for foundations or rebar. The specification is generated automatically by adding the necessary data that the program generates to the graphs.

You can display different properties of a few objects in one column.

A specification can be created for several types of objects at the same time, for example, for isolated and wall foundations, or for windows and doors. In this case, the specification will be formed only from parameters and properties that are common to elements.

8 CREATING MODEL

8.1 Wooden structure

The first step of the research was to create a model of a wooden industrial building to evaluate the system's ability to work with wooden materials.

The design revealed several functional shortcomings of the system during the work with elements made of timber and lumber:

1. There are no system presets by tree type. It is not possible to detail the tree to specific breeds.
2. The system allows you to create your own material by setting the necessary visualization parameters for it, such as hatching, color, and so on, but it is not possible to set the main physical characteristics of the material that are relevant for construction (strength, weight, etc).
3. The limitation of the system is related to the use of lumber:
   - There are no multi-layer lumber in the system;
   - When you try to create the required lumber (as the user's material for work), it is not possible to set the direction of the layers (this function is necessary for lumber such as CLT, LVL and so on).
4. There is restriction on the geometric shapes. The system does not allow working with elements that have a radial shape, which makes it impossible to design curved timber beams, for example, arches of various shapes.

The presence of these limitations led to the inability to complete the project and the refusal to use wood and lumber as the main design material. However, this allowed us to fix the weaknesses of the system and draw conclusions about its restrictions.

Then it was decided to design the building from metal structures.

8.2 Metal structure

It was decided to design an industrial building, the structures of which were previously designed for educational purposes. This model is a training one. As part of the work, there was no task to complete the project of a real building. The 3D view of the building model is shown at the Figure 9.

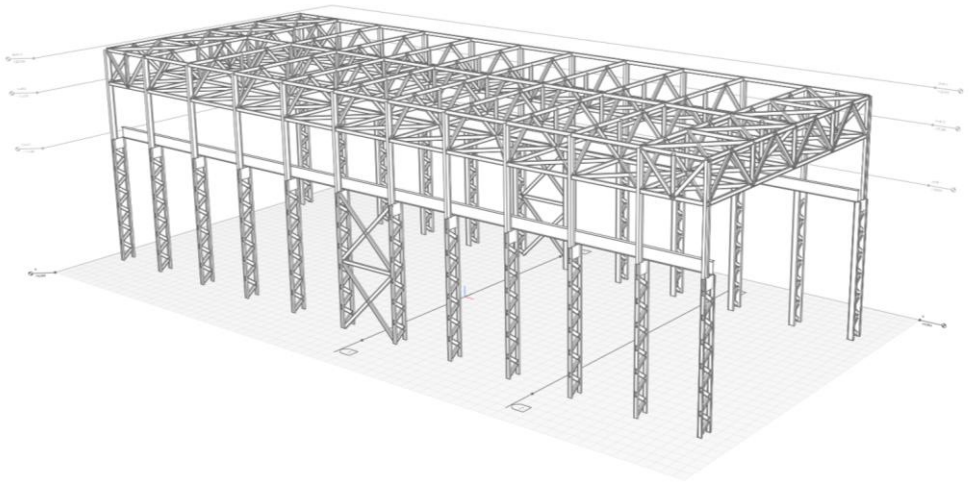

Figure 9 The 3D view of the metal building

The building has the following dimensions: the width is 24 meters, the length is 66 meters. The column spacing is 6 meters. The structure of the building is a frame structure and consists entirely of blocks made of metal elements. Load-bearing elements are columns consisting of upper and lower parts. The lower part of the column is two-branched and consists of two I-beams connected by a diagonal grid. The upper part of the column is single-branched and also designed from an I-beam. Due to the fact that the building is a workshop for industrial purposes, it became necessary to design crane runway beams. Crane runway beams have an I-beam profile and are supported on the lower parts of the columns.

The main supporting structure of the roof is a diagonal truss span of 24 meters, which is supported on columns. The trusses are connected by links along the upper and lower chords to ensure spatial stability in the vertical and horizontal planes. Steel was chosen as the basic material for all structures.

The first step was to draw grid lines on the base level of the model. Then, using the tool "Level", horizontal sections and their corresponding level plans were created, and their heights were set in accordance with the project.

The next step was to create the main load-bearing structures - columns. The tool "Column" was used for this purpose. Due to the fact that the I-beam cross-section required by the calculation was not available in the Renga, it was decided to create a new column cross-section profile that has all the necessary characteristics. Creating a new section, in our case an I-beam, as well as changing the parameters of an existing one, occurs in the dialog box "Column styles", which you can access from the panel "Properties". An example of creating a new column style, as well as the accepted cross-section characteristics, is shown in Figure 10. The cross-Sections of rolled metal elements for the column grid, truss elements, and links were modeled in the same way.

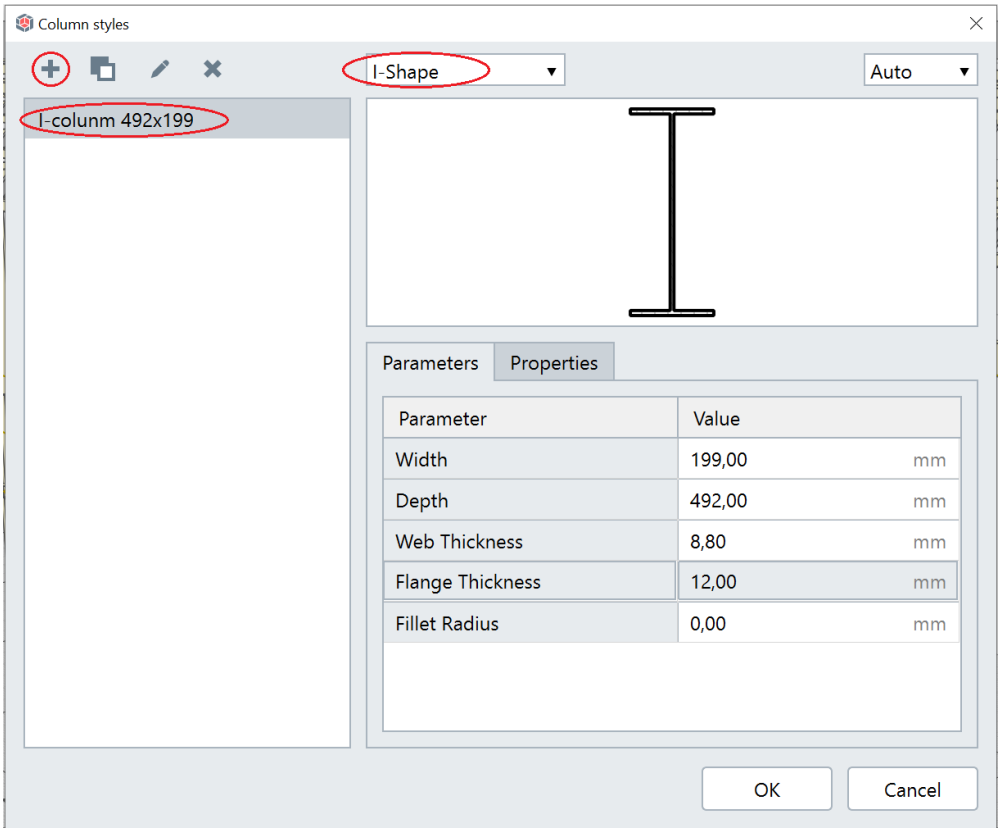

Figure 10 Creating a new column style

The grilles of the lower parts of the columns were created using the tool "Beam". The beginning and end of each element are clipped vertically. All elements of trusses (chords, struts, and braces), vertical and horizontal links on trusses, as well as crane runway beams, were modeled using the tool "Beam".

Hereby, it is possible to summarize the results of modeling by highlighting the advantages and disadvantages of using Renga as a tool for creating the structural model of a metal building.

The advantages are as follows:

- the ability of object snaps that make it easier for users to build the model;
- the ability to create objects on a 3D view using object snaps to existing structures;
- quick setup depth of view on plans;
- there is a built-in catalog of materials with the function of adding user materials (setting display characteristics and material properties, such as density and thermal conductivity, as well as additional characteristics and their values, if necessary);
- possibility of a flexible configuration of the element cross-section depending on the design needs;
- the presence of function of automatic vertical and horizontal cutting beams.

The disadvantages are as follows:

- facades are not created automatically. To create a facade, it is necessary to use the tool "Elevation";
- lack of rolled metal profile libraries;
- it is not possible to adjust the line thickness, which is especially important on plans and sections.

9 COLLABORATION AND INFORMATION EXCHANGE

9.1 Collaboration

A collaboration mechanism is implemented in the Renga system. This mechanism consolidates all three systems: Renga Architecture, Renga Structure, and Renga MEP. Now, architects and engineers may work together on a single project. Collaboration in

the Renga system allows different specialists to work on the project simultaneously, which reduces the risk of conflict situations, such as overlapping elements, lack of joining elements, gaps, inaccuracy of object placement, at the time of making changes to the model by one of the users.

The collaboration functionality in Renga will help designers reduce the time needed to work on a project since work on different parts of the project can be done in parallel. Besides, the collaboration will improve the quality of project execution, while organizing and maintaining collaboration does not require time-consuming configuration and complex administration.

Through the tool "Sync", project participants may work with up-to-date information on the 3D model and correctly evaluate the design, spatial planning, engineering, and other decisions made, and coordinate them with each other in time. This can help to avoid project errors, which can cost a lot of money not only to the project organization but also to the customer during the construction of the object.

As an example of collaboration, we can cite the case when one specialist places enclosure structures, the second one begins to design window openings in them and fill them immediately after the walls appear. In the future, Renga developers plan to improve the collaboration tool, which will allow two specialists to edit one object without conflict (for example, one engineer changes the section of a column, and the second one changes the material at the same time).

Another advantage of working together in Renga is the ability to work on a single project, being located remotely from other team members. The collaboration mechanism can be hosted on any server that is accessed via the Internet.

It is necessary to download and install the Collaboration Server application to work together on a project. Next, you will need to specify the installation folder and server settings for sync, such as the user name, the name of the server or personal computer where the project is published, the port, and the polling interval. The polling interval parameter with the specified frequency checks connections and, based on the analysis results, disables invalid ones. Due to this, the user can re-connect to the collaboration in case of network problems.

The person responsible for the project must create a project in Renga, enter information about the project, define the boundaries of the site using axes, and make the necessary notes. After that, the file is published to the shared server using the command "Publish"; the collaboration transaction log is created on the server at the same time. After the project is published, a collaboration transaction log is maintained on the server in the Renga Collaboration Server\Projects folder. The log describes all changes to the project.

All changes in the model made before syncing are saved in the user's local copy, which is located on their personal computer. These changes will not be available to other users. The user who made changes in the model must publish them themselves, otherwise, all changes will not be saved on the server and will be lost for collaboration.

9.2 Export

Currently, one of the most important aspects of a design engineer's work is interaction with:

- other software for collision detection;
- related specialists who work in other design systems;
- experts who require a specific description of the model;
- customers who use various programs to evaluate the model.

Renga programs allow converting the model to formats that can be used to transfer the model to other design and visualization systems.
For maximum integration of Renga products into the existing enterprise information environment, the system can use the following formats: .csv, .dwg, .dxf, .pdf, .ifc и 3D formats.

9.2.1 CSV export

CSV is a text format designed for a tabular data presentation. Any spreadsheet editor, for example, MS Excel may be used to open CSV format files (Renga. User manual). CSV files contain all project data, from the Renga version the project was created to the floor of the projected building the shortest reinforcing bar is located on.

Macros that are created for working with Renga model data in MS Excel allow you to get the following types of specifications:

- explication of premises;
- specification of door marks;
- list of doorways;
- specification of window marks;
- list of windows;
- specification of columns;
- beam specification;
- specification of columnar foundations;
- specification of strip foundations;
- specification of reinforcement elements;
- bill of materials;
- steel consumption statement.

To get any of the listed specifications, you need to export the data to CSV format using the option “CSV Export”.

9.2.2 DWG/DXF export

Drawings made in Renga can be exported to DXF/DWG formats for subsequent data exchange with other computer-aided design systems (CAD). There are only drawings available for export into DWG/DXF in Renga (Renga. User manual).

The required version of Autocad that the exported drawing will be compatible with can be set when converting the file.

The option “Batch DWG/DXF Export” allows you to convert a few drawings at once, created in Renga (Renga. User manual).

9.2.3 PDF export

PDF is a cross-platform open format for electronic documents (Renga. User manual). There are only drawings available for export into PDF in Renga. If you need to get a PDF file for printing or use in other applications later, use the option “PDF Export”.

Several drawings can be exported to PDF at the same time using the option “Batch PDF Export”. A multi-page PDF file will be created.

Renga also supports exporting to 3D PDF format. Specifically for this purpose, the application "RNPTo3DPDF" was created, which allows you to get three-dimensional PDF files that are compatible with the Adobe Reader application. This function allows, for example, to transmit an intermediate version of a 3D model without using the IFC format. The recipient will have the opportunity to get acquainted with the information model independently, without using specialized programs. The user can rotate the model, change its scale, hide and isolate elements, and make arbitrary sections of the model after uploading the model to Adobe Reader.

9.2.4 IFC export

IFC is a data format with an open specification developed by buildingSMART to simplify cooperation in the construction industry (Renga. User manual). It is possible to export files in IFC format using the command “IFC Export”. Renga works with the IFC4 format. You can use this format to send the model, for example, to Solibri Model Checker and check for collisions in your project, or use AxisVM to get beams and columns with non-standard profiles.

Users can set which object properties will be passed to the IFC depending on the goal, as well as redefine object types if it is necessary. This allows you to meet all the requirements of the state expertise for a digital model or define the Model View Definition (MVD) for other tasks creating a project. The MVD describes which objects, representations, relationships, concepts, and attributes are necessary for the project participant and the application to perform the requested task (BIM Corner).

You must set the following settings, to export to IFC4 format and determine the model composition:

- Type mapping file. Defines object types to export and their relation to IFC4 object types. Objects not specified in the type mapping file will not be exported (Renga. User manual).
- Parameter mapping file. Specifies which object properties to export and their correspondence to the IFC4 object attributes (Renga. User manual).

- Objects to layer mapping file. Defines which IFC layers will contain objects of the specified types (Renga. User manual).

The matching of parameters and properties determined in Renga to IFC parameters and properties will be set in the parameter mapping file. This file having the JSON format can be opened in any text or specialized editor, such as JSON Editor Online.

Exporting, IFC models are passed with materials whose properties can be edited (color, hatching, physical properties). 3D objects that have been logically cut out, such as walls that have been clipped by a roof, will be passed to IFC nonparametrically, i.e. only geometry.

9.2.5 3D export

Converting a model to 3D formats such as OBJ, Collada, STL, C 3D, JT, ACIS, STEP, and Parasolid allows data exchange with other computer-aided design systems (CAD) (Renga. User manual) (Table 54).

Table 51 Types of data export in 3D format

File format	For Rendering	For CAD Data Exchange	For 3D Printing
Wavefront object (.obj)	+		
Collada (.dae)	+		
StereoLithography(.stl)			+
C3D (.c3d)		+	
ACIS (.sat)		+	
STEP (.stp)		+	
Parasolid (.x_t, .x_b)		+	
JT (.jt)	+	+	

Formats C3D (.c3d), JT (.jt), ACIS (. sat), STEP (. step), and Parasolid (.x_t, .x_b) are used to export the model to solid-state formats. When you export a model to solid-state formats, the structure of the building is saved, but it is displayed differently depending on the format selected for export.

The OBJ and Collada formats are used for rendering tasks. The OBJ (.obj) format contains only 3D geometry and is used for data exchange with applications that work with 3D graphics. The COLLADA (.dae) format is based on XML and is designed for exchanging models between 3D applications.

The STL (.stl) format is used for storing three-dimensional models of objects and for 3D printing

9.4 Import

In the Renga system, there are two possible options for converting objects after transmission:

- The object is passed parametrically. This applies to objects that are created following the basic configuration described in the IFC 2x3 or IFC 4 specification. It is converted to the corresponding Renga object, and its parameters and properties are editable (color, hatching, physical properties).
- The Object is represented nonparametrically in the model. Then it is not converted to a Renga object and is defined only by geometric data. It is possible to move, copy, and display it in the model and on elevation plans. This IFC object also gets several additional parameters for further work with it in the Renga model. All universal operations are available working with IFC objects.

Two test cases were used to test the functionality of importing from external systems:

- importing a model of a multi-story concrete building designed in the Revit program;
- importing of a metal structure modeled in the Tekla Structure program.

The import functionality was not tested on wooden structures due to the previously described limitations of Renga for working with wooden materials.

1. Results of importing a file from Revit.

The import operation did not cause significant problems. Comparisons of the graphic display of 3D models and plans are shown at the Figure 11 and Figure 12, respectively.

Figure 11 The 3D views of the model in Renga (left) and Revit (right)

Figure 12 The floor plans in Renga (left) and Revit (right)

The following features were highlighted based on the results of testing the import from Revit program:

- Importing objects, the system does not use the built-in material catalogs but creates all the materials again as the user's materials. However, there are no problems in this case.
- All families modeled in Revit (families of windows and doors) were imported parametrically as Renga objects while preserving all previously set properties.

- The external walls of the building were imported parametrically, with the layer thicknesses and material characteristics set in Revit. However, importing intersecting partitions, their display format changed.
- Importing doors, the door opening direction is not displayed (the door is displayed as closed).
- The grid axes were not imported.
- Level plans were imported correctly (the names of the plans and their elevation marks were moved to Renga without changes).

2. Results of importing a file from Tekla Structure.

The following features were highlighted based on the results of testing the import from Tekla Structure program:

- Import model objects have not been implemented in full. Model objects are not defined as Rank objects, and object parameters are not fully identified. Manual modification of the model in the Renga is required to ensure the completeness of the model.
- The model is inserted at the base level (0.000). The import was performed without splitting into levels, which does not allow you to see the assignment of objects to levels.

Therefore, a comparison of Renga's capabilities for importing data from other systems allows us to make the following conclusions:

- Due to the limited functionality of the system for working with wooden objects, it is impractical to import wooden models.
- The import option for concrete and metal structures is less complicated for Revit program. Importing from Tekla Structure program, significant improvements to the model are required on the Renga side. Depending on the specific imported model, the number of improvements from Tekla Structure may be such that the import is not effective.

10 CONCLUSION

Based on the results of the work, including theoretical and practical blocks, the Renga program is a rather promising product developed to facilitate the design process. Basic

operations included in the program allow you to design a building or structure of any complexity.

The obvious advantage of the Renga program is such options as the ability to automatically reinforce structures, which greatly simplifies the design process of reinforced concrete. The Renga MEP program makes it possible to design water supply, sewerage, power supply, and ventilation systems. This allows civil engineers and MEP system engineers to work in the same program, without transferring the project file to third-party applications. The basic principles of visualization help to accurately display the architectural component of the project. The ability to export the model to many formats allows you to render the project, for example, in the Autodesk 3ds Max or MAXON Cinema 4D programs, search for possible collisions, for example, using the Solibri Model Cheker program, or get the required data tables for further viewing in MS Excel.
Renga's ability to import data from related systems allows you to use the program to combine data from different sources. However, importing data, you must take into account Renga's restrictions on getting data from Tekla Structure.

Choosing a product for design, it is necessary to keep in mind that Renga has limitations on working with wooden materials. At the moment, there is limitation of the functionality of the program - the inability to use Renga Software for the design of wooden buildings consisting of wooden and various lumber, such as CLT, LVL, curved timber beams, etc.

However, Renga Software is developing quite quickly. New releases of the program, in which developers add new features and fix existing bugs, are released several times a year. This indicates that in the near future Renga Software may take one of the leading positions in the field of software for information modeling purposes of metal and reinforced concrete buildings.

FIGURES

TABLES

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