Fences Application of the CATIA Program in Architecture and Construction

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Abstract. Nowadays, modern computer programmes are widely used in the design process. Information technology provides designers with the tools for extending and facilitating creative practices. Computer programmes offer a modern approach to the architectural design process, help maintain control over it and ensure the accuracy of documents. The use and application of CATIA, increasingly chosen as support for design activities, has been discussed in the paper. Both key features to create the surface geometry of the model and the analyses of extremely complex shapes have also been demonstrated.

1. Introduction
CATIA was released in 1977 by French aircraft manufacturer Dassault. The range of this software allows it to be applied in a wide variety of industries, such as aviation, automotive, architecture and construction. Moreover, CATIA is the perfect tool for designing home appliances, injection molds, press-forming dies, blanking dies, elements made of metal sheet, plastics, composite materials. The software allows designers to virtually analyse the ergonomics of designed products. Furthermore, CATIA offers a tool to easily create Class A surfaces (called stylistic surfaces).

2. Materials and methods
The paper also shows the examples of the use of CATIA software which has been applied in the following outstanding architectural projects: The Walt Disney Concert Hall in Los Angeles, the Guggenheim in Bilbao, Spain, the Dancing House in Prague, the Heydar Aliyev Centre in Baku, Azerbaijan, the Messner Mountain Museum in Italy, the Dominion Office Building in Moscow, the Dongdaemum Design Plaza in South Korea. The software enables users to perform virtual design experiments with architectural objects, creating curvilinear shapes, as well as aerodynamic and curved surfaces at different angles. In addition, CATIA promotes innovative technologies and materials employed in the creative design processes. In particular, it should be noted that the software facilitates the modelling process, ensuring that the modifications made during the construction process are easy and effective as well as enabling designers to define contours, determine the surface parameters and perform an analysis of the quality of a plane [1].

3. The preparation of the body of a building with the use of CATIA V5
Catia V5 is a parametric and associative system which means that at every step of designing an object it is possible to introduce changes in separate elements. On the basis of these changes, the whole
construction can be redesigned, and all the connected details can be updated. What is more, 2D technical drawings, material indexes, various visualisations and simulations can be created in accordance with the changes introduced. The programme also creates a tree of operations history which contains all the actions undertaken while preparing a project step by step, and which makes it possible to introduce changes. This software is an extremely efficient tool used for 3D designing, automatic creating of drawings and technical documentation as well as preparing simulations, comprehensive analyses and calculations connected with the designed items. Nowadays, in the process of designing, before unique structures are built, their virtual equivalents, models, are created. Such models are used to perform simulations and do calculations in order to optimise a building structure. The following paper presents, with the use of the Catia V5 programme, the approximate course of action taken when designing the shape of the outer elevation surface of two towers of a sophisticated building known as “Ginger and Fred” which has become an integral part of the landscape of Prague.

The first step of project activities was entering the layout of the left tower. In order to do so, tools typical for drawing, such as a line, circle, arc, or spline, were used, and, subsequently, profiles of an adequate shape were placed on relevant surfaces (Fig. 1a). These profiles constitute the tiring of the analysed building, and each profile is of the shape required for a given level of the tower (Fig. 1b). Next, additional guide curves connecting profiles on different levels with one another were added on each tier (Fig. 2a), and, subsequently, profiles and curves for the description of the second tower were prepared (Fig. 2b).

Afterwards, by means of Multi-Sections-Surface tool, on the basis of the defined profiles and guide curves, the surface of the left tower was created (Fig. 3a). An operation called Blend was used to erect the surface of the right tower and the function Fill was used to close the upper and lower surface. That was the final phase of the design work; their outcomes are visible in (Fig. 3b).

![Figure 1](image1.png)

**Figure 1.** Preparation of the ground floor slab (a) and the profiles of respective tiers (b).
Figure 2. Entering additional guide curves (a), the building grid (b).

Figure 3. The process of surface redefining (a), the exterior of the building (b).

An outer surface of a building prepared in such a way is a starting point for a further design process which is connected with adding typical elements such as walls, ceilings, stairs, windows, elevators, etc. When the project works are finished, the project is checked and approved, it is possible to prepare engineering specification in a form of 2D drawings (floor plans, cross-sections, detailed views, etc.) which, further, constitute a site instruction.

4. Contemporary architecture – the CATIA program
A renowned architect Frank Gehry in his architectural design studio (existing since 1962) creates his unique solid models characterised by complex geometry with the use of CATIA. The structures he designs are of distinctive shapes and are recognized city landscape elements all over the world. Ginger and Fred – A Dancing House in Prague (1996) is the first building that Gehry has designed using CATIA. An eight-storey building made of glass and concrete with windows placed at different levels
is an office block with a restaurant and an observation deck at the top. The two parallel towers, one static and the other dynamic, are evocative of a dancing couple. It is an utterly site-specific structure which, apart from matching the landscape of the city in an ideal way, provides a link between the present and the past, modern and traditional. Frank Gehry also used CATIA to design the structure of a museum of modern and contemporary art in Spain, i.e., Guggenheim Museum in Bilbao (1997). Its dynamic form clad in titanium, glass and limestone consists of contorted, undulating elements. The body of the building is in itself interesting to modern art enthusiasts. Walt Disney Concert Hall in Los Angeles (2003) is the third building in the design of which Gehry used CATIA. It is a concert hall which is the home to the Los Angeles Philharmonic Orchestra. The building is covered with titanium, which made it possible, due to its properties, to achieve the unusual shape characteristic for this building – that of sails in the wind [2].

Zaha Hadid (1950-2016), the founder of Zaha Hadid Architects, the Pritzker Prize winner in 2004, also used computer-assisted designing - the CATIA programme - in her projects. In her work she always appreciated people brave enough to experiment with materials and proportions [3]. The Heydar Aliyev Centre in Baku (2012), which is a remarkable cultural venue, is a symbol of Azerbaijan. It houses a museum, a library, exhibition halls and a concert hall. The building has a curvilinear continuous form in a shape of a concrete roof and walls. Due to multiple options provided by the CATIA programme, its fluid overlapping lines create folds resembling waves give the impression of being skilfully matched to the topography of the area (Fig. 4).

Zaha Hadid also used the parametric qualities of CATIA when designing Dongdaemun Design Plaza in Seoul (2014). The front elevation of the building is covered with perforated aluminium panels of various size and bend radius. This construction object serves a variety of functions; it is an exhibition and conference centre and, also, is an example of a model public space where the city dwellers can go and relax or integrate with others among greenery in the centre of the city. Finally, the Messner Mountain Museum devoted to a legendary Himalayan climber, Reinhold Messner, is a work by Zaha Hadid which is built in the top futuristic style. It is located at the top of Alpine peak in the South Tyrol. Embedded in a mountain, located on three levels, build with light grey concrete panels, the museum is devoted to mountaineers, Himalaya climbers, and the beauty of the mountains. In the body of the building there is a terrace which is integrated with the building and which serves as an observation deck offering the most remarkable views on the picturesque landscape which surrounds it.

| Article I. | Fig.1. Architectural structures – the use of the CATIA program |
|-----------|---------------------------------------------------------------|
| Article II. | „Ginger and Fred” | Article III. | Guggenheim Museum in Bilbao |
| An architekt: Frank Gehry | Location: Prague, the Czech Republic | An architekt: Frank Gehry | Location: Bilbao, Spain |
| Finished: 1996 | Finished: 1997 | |

Source: [https://www.foga.com](https://www.foga.com) [4] Source: [https://www.architecturaldigest.com/](https://www.architecturaldigest.com/) [5]
| Article IV. | An architekt: Frank Gehry | Article V. | An architekt: Zaha Hadid |
|----------------|-------------------------|----------------|-------------------------|
| Article VI. | Location: Los Angeles, USA | Article VII. | Location: Baku, Azerbaijan |
| Article VIII. | Finished: 2003 | Article IX. | Finished: 2012 |
| Article X. | | Article XI. | |
| Article XII. | Source: https://www.architecturaldigest.com/ | Article XIII. | Source: http://www.bryla.pl/ [6] |
| Article XIV. | Dongdaemun Design Plaza | Article XV. | Messner Mountain Museum |
| Article XVI. | An architekt: Zaha Hadid | Article XVII. | An architekt: Zaha Hadid |
| Article XVIII. | Location: Seul, South Korea | Article XIX. | Location: Tyrol, Italy |
| Article XX. | Finished: 2014 | Article XXI. | Finished: 2015 |
| Article XXII. | | Article XXIII. | |
| Article XXIV. | Source: http://www.zaha-hadid.com/ [7] | Article XXV. | Source: https://www.archdaily.com [8] |

**Figure 4.** Architectural structures – the use of the CATIA program

5. Results and discussions

Current spatial modelling and a vast array of possibilities in terms of construction and materials provide contemporary architect with a significant discretion freedom of expression [9]. Due to 3D rendering, defining curves and surfaces, the CATIA programme facilitates the process of designing buildings with a sophisticated form.

6. Conclusions

The paper presents the use of the CATIA programme in contemporary architecture on the example of the selected works of renowned designers who in their work used CATIA software. All the examples presented in the paper show that the programme is a precious tool in the hands of architects. It allows to create building objects with futuristic and complex shapes and enables the edition of a project at every stage. Buildings of this type can be more and more frequently found, and designing them is a challenge and is indicative of an architect’s prestige and genius. Owing to such software and modern
materials used in civil engineering, ideas become reality. An additional asset connected with the use of the software is the possibility to create analyses and simulations in terms of endurance, aerodynamics, as well as the visual ones, which helps to eliminate design flaws.

References
[1] Wełyczko A., CATIA 5. The Art. Of Surface Rendering, Helion Press, Gliwice 2010.
[2] Tubielewicz-Michalczuk M., Application of Titanium Properties in Civil Engineering and Architecture, Key Engineering Materials, Vol. 687, pp. 220-227, 2016.
[3] Zukowsky J., A Guide to Contemporary Architecture, Arkady Press, Warszawa 2016, s. 84-85.
[4] https://www.foga.com
[5] https://www.architecturaldigest.com/
[6] http://www.bryla.pl/
[7] http://www.zaha-hadid.com/
[8] https://www.archdaily.com
[9] Tubielewicz-Michalczuk M., Fence Designs with ArchiCAD Software, IOP Conference Series: Materials Science and Engineering. Vol. 471 (2019) 082001, s.1-6