

Plastic Forms of Architecture in Dynamo – Revit

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Abstract

The paper presents the results of research on working with the Dynamo-Revit bundle when creating plastic architectural forms of complex geometry. The Lotus, Canopy and Parametric Pavilion objects were chosen as models for the researching. For the presented architectural objects the least resource intensive nodes and their bundles were selected. Nodes and their bundles in such a way as to optimally use the capabilities of programs and not overload computer resources were selected. The scripts developed in the Dynamo program for creating the presented models are briefly described. Explanations for the most significant fragments and full scripts used to work with models are given. The possibilities of the Dynamo program for visual (parametric) programming are briefly analyzed. Some possibilities of work of its bundle with Revit are studied. The two-way work of the Dynamo-Revit bundle for import-export of the model was analyzed, including when changing the code to correct the model. It is advisable to continue working in this direction in order to obtain more concise and universal algorithms (chains of nodes) that allow varying the initial data and options for the shape of plastic architectural objects.

Keywords

Parametric programming, visual programming, Dynamo, Revit, modeling, complex geometry, plastic forms, joints, nodes.

1. Introduction

There is an increasing need to work with objects of complex geometry in modern architecture [1, 2]. It is convenient to use visual (parametric) programming, for example, in the Dynamo – Revit bundle to create models of architectural forms of complex geometry [3-8]. This type of programming allows you to quickly and clearly create scripts and obtain models of complex objects for further work with them in other software systems, for example, in Autodesk Revit, whose standard tools do not always allow you to create elements of complex geometry.

Open source Dynamo provides a convenient way to control the tools used. Dynamo – Revit bundle transfers the created model in both directions of this bundle, which allows you to constantly monitor the result in the form of a 3D model and make the necessary adjustments to the script in a timely manner, which are almost instantly reflected in the model exported to the second program of this bundle.

2. Conducted studies

2.1. Research methodology

The aim of the work was to develop scripts for creating models of plastic architectural forms of complex geometry in the Dynamo – Revit bundle. Also, the task was to study the bidirectional work of a bunch of these programs when exporting models and making adjustments to the open Dynamo code to change models.

For this, models of the following three objects were created:

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1. Lotus.
2. Canopy.
3. Parametric pavilion.

These architectural objects were not chosen by chance, because the development of these models was required by architects when designing real objects. Modeling them with standard Revit tools was almost impossible or led to a significant complication of the project, and, consequently, to an increase the laboriousness of the implementation of the file. As a result, it would be possible to work with the file not on every computer of the design organization. An unreasonably large number of man-hours would have been spent on the development of such a model.

One of the main objectives of the research, the results of which are presented in this article, was to find the most optimal solution in terms of reducing the cost of computer resources in the process of creating models based on the developed scripts. In the course of the research various nodes, similar in work, and their bundles, which made it possible to obtain the presented models, were used. Changes in system parameters were analyzed when working with different scripts for the same model. The most optimal codes are presented in this work.

2.2. Lotus

To create the Lotus object (Figure 1), arches for the petals were first created. For this, the **ArcByThreePoints** tool was used.



Figure 1: Lotus object in the spatial environment

Next, the petal surfaces were formed (Figure 2). At the same time, it is conceptually convenient to use the **Surface.BySweep2Rails** node, which allows you to extrude the profile of the section of the petal along the path and an additional direction.

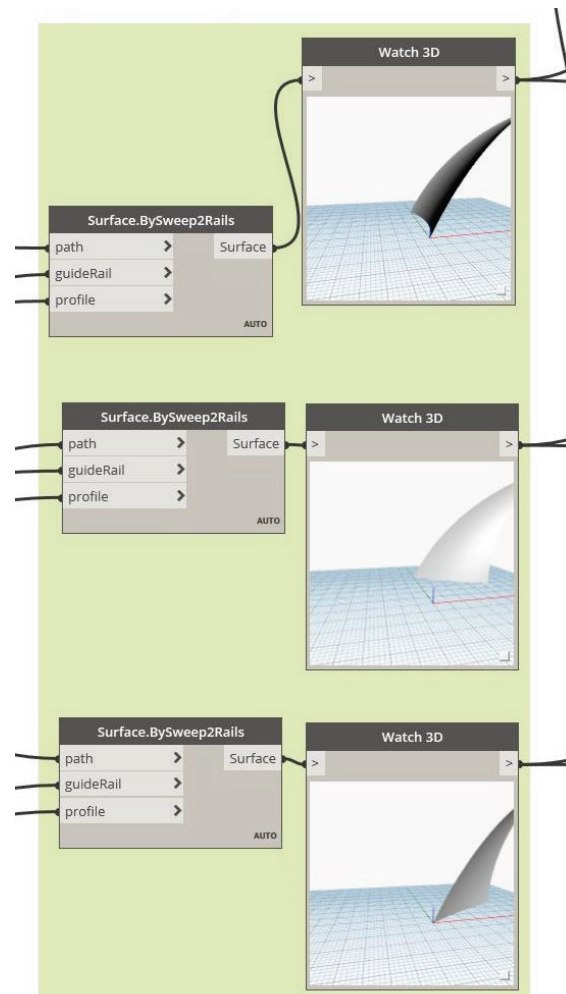


Figure 2: Creating surfaces of petals

The construction was formed from 8 petals (Figure 3), evenly distributed around the circle. Nodes **Circle.ByThreePoints**, **Polygon.RegularPolygon** were used.

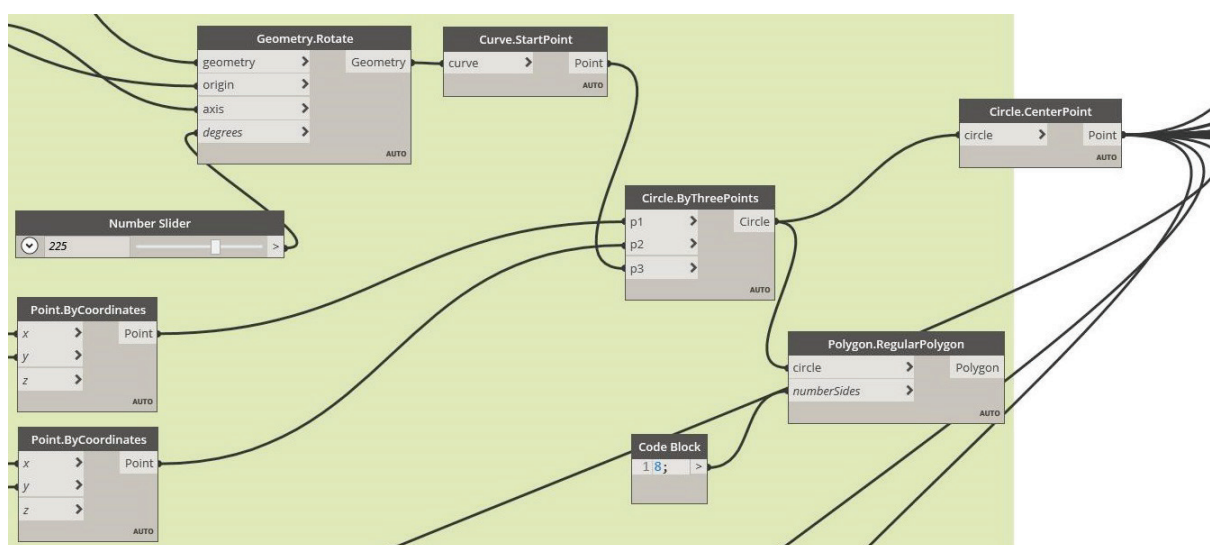


Figure 3: Formation of the construction from 8 petals

Next, the lower part of the object was created based on a truncated cone.

The resulting model is shown in Figure 4.

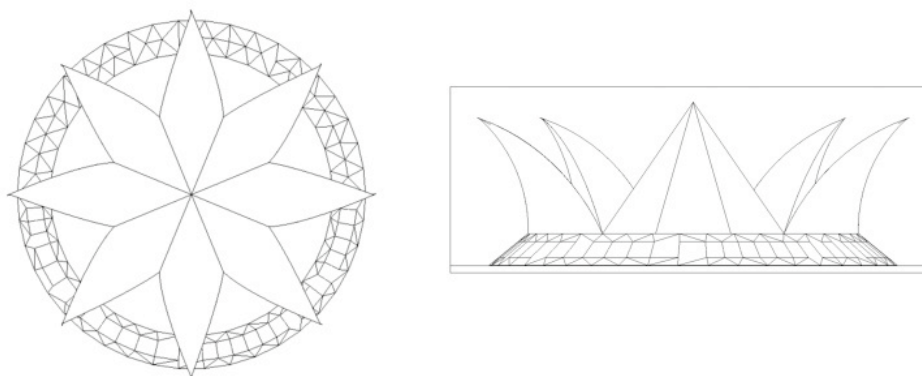


Figure 4: Lotus Object Model

The created Lotus object (Figure 5) was exported to Autodesk Revit for further work with it. For this, the **ImportInstance.ByGeometries** tool was used.

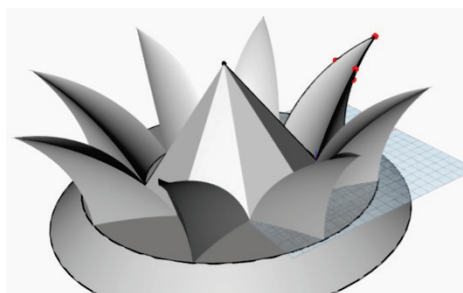


Figure 5: Object Lotus

The developed script for creating a Lotus object model is shown in Figure 6.

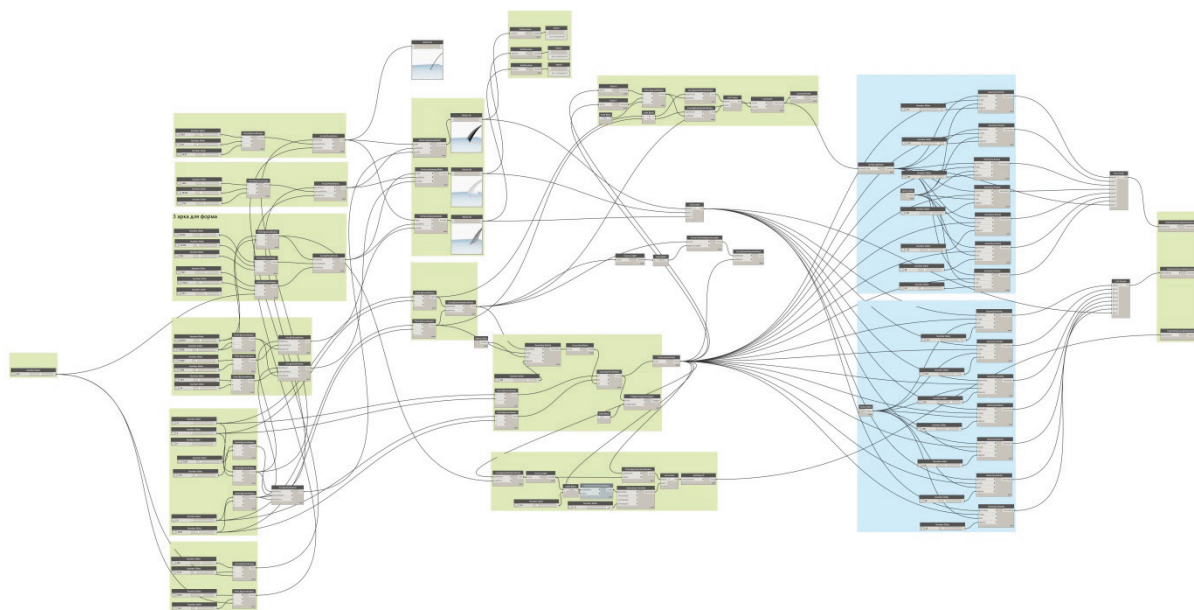


Figure 6: General view of the developed script for creating the Lotus model

2.3. Canopy

To create Canopy (Figure 7), the arch was formed (Figure 8).



Figure 7: Canopy in the spatial environment

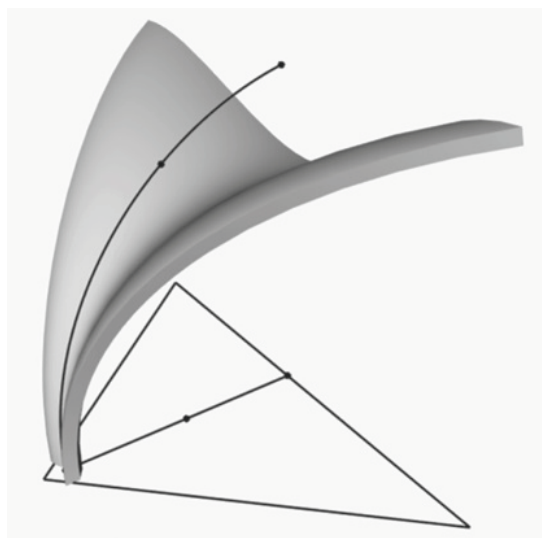


Figure 8: Arch

The creation of the trajectory of the arch was carried out along the reference line and three points (Figure 9).

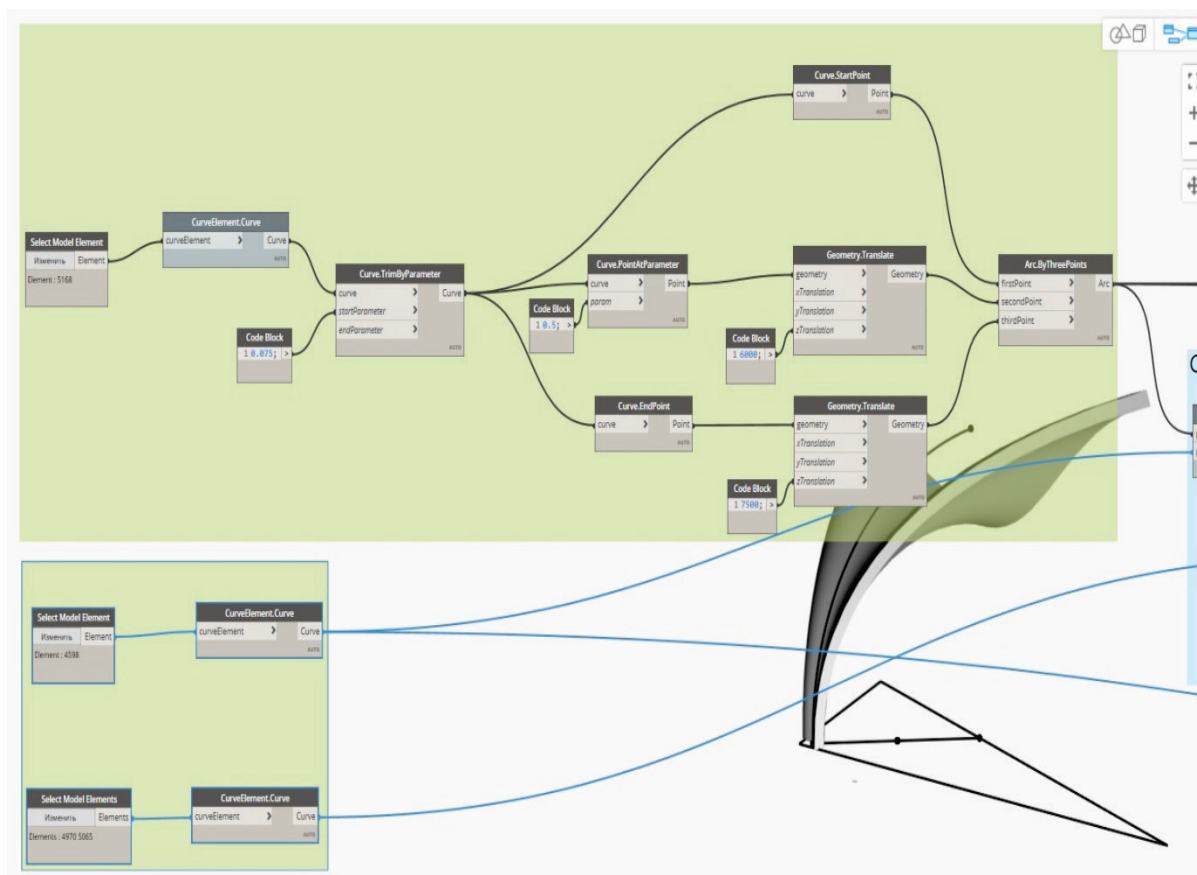


Figure 9: The creation of the trajectory of the arch from a reference line and three points

For this, the nodes **Curve.TrimByParameter**, **Curve.PointAtParameter**, **ArcByThreePoints** were used.

Then the curved surface was created with 16 lines on it (Figure 10).

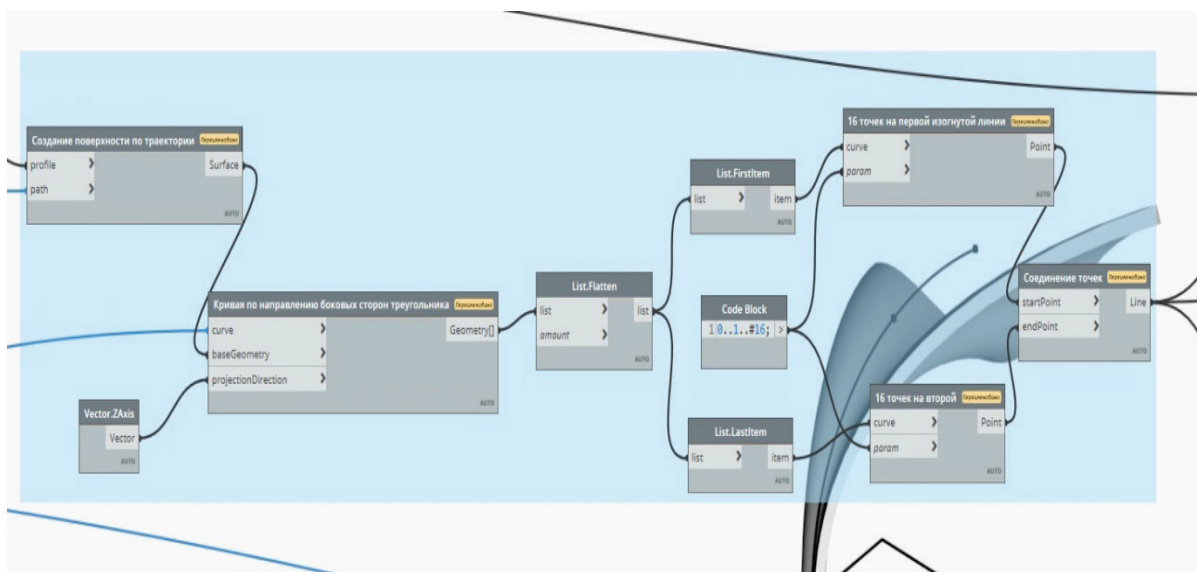


Figure 10: Creating the curved surface with 16 lines on it

Next, the curved surface of a given shape was formed (Figure 11).

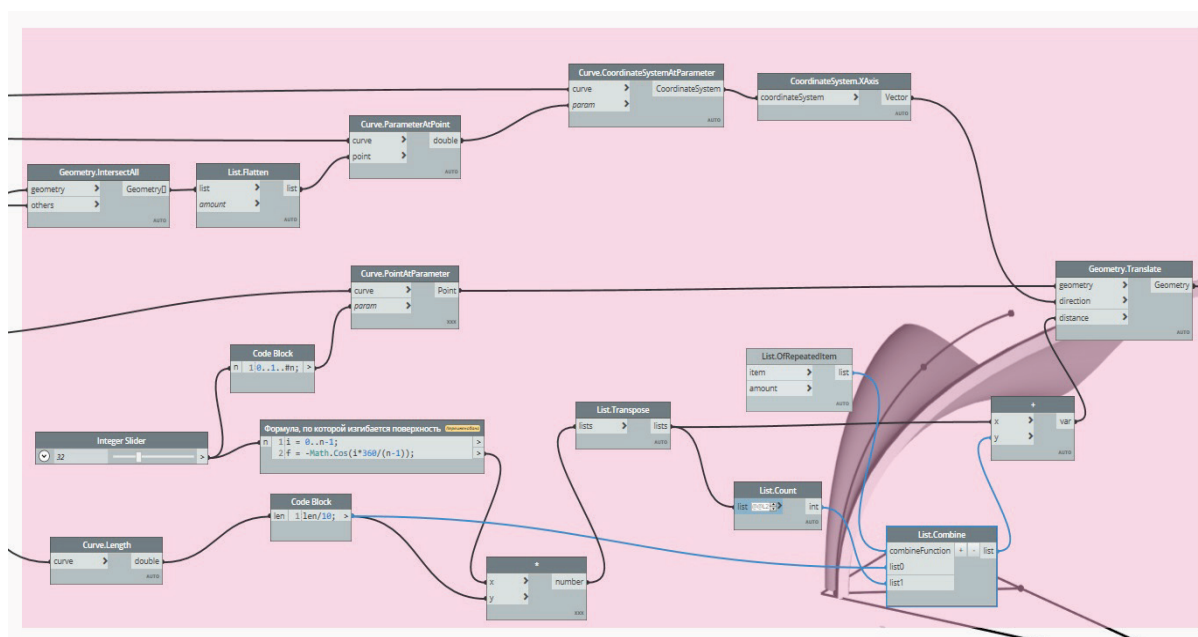


Figure 11: Creating the curved surface of a given shape

Then the three-dimensional shape on the basis of the resulting curved surface was created. Its edges were trimmed (Figure 12). The area and volume of the resulting form were also calculated.

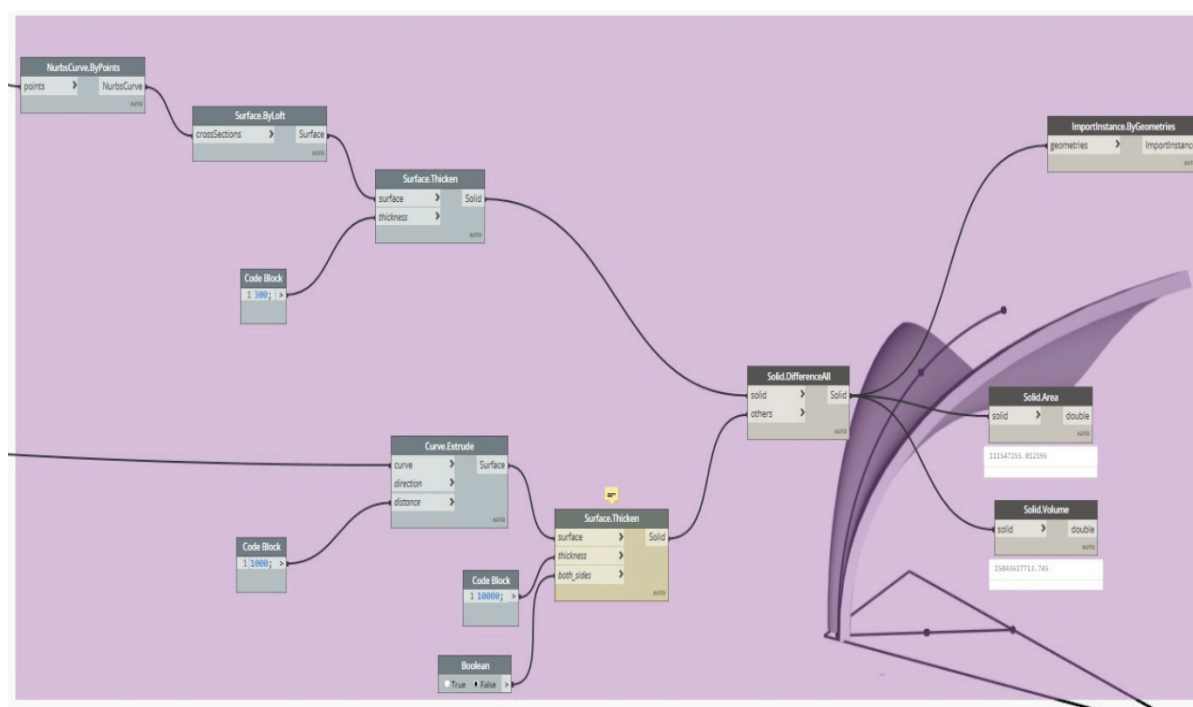


Figure 12: Creating the 3D Shape from the Curved Surface, trimming edges, calculation of its area and volume

The resulting Canopy model is shown in Figure 13.

The general view, the plan for the location of the main elements and the section of the resulting model are presented.

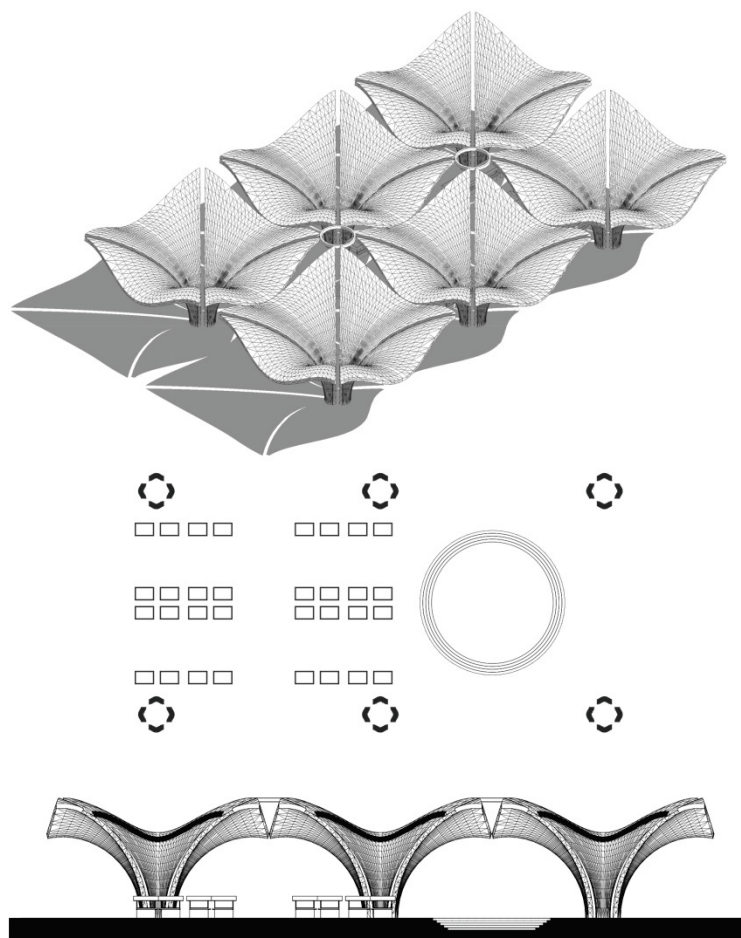


Figure 13: Canopy model

The general view of the developed script for creating the Canopy model is shown in Figure 14.

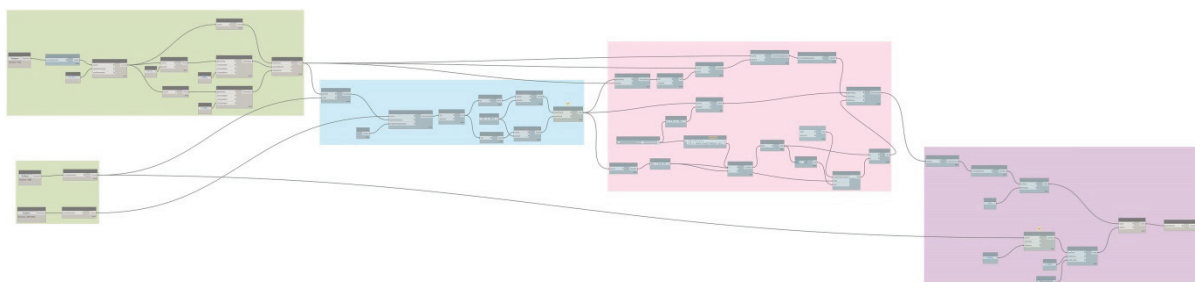


Figure 14: General view of the script for creating the Canopy

2.4. Canopy

The procedure for creating the Parametric pavilion (Figure 15) was divided into three main stages (Figure 16):

1. Creating the array of walls.
2. Formation the openings.
3. Subtraction of volumes.

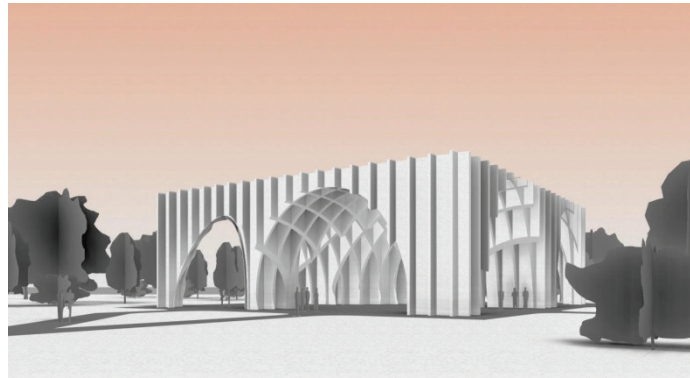


Figure 15: Parametric pavilion

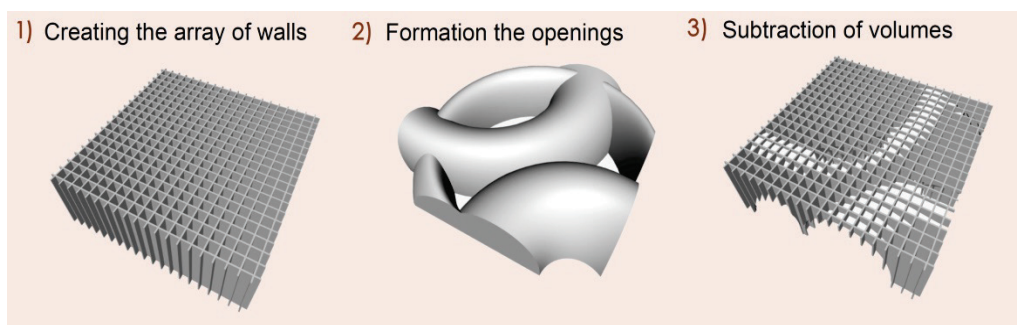


Figure 16: The main stages of creating a model of the Parametric pavilion

To create the array of walls (in two directions), **PoligonByPoints**, **CurveExtrudeAsSolid** nodes were used (Figure 17).

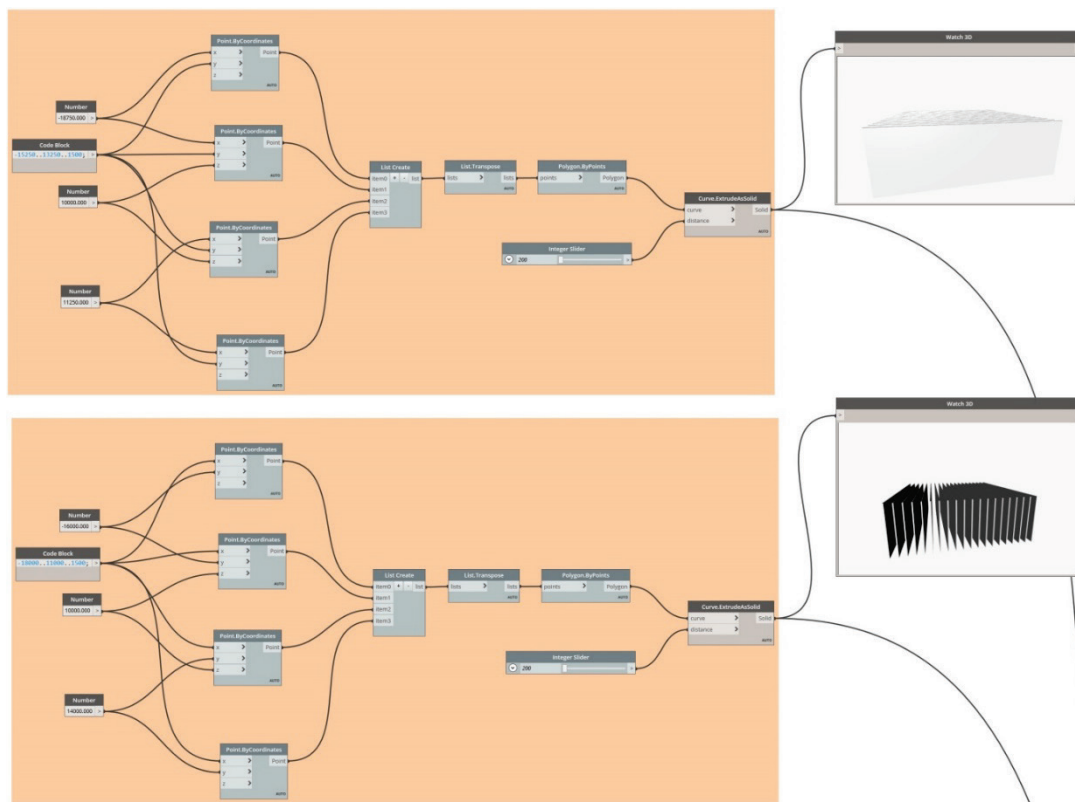


Figure 17: Creating the array of walls

To form volumes, which were then subtracted from the resulting array of walls, the **SolidByLoft**, **SolidDifferenceAll** tools were used (Figure 18). Three volumes were created and removed from the wall array volume.

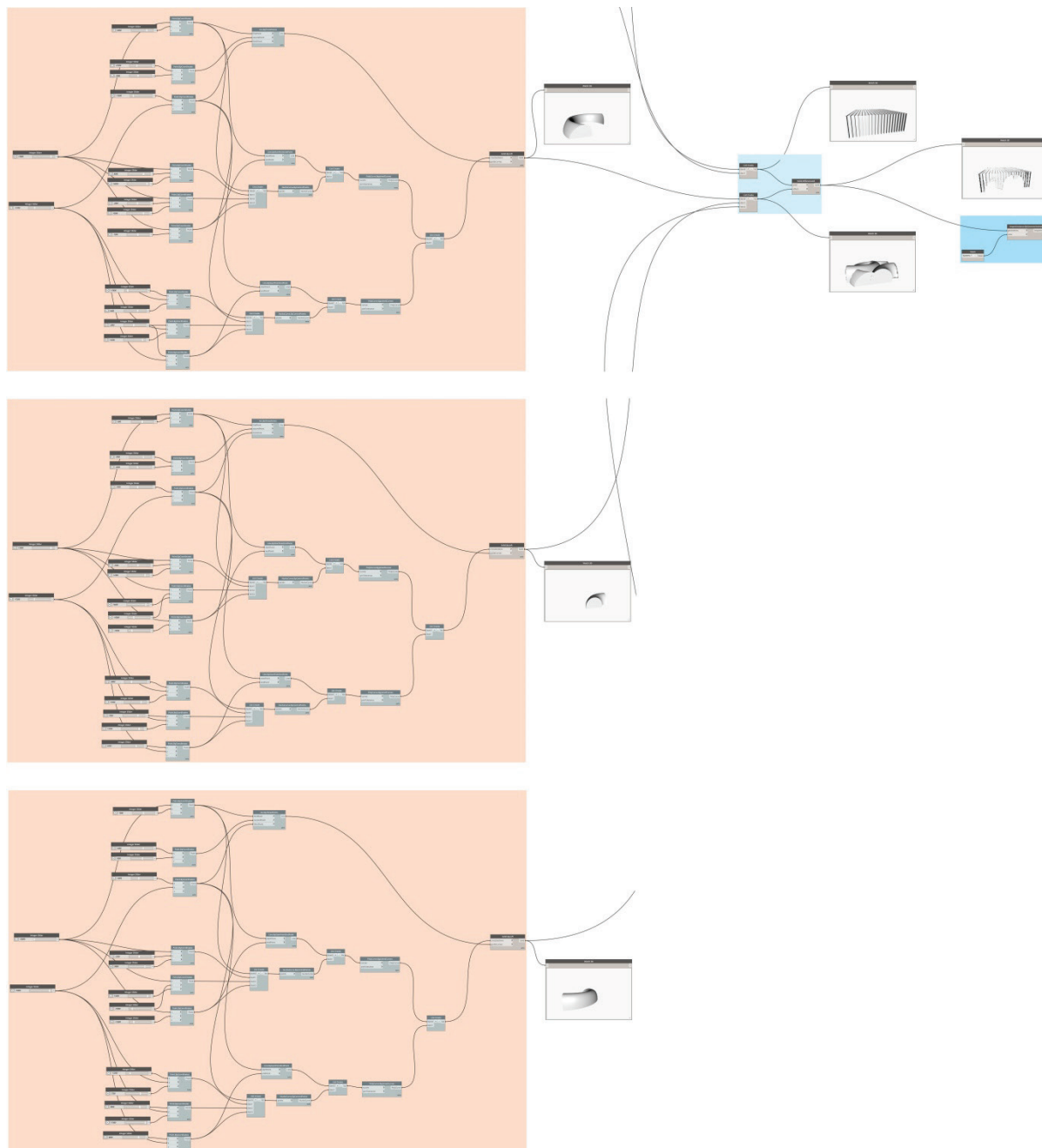


Figure 18: Creating three volumes to subtract from the array of walls

The resulting model of the Parametric pavilion is shown in Figure 19.

The general view, top view (plan), and the section of the resulting model are presented. The parametric pavilion model can be used for further work on the project. To do this, the pavilion must be placed in some kind of environment (an area of existing development or a newly designed architectural environment). For further work, the pavilion model is imported into a graphic software package, such as Graphisoft Archicad, Autodesk Revit, and others.

Autodesk Revit was chosen for further work on the project.

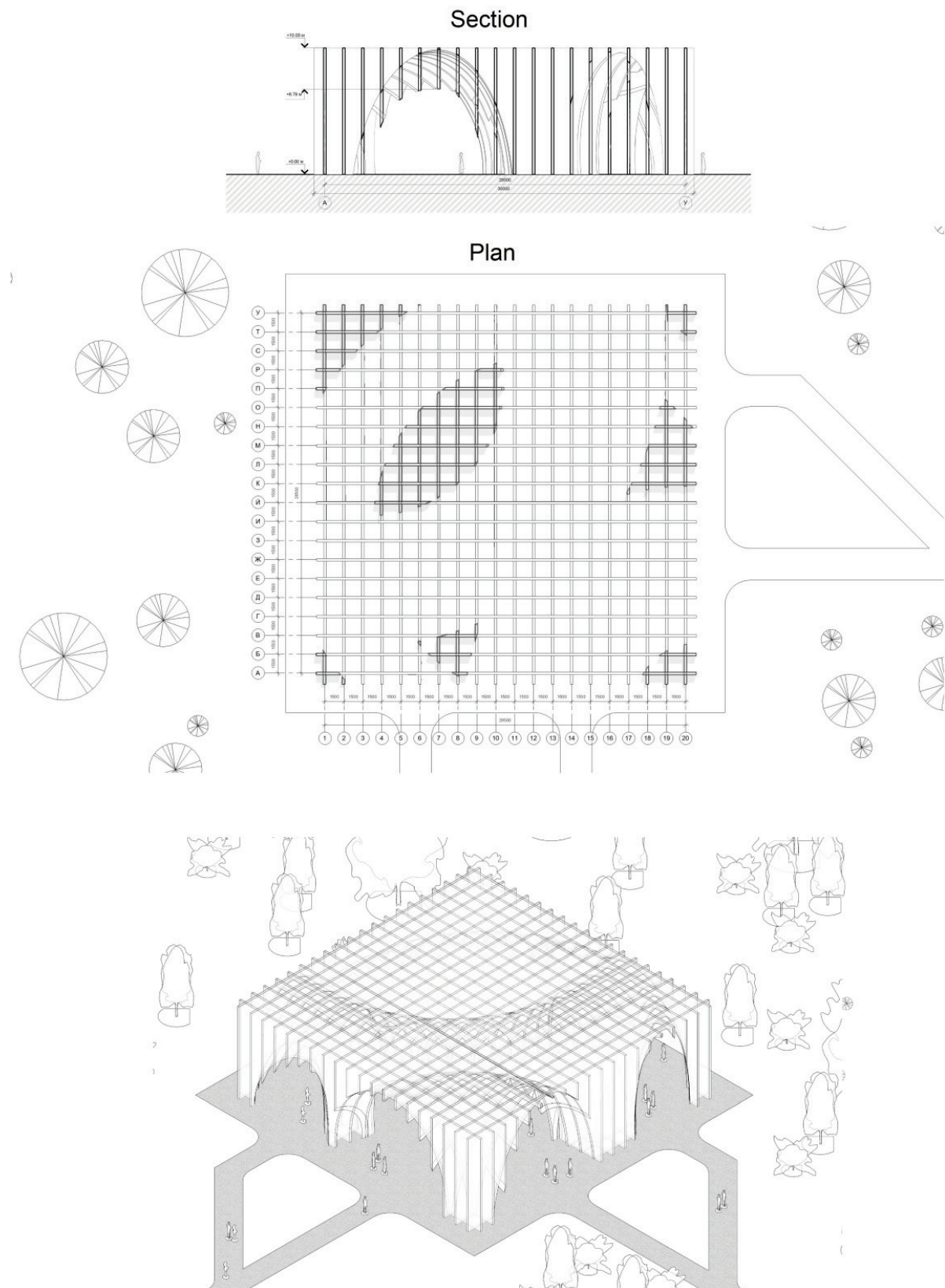


Figure 19: Parametric pavilion model

The Parametric pavilion model was imported into Autodesk Revit for further work with it. For this, the **ImportInstanceByGeometriesAndView** tool was used (Figure 18).

A general view of the developed script for creating a model of the Parametric pavilion is shown in Figure 20.

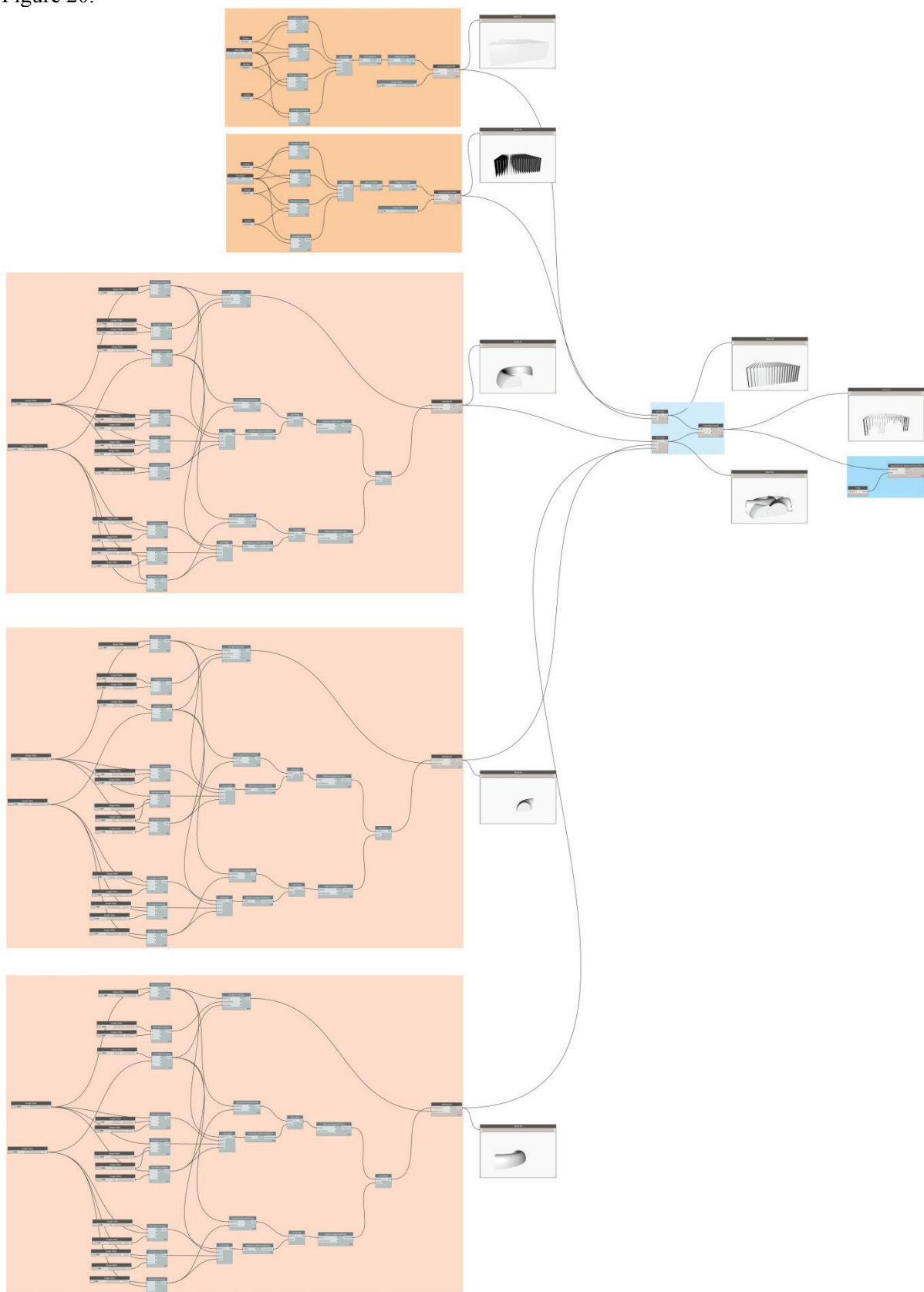


Figure 20: General view of the script for the Parametric pavilion

The Parametric pavilion model was imported into Autodesk Revit for further work with it (Figure 21).

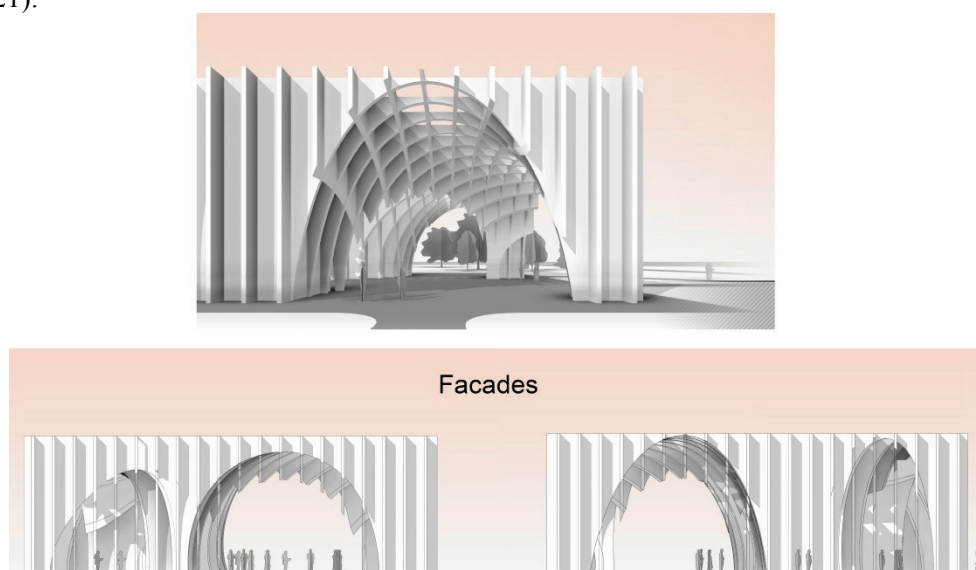


Figure 21: Parametric pavilion in Autodesk Revit

3. Research results and conclusions

The presented program codes for presented architectural objects could be successfully used by architects and designers in their practice. The presented scripts are the result of the research to compare similar nodes, as well as their bundles, and to identify the most optimal ones in terms of load on computer resources.

Working in conjunction with Dynamo – Revit to create plastic architectural forms of complex geometry provides the opportunity to obtain unique forms. The two-way work of the bundle for import – export of the model makes it possible to quickly and correctly change the model, finalizing it to the required parameters. The bundle of these programs can be used not only to create complex architectural forms, but also in other branches of science and technology when working with elements of complex geometry.

It is planned to continue work in this direction. For the research, more complex models, created on the basis of the presented ones, as well as new objects used in real architectural projects will be used.

It is advisable to continue working to obtain more concise (using Design Script and Python languages) and universal algorithms (node chains) that allow varying the initial data and the shape of plastic objects.

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