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TECHNICAL NOTE

## Applications and usability of parametric modeling

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#### **Abstract**

A parametric model is a computer representation of a design made with geometric shapes with constant and variable properties. Variable attributes are called parameters. The designer can change the parameters in the parametric model to search for different alternative solutions to the problems in the model. The parametric model is obtained automatically by changing the only parameters without needing to changing or redraw. In this study, it is aimed to give information about the concepts, advantages, application areas and applicability of parametric modeling. Also modeled using parametric modeling and examples from a numerical example selected as the best student project in the category of international competition are given. In this study, it has been seen that parametric modeling provides convenience in terms of time and application. This method, which is among the latest trends of the technology age, accelerated the development of works in the field of architecture, civil engineering and industry.

### Keywords

Architecture; Civil engineering; Parameter; Parametric modeling

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#### 1. Introduction

Parametric modeling is a method based on relational thinking and these relationships are designed with parametric modeling toolsIn modeling, the definition parametric and presentation of the relationships that formed the geometry are give up to the user. This case allows users to create the algorithm of the model. The algorithm includes the rules that occur when the parameters are associated with each other. The parameter can be called a restrictor or limit that determines the boundaries of any event [1]. Although parametric modeling is new as a concept, the history of parametric thinking and design dates back to the oldest. With the developing technology and the widening horizon of thought, modern designs with extreme geometries emerge outside of the traditional construction in architecture and construction industry. However, the formation of more complex structures with traditional modeling methods has become difficult and time consuming. So, computer-assisted parametric modeling have been developed in which complex relations can be designed [2]. Fig. 1 shows some of the structures created using parametric modeling.

Parametric design process consists of determining the parameters, designing the relations between the parameters, determining the estimated geometry, creating variations and testing the resulting product [3, 4]. These stages are in close contact with each other and affect each other. In architectural and engineering applications, the needs of the researchers increase the interest in parametric modeling and many studies are carried

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Fig. 1. Some of the structures created using parametric modeling

out in this field. In a study by Turrin [4], it is discussed the benefits of combining parametric modeling and genetic algorithms to improve the performance of the design. Aish and Woodbury [5] draws attention to the advantages of parametrically correlating the geometric model, schemes and constraints. In this paper, Dino [6] discussed the algorithmic basis of parametric design, variations of algorithm variables, and parametric productive design systems.

In this study, it is aimed to give general information about parametric modeling which is one of the biggest contributions of the developing technology in the fields of architecture and engineering. The purpose of parametric modeling, its application areas, its applicability, its place in the world, its advantages are emphasized. In the "Tekla Global BIM Awards 2018" competition, which is organized internationally by Trimble company, the parametric model that receives the best project award in the student category has been discussed.

The modeling process of this parametric model is explained.

#### 2. Parametric modeling

The parametric modeling scheme is created by parameterizing a geometric model according to the desired properties. A parametric modeling scheme shows which attributes of a geometric model are parameterized and how the designer can change the values of the parameters. Fig. 2 shows six different parametric models obtained by changing selected parameters of a column.

The research conducted by the North American Precast Concrete Software Consortium (PCSC) [8-10] has shown that the general design process for precast concrete projects can be divided into three main headings being the assembly layout, assembly details and part details (Fig. 3). Although the application was carried out in the precast concrete area, the three main titles apply to all sectors of the construction.

141 Kalkan et al.

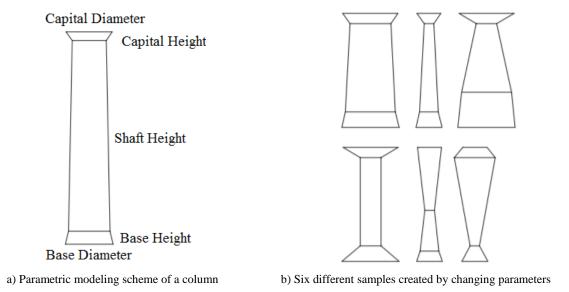


Fig. 2. Different parametric modeling scheme [7]

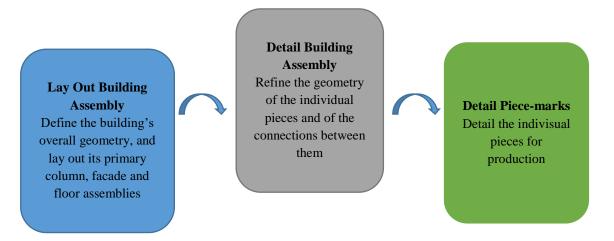


Fig. 3. Shows details of the design process

While creating a parametric model compared to the traditional CAD model, transforming the model into an algorithmic form and creating a flowchart is challenging in the first place, it will tolerate the difficulty in the first part with the ease provided in the later stages of the model. Parametric modeling programs offer users two different modeling windows for modeling. One of these windows is used to generate the algorithm, while the other is used to display the geometry resulting from the algorithm. Rhinoscript, Mayascript, Dynamo and Grasshopper are advanced programs used in

parametric modeling. Fig. 4 shows the algorithm and modeling windows of a study that was previously performed parametrically.

Each component works with input and output logic when creating the algorithm. In order to establish a relationship between the parameters, the output of a parameter is linked to the input of another parameter in the network system. In this way, the desired change to be made in the model that is created depending on the algorithm will be provided by presenting of the new geometry which is created by changing the parameter to the user.

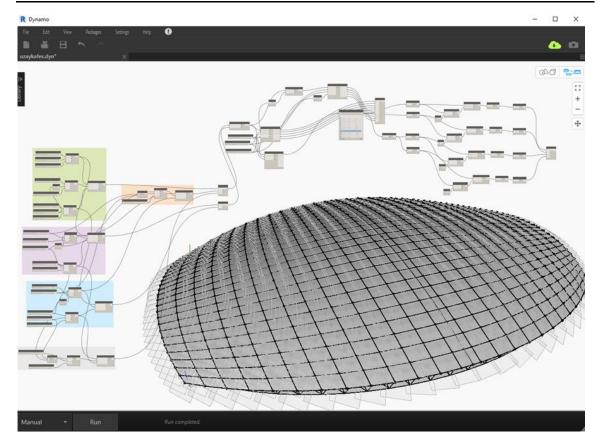


Fig. 4. The algorithm and modeling windows of a parametric modeling

#### 3. Advantages of parametric modeling

Many changes occur in the design process of a model. Making changes to a model with conventional CAD methods leads to time and labor force equivalent to modeling from the outset. With parametric modeling, both labor force and time loss are greatly reduced. Some of the advantages of using parametric modeling are:

- Taking into account model size, complexity, number of elements, elements connection angles, etc., the creating with parametric modeling of the model will be shorter and easier than conventional CAD methods.
- Any change in the design process or in the static solution process will be carried out instantaneously by changing the relevant parameters.
- The parametric model facilitates optimization studies. With the results to be obtained due to

- the change of parameters, it will enable to determine many effective parameters such as optimum section, size, height, material type, element type, mesh number etc.
- It will be possible to use the generated parametric model as a template project. In the project to be applied in different fields, height, slope, section dimensions etc. can be changed, allowing the same project to be revised without being re-modeled.
- By changing the parameters, it allows to obtain different combinations of the design of a complex model.

In many technologically advanced countries parametric modeling is used. Although the Building Information Modeling (BIM) system, which is used in many parts of the world, has gained importance in recent years, its foundations have been based on many years ago (Fig. 5).

143 Kalkan et al.

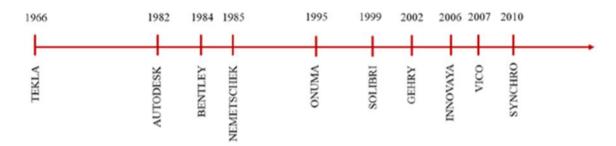


Fig. 5. Founded years of BIM software developers [11]

It can be said that parametric modeling is based on long years ago with the BIM system created by the logic of the paremetric study.

# 4. Selected parametric model as numerical example

### 4.1. Definition of parametric model

In this study, the numerical example which was prepared parametrically by the BlackSea-Trom team [12] chosen as the best student project in the student category in the international "Tekla Global BIM Awards 2018" [13] competition are selected. BlackSea-TORM is designed as an Expo fair building concept. In order to increase the sensitivity to alternative energy sources, the windfall form is used in the design of the structure, taking into consideration the renewable and sustainable energy theme. Besides the environmentalist form of the fair center, it is aimed to add socio-cultural richness to the region with its aesthetic beauty. BlackSea-TORM, which includes parking, exhibition and respite areas, consists of 2 floors in total. The fair center having a total area of 19000m<sup>2</sup> and 15.5m total height includes the parking and fair floor, with 7.5m and 8m height, respectively. Structural stabilization is achieved by reinforced concrete circular columns with specific intervals to along the curved roof form, 3 steel elephant foot in each, totally 9. The ground floor with reinforced concrete beam slab is placed on the reinforced concrete circular columns in the basement floor. The basement columns are arranged to allow parking and maneuvering of vehicles. The curved surfaces covered with transparent panels add spaciousness

and modernity. Fig. 6 shows some views of BlacSea-TORM parametric model.

### 4.2. Challenges of project and solutions

With this project, model the structure which is difficult to manually create in Tekla Structures program is modelled using parametric modeling method. For this purpose, a joint project has been realized by utilizing the interaction of Tekla Structures with different programs. The problems and solutions in this project are summarized below:

- The structure with freeform caused difficulties in modeling manually. In order to remove this difficulty, the structure is constituted with a program that can do parametric modeling [Fig. 7].
- The Plugin is created in the .Net environment using TeklaOpenAPI for transferring the parametric model to Tekla Structures. Thanks to this Plugin, a link has been established to share the updated model data with Tekla structures and, which can be updated on any change in parametric model. Thus, the desired freeform model is transferred to Tekla Structures environment easily. Fig. 8 shows some of the coding for the plugin created for the transfer of the parametric model generated by the Dynamo program to the Tekla Structures program.
- The elements connections on the roof and side surfaces are designed as a Mero System. Although there are many types of connection elements in Tekla Structures, the unavailable of Mero System is lacking. To solve this problem, a sphere form which is not found in Tekla Structures is created in a different program and

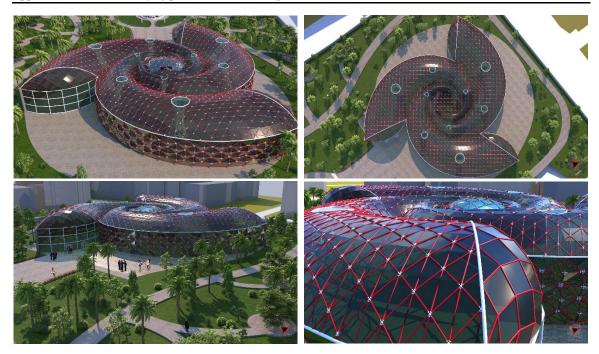


Fig. 6. Some different views of BlacSea-TORM parametric model

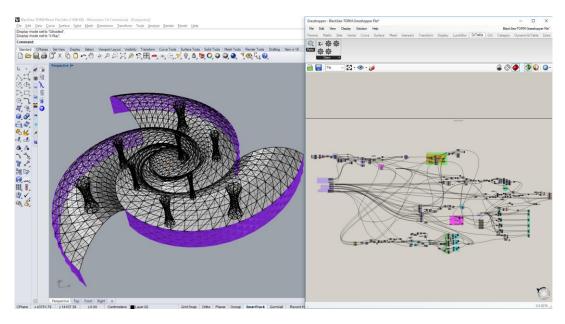


Fig. 7. Parametric model of selected numerical example

imported as an item in IGES format, and a "RUFER" which is a semi-parametric connection detail is created in Tekla Structures [Fig. 9]. With the use of RUFER, the connection elements of different number of bars in the project are easily created.

By doing so, both efficient use of time and interdisciplinary work of team members have been ensured during the project. Fig. 10 presents detailed views of the completed project

145 Kalkan et al.

Fig. 8. A some of the encoding of the created plugin

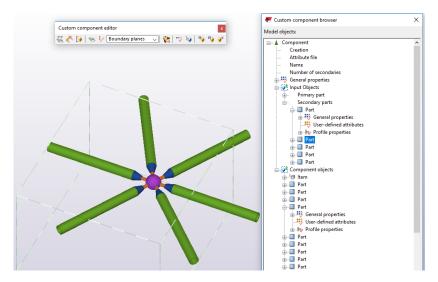


Fig. 9. Creating of a semi-parametric connection detail

#### 5. Conclusions

In this article, it is aimed to create awareness by provide general information about parametric modeling method which is frequently used in many countries. The parametric modeling method, which is thought to replace the traditional CAD methods that have been used for many years, provides both time and labor gain. Parametric modeling allows

optimization studies with instant implementation of the desired change in the project. In this way, optimum section, height, span, material type, element type etc. helps to determine many effective parameters. With selected numerical example, it can be seen how solutions are solved by using parametric modeling method. The solution of problems that may arise in all projects can be obtained by parametric modeling methods.

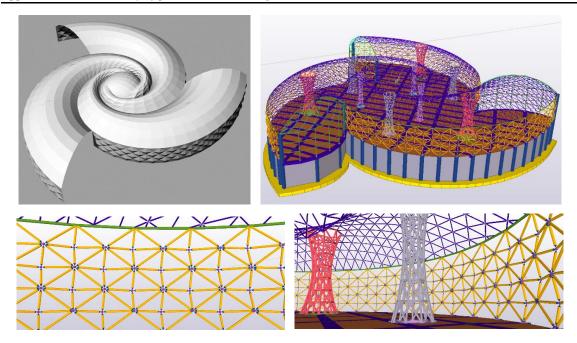


Fig. 10. Details of BlacSea-TORM parametric model

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