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GEOMETRIC 3D MODELS OF SPIRAL STRUCTURES INSPIRED BY CONTEMPORARY ARCHITECTURE

Luka Kilibarda[1], Milica Milošević[2], Ljubica Tica[3] and Magdalena Dragović[4]

Abstract

This geometric research is inspired by numerous magnificent structures-buildings around the world, which applied spiral geometry. Here we will present some of these architectural wonders and their basic geometric concepts.

The intention of our work is to present the palette of 3D structures modeled in engineering software Auto CAD, where 3D operations with solids were available.

Our concept concerning modeling of spiral building structures follows the basic geometric principles of simultaneous rotating and translating of an element along given geometric axis. The simple geometric shapes of circle, square, triangle and hexagon were combined in order to create the basic unit of spiral structure. We employed repetition of the basic unit, with variations and the moving option in zigzag direction, around the central core (imaginary or real). Fake spiral concept is also included.

As the result, we presented five types of spiral 3D models - structures with their geometric characteristics.

***Key words**: contemporary architecture, spiral structure, 3D model, basic structural unit.*

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1. INTRODUCTION

In the last decade, the contemporary architecture characterizes specific and sophisticated spiral geometry, where screw, twisted, swirling, or wrapped shapes of buildings appear. Their interesting structure, elegancy, uniqueness and beauty affects on the observers eye. A lot of interesting buildings in such manner were built around the world: Evolution Tower (in Moscow-Russia), Spiral Tower (in Nagoya-Japan), The Turning Torso (in Malmo-Sweden), Revolution Tower (in Panama City-Panama), etc. All of them surmount great heights and all kinds of influences including gravity, torsion, wind, etc.

Spiral-twisted shapes, or models are the matter of interest and research in various areas, closely connected to architecture and design, like: patent for twisted building construction [3], innovative architectural forms and technologies [5], characteristics of tall building structures [2] etc. Numerous famous architects were challenged by "spiral" design task [1].

Spiral architecture, in our case, was an inspiration for 3D modeling imaginative task: to create 3D structures based on predefined style – 5 geometrical "inspirations". We chose five building structures (some of them are built, while the others are in the design phase, different in geometric concept. The main geometric characteristics were analyzed and applied on new structures. The variations on each type of model are also presented.

2. FIVE 3D GEOMETRIC MODELS WITH "INSPIRATIONS"

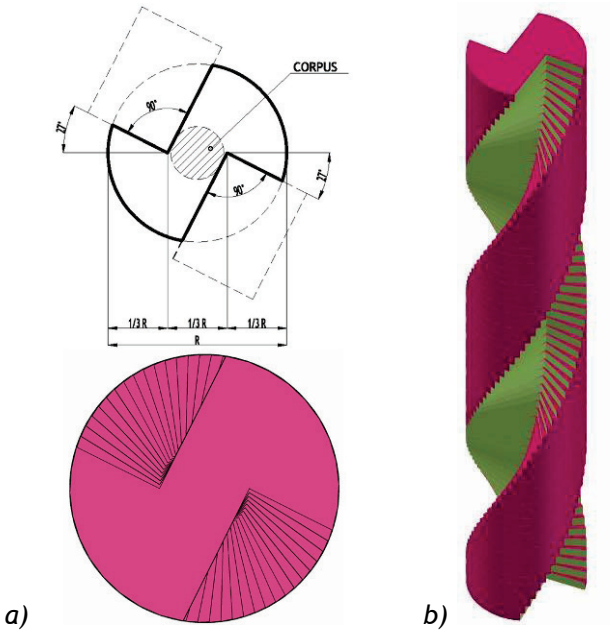
Each modeled 3D structure, presented in our research is associated with specific term and geometry, and accordingly named by it: "Two in One", "Fan", "Propeller", "Star" and "Lego". The models were created in engineering software Auto CAD and modeler 3D SketchUp. The dimensions of the geometric shapes were in the second plan, but proportions were emphasized.

2.1 The inspiration No 1.– Two in One

The Mode Gakuen Spiral Tower in Nagoya (design by N. Sekkei) is magnificent building with triple - "wings", tapering towards the top of the building (Fig. 1)[6], which initiated the creative association to the “wrapping” of the central cylindrical core with spiral surfaces.

***Figure 1**. Mode Gakuen Spiral Tower in Nagoya; inspiration - "Two in One"*

1. The cylindric corpus of the structure No. 1 is spiraly cut. The basic shape - a circle is cut with two rectangles (Fig.2a). The spiral rotation of the basic unit, along the vertical axis, enables the interfering of both spiral surfaces (outside) and empty space (inside).



a) *b)*

***Figure 2**. Structure No.1: a) Floor plan; top view b)3D model*

2.2 The inspiration No 2. – The Fan

2. The idea of central core wrapped with spiral sequence of basic units, like staircase, where the observer clearly distinguishes core from the wrapper, appear in the proposition design for the skyscraper in Abu-Dhabi by Nabito Architects (Fig.3) [7].

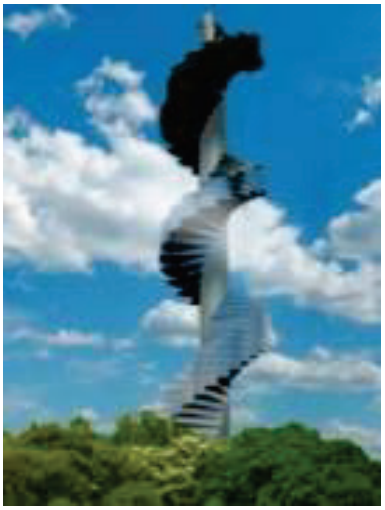
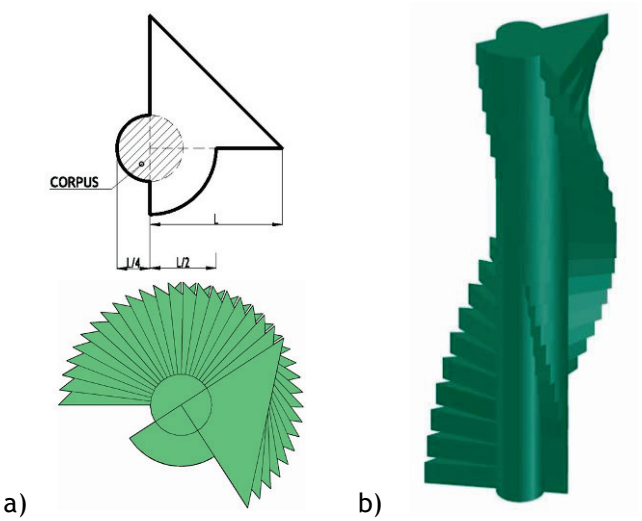


***Figure 3**.The winner of New York contest for the design-Abu Dhabi skyscraper*

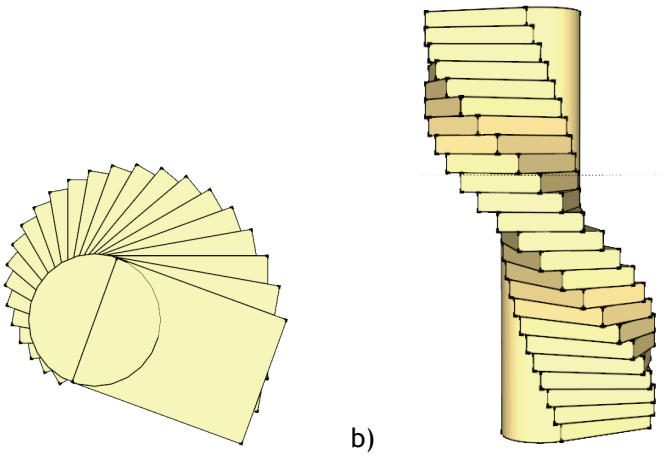
The geometric shape of the basic unit of model No. 2.1 is a union of a quarter circle, right-angled triangle and a smaller circle (Fig. 4a). The core, a cylinder, is wrapped with the spiral sequence of basic floor units (Fig. 4b).



a) b)

***Figure 4**. Structure No. 2.1 – a) Floor plan; top view b) 3D model*

The variation structure No. 2.2 has a corpus of the structure like cylinder. The main floor unit is geometricaly union of a rectangle and a circle, which is uniformly rotated along the core (Fig.5).



a) b)

***Figure 5**. Structure No. 2.2 – a)The base unit; b)3D model*

2.3 The inspiration No 3. – Propeller

3. The main core of a Diamond Tower is a cylinder with 3 additional elements (shape of propeller) which contionously rotate obtaining one spiral turn up to the top of the building 432m heigh. The

building is under construction since 2011., and planed to be finished in 2017.(Fig.6) [8].

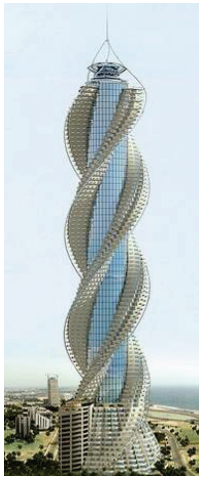
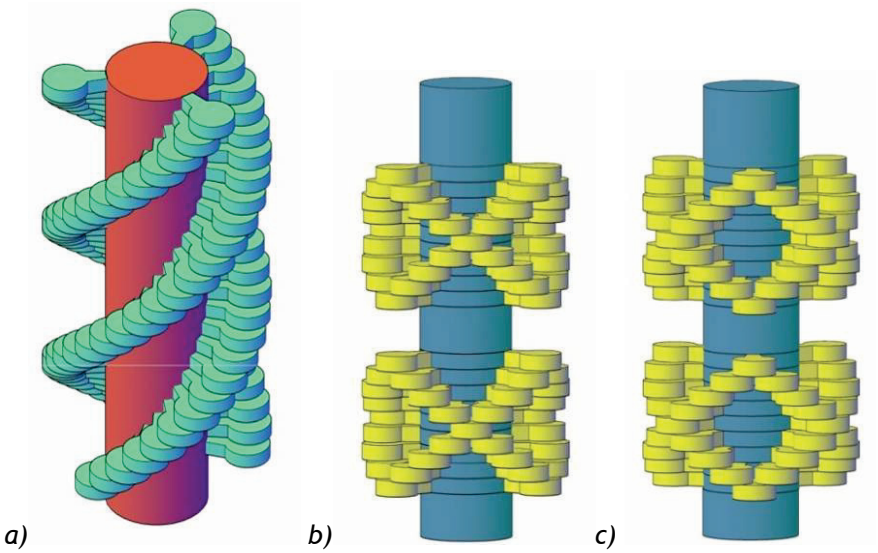


***Figure 6**. Diamond Tower, Jeddah, Saudi Arabia*

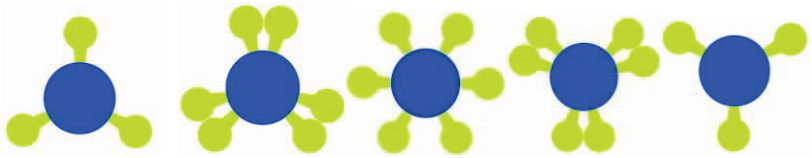
4. Central core of model No. 3.1 is a cylinder. Each floor unit has three satellites – circular in shape with the plug-in. The final structure has an association to the interlocking (Fig.7a).



a) *b)* *c)*

***Figure 7**. a)Structure No. 3.1 - 3D model;*
b)Structure No. 3.2 - 3D model-view 1; c) Structure No. 3.2 - view 2

5. The varition structure No. 3.2 has the same basic unit, but facade occurs in a different form, cosed by playing of the satellites. In the first tranzition satellites are duplicated (Fig.8), after which a spiral motion continues in two opposite directions. Hense, the two helical paths intersect in the middpoint (Fig.7 b,c). The same composition repeats after a „pause".



Initial *the basis* *ultimate*

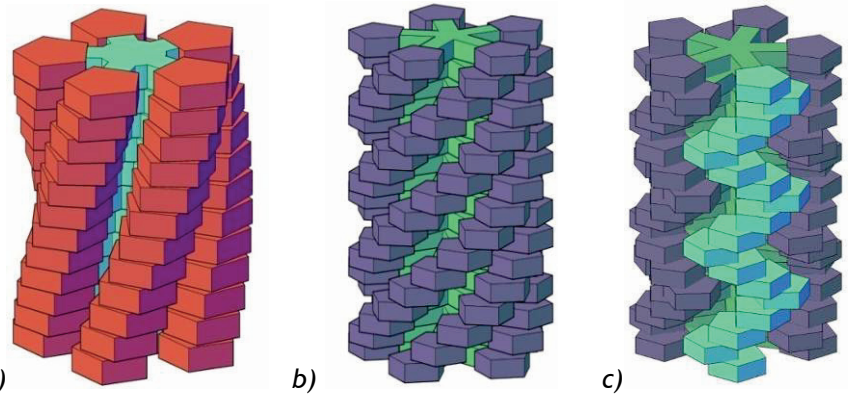
***Figure 8**. Structure No. 3.2 – satellite variations in separate floors*

2.4 The inspiration No 4. – Star

Eco Skyscraper design concept for the city consists of two twisting towers connected by bridges. The interesting modeling approach complies with energy efficiency, planting, wind energy, etc. (Fig.9) [9].

***Figure 9**. Eco Skyscraper, designed by V. Pawar, Noida - India*

Horizontal block unit of model No.4.1 is composed of a circular core and five radial satellites, pentagonaly shaped. Whole horizontal block continously rotates along the vertical axis and makes the final dynamic structure with terraces (Fig.10a).

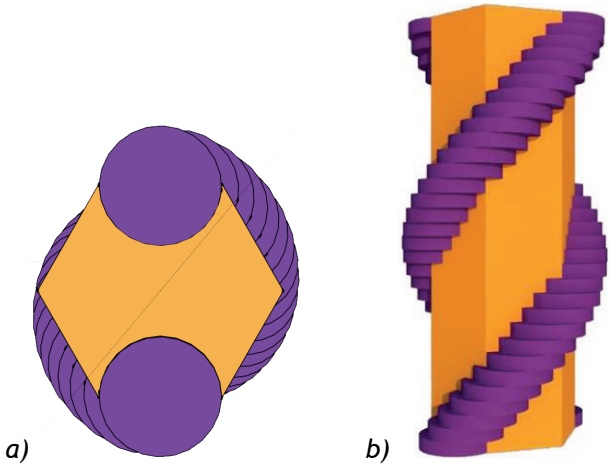


a) *b)* *c)*

***Figure 10**.a)Structure No. 4.1- 3D model; b)Structure No. 4.2- 3D model; c)Structure No. 4.3 - 3D model*

The same disposition of five pentagonal satellites, without specific emphasis on the geometry of the core (model No.4.2) lightened previous massive structure (Fig.10b).Zig-zag motion of the pentagonal units on the fasade made interesting variation of the same concept (Fig. 10c).

The variation structure No. 4.4 is modeled with hexagonal core. The basic floor unit shape is a union of hexagon and two circles. The final structure proposed spiral movement of circular parts (Fig.11).



a) *b)*

***Figure 11**. Structure No. 4.4- a)top view; b)3D model*

2.5 The inspiration No 5. – Lego

This modern structure offers a special concept of architecture. Changes on the façade (pixilated) made a dynamic, obtained with a cuboid-surfaced spiral cuts into the side of the building. This 77 store high building, in Bangkok is designed by architect O. Scheeren (Fig.12) [10].

***Figure 12**. MahaNakhon Tower, designed by Ole Scheeren, Bangkok, Thailand*

Geometry of structure No. 5 is fake spiral. The hole - cube on each fasade's side moves diagonally, continuously changing the position in separate floor levels. This movement causes changes on each floor shape (Fig.13).

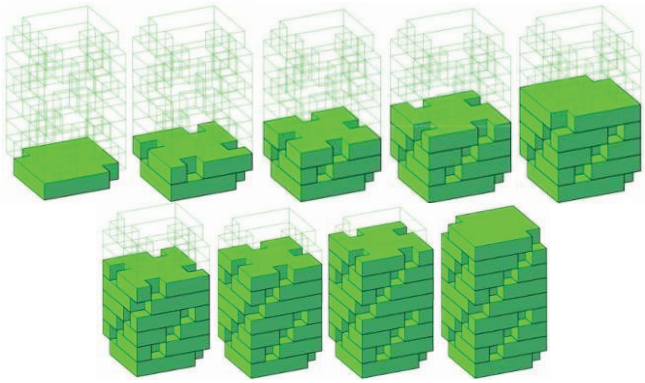


***Figure 13**. Structure No. 5 – 3D model*

The main characteristics of 3D structures are emphasized in Table 1: geometry of the base unit, the fill rotation angle - $\varphi/^{o}$, rotation "step" angle - $s/^{o}$, number of floors – n.

***Table 1**. The overview of 3D structures with geometrical characteristics*

	Model	**Basic geometry**	φ	*s*	*n*
No. 1	*Two in one*	*Circle and rectangle*	*360*	*5*	*72*
No. 2.1	*The fan*	*Circle and triangle*	*147*	*7*	*22*
No. 2.2	*The fan*	*Circle and rectangle*	*240*	*10*	*24*
No. 3.1	*Propeller*	*Circle with satellites(circle)*	*225*	*7.5*	*34*
No. 3.2	*Propeller*	*Circle with satellites(circle)*	*60*	*7.5*	*30*
No. 4.1	*Star*	*Circle with satellites(pentagonal)*	*72*	*6*	*12*
No. 4.2	*Star*	*Rectangle and pentagonal*	*324*	*18*	*18*
No. 4.3	*Star*	*Rectangle and pentagonal*	*72*	*18*	*18*
No. 4.4	*Star*	*Hexagon with circle*	*310*	*10*	*22*

3. Conclusion

3D modeling of spiral structures is challanging and inspirative task for designers in a wide spectar of areas, whether scientific or practical. The architecture, as a living surroundings by its dynamics imitates the way of living, full of changes. Somehow, it seems that the spiral architecture also complies with this "concept", by taking care of implementing of eco design, energy efficiency (solar panels, wind turbines...), green architecture etc. Often they look like organic "sculptures" [4]. Such "inventions", built all over the world are astonishing both in technologies and imagery.

The basic geometric principles, presented in this research, were taken over from existing building structures, or designs, grouped in five diferent types. Based on concept of unit, or block, spiral

movement they explore the combinations of circular and polygonal shapes. The variations are endless and rely on imagery of the designer.

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