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Specific Features of Modeling a Structure Containing Slices of Paraboloid in Different Modeling Software

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Abstract: The aim of this paper is to show the similarities and the differences in the use of the most common modeling software packages in modeling a paraboloid and its slices. Comparison of the modeling process in AutoCAD, 3DS Max, Rhinoceros 3D and Sketch up was conducted in order to examine the potential of these software in modeling structures containing slices of a paraboloid. The results are summarized and the most adequate software is chosen.

Keywords: 3D modeling, paraboloid, AutoCAD, 3Ds max, Sketch up, Rhinoceros 3D.

1. INTRODUCTION

In architectural modeling it is important to choose the right software to work with, especially when it comes to some atypical forms in objects. Working with doubly ruled surfaces can be very complicated in some programs, while in other the results come much faster. The aim of this paper is to show which software is the most adequate to create a model of an object that contains slices of a rotational paraboloid.

The most common software packages, used in architecture are taken into consideration: AutoCAD, Sketch up, 3DS Max and Rhinoceros 3D. Modeling process is described for each of the programs, prominent characteristics and details of the process are emphasized and the conclusions drawn about the suitability of each program for this task.

2. PARABOLOID IN ARCHITECTURE

Parabola in geometry is a conic section created by a right cone and a plane which is parallel to the tangential plane touching the generatrix of the cone. Another way to construct a parabola is with a focus (F) and a directrix (L), where the distance of any point on the parabola and the focus is equal to the perpendicular distance of the same point on the parabola and the directrix. [1] In algebra, a parabola is a graph of quadratic functions of the form: [2]

$$(1) \quad f(x) = ax^2 + bx + c, a \neq 0.$$

A line that passes through the focus and is perpendicular to the directrix is the axis of symmetry of the parabola. The point of intersection of the axis of symmetry and the parabola is called the vertex (V) and it is the point of the highest curvature of the

parabola. Focal length of the parabola is a parameter which indicates the length between the vertex and focus, measured along the axis of symmetry. Each parabola can be repositioned and scaled to coincide with any other parabola, which means that all parabolas are similar. [3]

Geometric surfaces created from parabolas are paraboloids, doubly ruled surfaces created by rotation or translation of the parabola. The elliptic paraboloid is a doubly ruled geometric surface formed by rotation of a parabola around its axis of symmetry. Hyperbolic paraboloid is a geometric surface, formed by translation of a parabola along the parabolic trajectory and has a hyperbole as a horizontal section. [4] Object that is a subject in this paper contains an elliptic paraboloid, which is in practice often used for architectural structures. The application of an elliptic paraboloid is most common in the production of lenses for reflection since it is one of their feature that the light that goes in parallel with the axis of the parabola, is reflected through the focal point and vice versa. [5] The potential of application of paraboloid in architecture is great because of its favorable features in static, since the form of the parabola approximates a catenary curve. [6] Some of the completed structures in the world, that should be mentioned are: The Office Tower in London by Norman Foster (the popular "Gherkin") and the Galaxy SOHO shopping mall in Beijing by Zaha Hadid, which was used as a motif in the modeling of the object that is the topic of this paper, shown in Fig. 1.

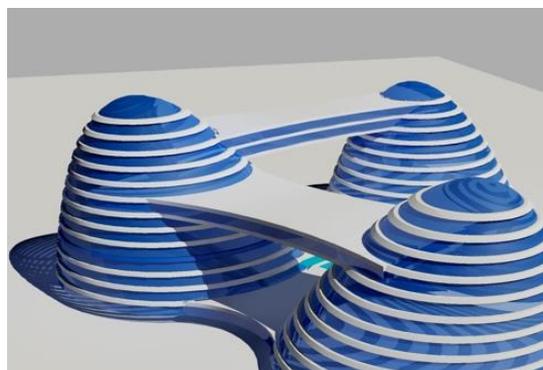


Fig. 1: Architectural object containing elliptic paraboloids

The complex consists of three objects shaped like

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elliptic paraboloids of different heights, but with the same parameters. The towers are 14 and 12 floors high and they are interconnected with several bridges. This is a simplified version of Zaha Hadid's project for the Galaxy SOHO complex.

In order to construct the required paraboloid, we must draw a parabola following these parameters: the distance between the focus and the vertex is $FV = 8\text{m}$; the distance between the focus and the directrix (L) is $LF = 16\text{m}$; and the height (H) is $H = 58\text{m}$. The parabola is rotated by 15° CCW, as shown in Fig. 2 below.

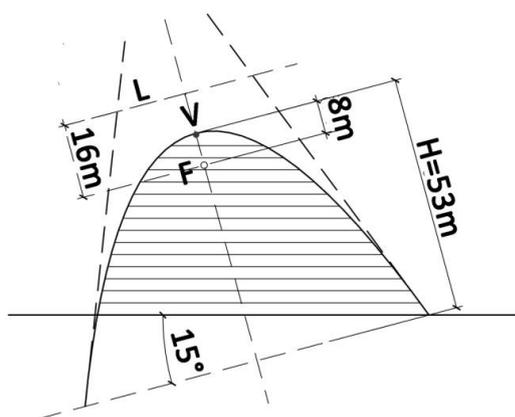


Fig. 2: Parameters of the parabola used in the architectural object

The form of the desired object is obtained from this parabola rotating around its axis of symmetry. Further slicing and modeling give the details of the object.

3. THE PROCESS OF MODELING IN DIFFERENT SOFTWARE

3.1 Modeling in AutoCAD

AutoCAD is one of the most frequently used software for drafting and modeling in architecture, but when it comes to modeling objects containing an elliptic paraboloid, it encounters a big problem.

Drawing a parabola, which is necessary for us to create a paraboloid, is extremely impractical in this software, due to the lack of a direct command for conducting this task. It is possible to construct a parabola with methods used in descriptive geometry, but it is a very long process. Having realised this problem, the developers have grasped the opportunity to upgrade AutoCAD using AutoLISP programming language that is used by it. This LISP programme in AutoCAD introduces a new command, with the keyboard shortcut: "PBL", which in few easy steps draws a precise parabola.

The program requires several parameters: the vertex and focus distance, the height of the parabola, the required accuracy of the curve. Parabola is positioned in the drawing by determining the focus point, shown in Fig.3. After drawing the parabola, to get paraboloid, we have to choose the command

"revolve", with an angle of 360° . The model obtained in this way, gives a lot of problems to the program, because AutoCAD requires a very strong computer configuration to work with curved geometry. (Fig. 3)

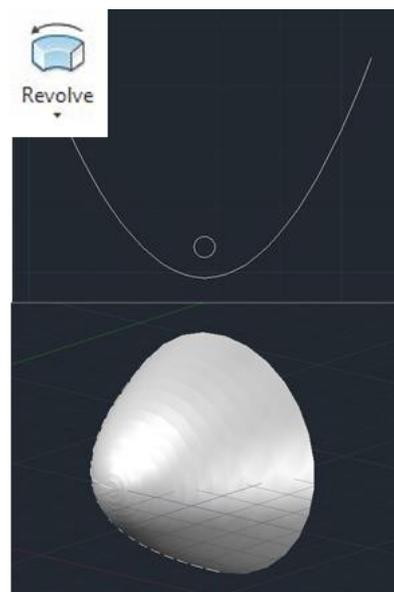


Fig. 3: Icon of the command "revolve" in the upper left corner, the inserted parabola (above) and the paraboloid created using the command "revolve" (below).

3.2 Modeling in Google Sketch up

In this program, drawing a parabola is also not included in the basic software package, but the plug-in that enables this is very easy to find and install. With the "Curve maker" plug-in one can draw different types of curves, such as the catenary, sinusoid, cosinusoida, spiral, helix, etc. The command to draw a parabola is in the drop down menu "Draw", in "Curve maker" where you select a parabola, as shown in Fig. 4.

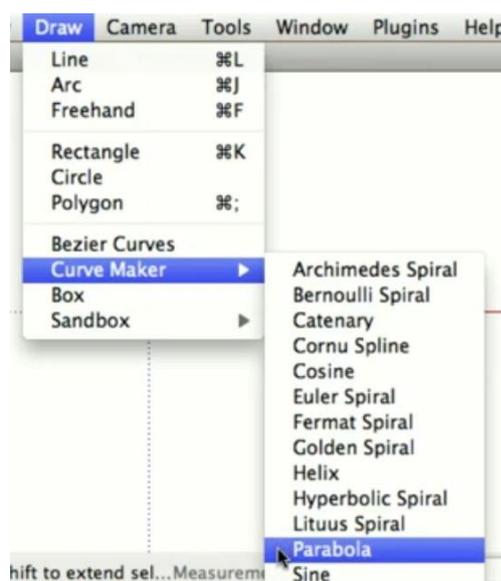


Fig. 4: Location of the plug-in and the command for drawing a parabola

In constructing, the prompted parameters are only height and width of the parabola, and for the precise construction it is necessary to draw the parameters of the parabola separately and then to use this plug-in to stretch the parabola. In order to create the paraboloid it is necessary to draw a circle perpendicular to the axis of symmetry of the parabola as shown in Fig. 5, and then select the circle.

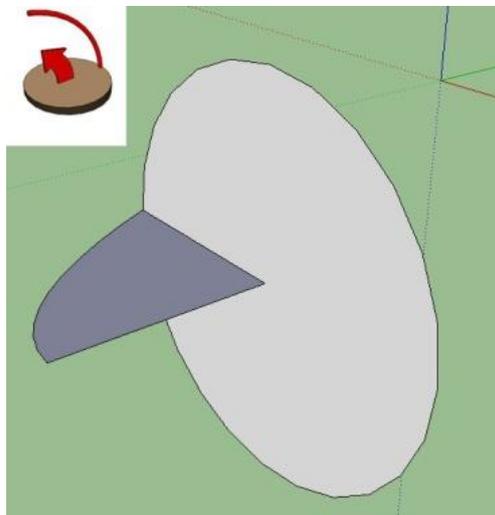


Fig. 5: Icon of the command “Follow me”; half of the parabola and the perpendicular circle

With the circle selected, starting the command, "Follow me" and selecting the half of the parabola we create the paraboloid shown in Fig. 6.

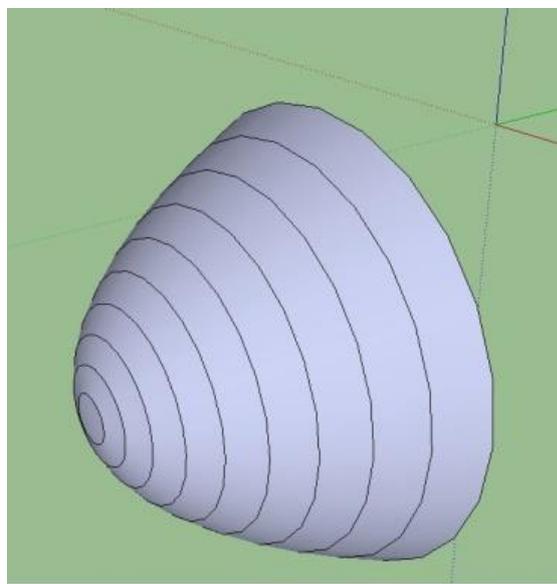


Fig. 6: The paraboloid created in Sketchup

3.3 Modeling in 3Ds Max

Paraboloid modeling in 3ds Max cannot be done directly. There is the possibility of importing a parabola drawn in some of the other programs or using vertex modeling, which would be inaccurate and would result with an object similar to a paraboloid. These two possibilities are very

impractical and would require a great amount and effort, so it is better to use other modeling software for creating the paraboloid and then import it into 3Ds Max, for further modeling. This is possible with all the software described in this paper.

3.4 Modeling in Rhinoceros 3D

Rhinoceros 3D is a relatively new software for 3D modeling that has many advanced features in the modeling process. The program itself has a separate command for rotational paraboloid modeling, which makes the modeling process easier than ever. The command for modeling a paraboloid is in the “Solid” drop down menu, named “paraboloid”. There are two options of combinations of input parameters: the first option is to provide coordinates of the focus and a point on the parabola that forms a paraboloid, and the other option is placing the focus and the vertex distance and height of the parabola or paraboloid as shown in Fig. 7.

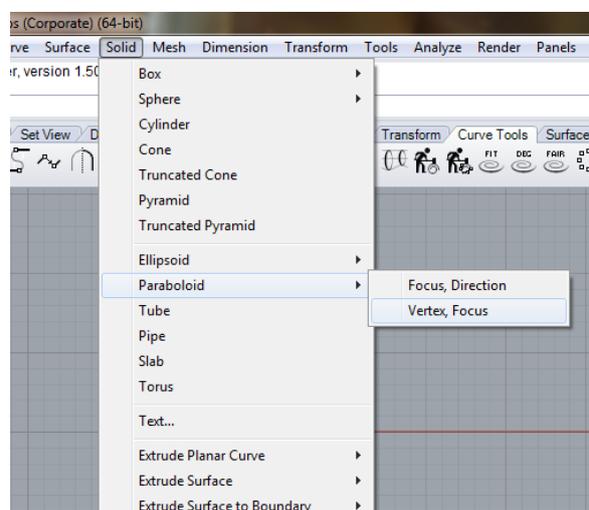


Fig. 7: User interface of Rhinoceros 3D and the location of the command “Paraboloid”

The obtained paraboloid is a solid and there is a possibility of separating the base of the paraboloid (Fig. 8). The further modeling process of the object is the same as for the other programs.

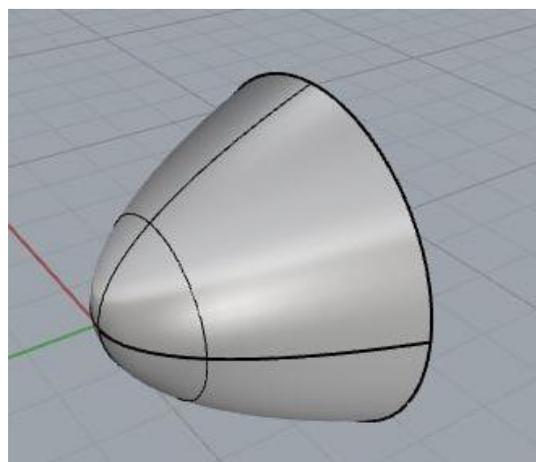


Fig. 8: Elliptic paraboloid created in Rhinoceros 3D

4. CONCLUSION

Having tested four programmes which at first sight seemed similar, when it comes to modelling a paraboloid, the conclusion is far from that, as they proved to be quite different. AutoCAD and Sketchup are most similar in the modeling process of doubly ruled surfaces. In order to draw a parabola, first it was necessary to find and install the appropriate plug-in, but after that, the process of modeling is very easy and convenient. When working with this particular model in AutoCAD there is the problem of memory, as well as the overload of the computer, which is not the case in Sketch up. As for the program 3ds Max, it was not possible to make a precise model of the paraboloid unless we imported the parabola from another program for architectural graphic, so it performed very poorly in this task. This is a rather disappointing fact, bearing in mind that this is possibly the most expensive and advanced programs of all four here listed.

The the most practical software for modeling a paraboloid and structures containing it, proved to be Rhinoceros 3D, the youngest of these. This program contains a built-in command that directly, precisely, and without overloading the computer creates a paraboloid. Since all of these programs are compatible with each other, it is easiest to model a paraboloid in Rhinoceros 3D, and then export the model in another format, or continue the process of modeling in this handy program.

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