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Architectural geometry

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Abstract. Architectural Geometry is an area of research, which combines applied geometry and architecture. H. Pottmann, A. Asperl, M. Hofer and A. Kilian firstly used the term “Architectural Geometry” in 2007 in their book at the same title. Cooperation of three geometers and an architect gave a great effect. [3] But sometimes it seems that architects understand the concept of architectural geometry in a slightly different way than the authors of the concept. Architectural geometry in this way means - special geometry, new, mysterious, which needs new magic wards. Concepts such as parametric architecture, parametric modeling and parametric design become fashionable slogans. But sometimes it is very difficult to understand what these terms mean. On a two-selected example of contemporary architecture the author wants to present that language of geometry is reliable in the field of architectural description. And knowledge of the geometry is required to the contemporary designer.

Key words: geometry, architectural geometry, design, architectural design

1 Introduction

Architectural design is a fantastic process. The empty space in a city was filled with a new structure. The designer must take into account in the assumed design solution context of the place - genius loci. The specified function has been placed in the prescribed form, in the geometrical form.

Analysis of two contemporary realized architectural objects can present some of the aspects of designing and shaping the surface as part of the architectural object.

2 POLIN – The Museum of the History of Polish Jews – the box with a surprise

The first object which was analysed it was The Museum of the History of Polish Jews. The building was built in 2009-2013, in Warsaw, at Anielewicza Street. The museum was realized in a small park in Muranów, district of Warsaw, in the former ghetto area, opposite the Ghetto Heroes Memorial. [4]

A design competition for the museum (2005) was won by the Finnish practice of Lahdelma & Mahlamaki. According to the jury, the winning design presented a perfect combination of rational and expressive forms. One of the architectural critics has called the object "box with a surprise."

Surrounding of the square, where is located the museum, create rectangular blocks of flats. Architects, authors of the design, described their project as a compromise between rather simple form of buildings which are situated around the square, the green open area of park and the expressive power of the monument of the heroes of the ghetto.

The main body of the museum building is a cuboid separated curved rupture described by the architects as *Yum Suf* – the parting waters of Red Sea.

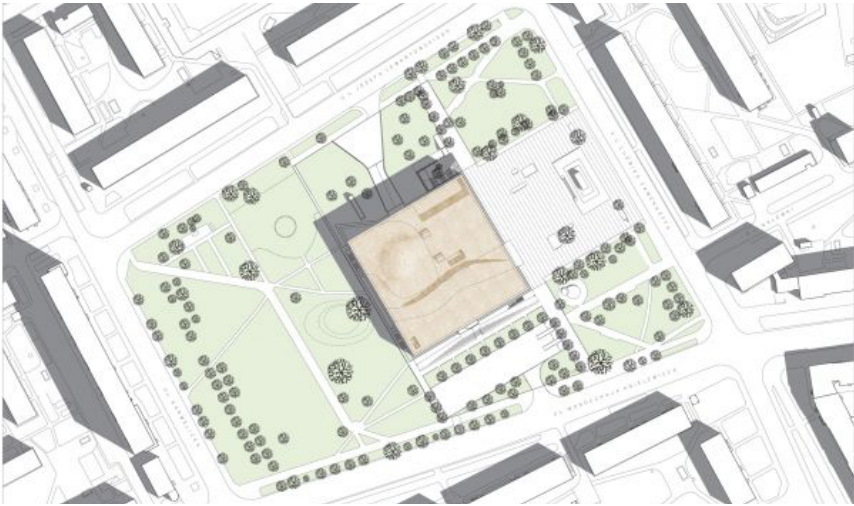


Fig. 1: Schematic diagram of the design a rectangular building with a curved "rupture"

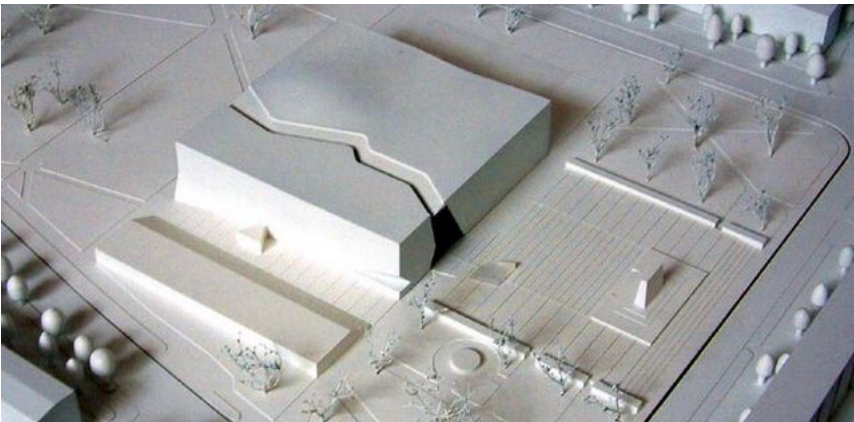


Fig. 2: Physical model of the museum

Curvilinear rupture of the building, symbolizing parting the red sea, has been designed as two load-bearing walls with a height of 20 m, with a total area of 2000 m².

The initial computer model of the walls was developed in AutoCAD based on scans of freehand design sketches. The final computer model of the steel structure of the walls has been developed in the RHINO. The biggest challenge for designers was to find solutions for shaping the discrete surface of the walls. The discrete representation of the surface was the mesh constructed with quadrangle's panels curved into two directions. The mesh of quadrangles was covered with shotcrete designed by Torkret company. [2]



Fig. 3: The steel structure of the wall and the final visual, result of the discrete surface

3 Złote Tarasy – commercial complex with a interesting overlap

The commercial complex „Złote Tarasy“ was realized in 2002-2006 in a central part of Warsaw at Plater Street. The building is located near the Central Station in Warsaw.

The American architect David Rogers from The Jerde Partnership – the international design office, designed the building. According to his description of the design the most important and interesting part of the complex should be the courtyard. This part of the complex should be like the urban quarter, a shopping arcade.

The main buildings of the complex are multi-usable objects with a typical architectural form for this type of objects. A distinguishing feature of the complex, kind of showcase of the object, is the overlap (the roof) situated over the inner courtyard of the complex. The surface of roof covering, under the premise of the design, was to resemble waving fabric thrown over the treetops...

The design office Ove Arup & Partners from USA developed the first part of the project roof covering. Engineers from Ove Arup have found the idea of shell structure as a solution for construction of the structural overlap. But the shell structures are implemented mainly as a reinforced concrete structure. And the inner courtyard of the complex need light, especially sunlight. So finally the discrete surface was realized as steel/glass structure and the triangle mesh was used as a representation of the surface. This part of design was realised by Waagner Biro from Austria. The company specializing in the construction of this type has designed a huge gridshell with triangular glass panels. Such design solution gave the greatest possibility to form in free way the curvature of the surface. [1] [5]

So the first architect's description of the design was realized as at approximately 10,000 m² free form surface similar to the cloth draped over seven spheres. [5]



Fig. 4: The computer visualization of the commercial complex “Złote Tarasy” in Warsaw



Fig. 5: The structural overlap – the landmark of this part of Warsaw

4 Conclusion

The realization of freeform shapes in architecture poses great challenges to engineering and design. The complete design and construction process involves many aspects, including:

- form finding,
- feasible segmentation into panels,
- functionality,
- materials,
- statics and costs.

On a base of the analysed objects is possible to present two ways for presenting discrete surface in architecture – as an invisible part of the object (POLIN The Museum of the History of Polish Jew) or as the most important part of architecture, which directly determines the aesthetics of the object. [3]

Only close cooperation of architects, engineers and geometers enables resolving issues related to designing and constructing of the freeform structures.

Geometry alone is not able to provide solutions for the entire process, but a solid geometric understanding is an important step toward a successful realization of such a project.

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