Peculiarities of the construction of rotating buildings

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Abstract The main goal of architects when designing, depending on the purpose of the buildings, is to create the most perfect and convenient working or living conditions for people. One of the important factors in this regard is to ensure the orientation of the building's facade in such a way that daylight and sunlight penetrate as much as possible. Based on the above, to meet this requirement, buildings are often equipped with wide windows, glazed balconies, or their facade parts are completely covered with stained glass. Many buildings include a large number of terraces and open balconies. Many architects have gone further and have already implemented many projects where the building itself or its floors rotate and it is possible to orient it in the desired direction. The idea of building rotating buildings arose at the beginning of the last century and gradually developed to such an extent that for several years now very interesting projects of rotating skyscrapers have been developed. Due to its engineering solution, the construction of such buildings is associated with significant costs, and their implementation is only related to finding financing.
Keywords: building, rotation, construction, frame, mechanism, steel.

1.Introduction

The first rotating building project was presented in 1920 by the architect Vladimir Tatlin. He also built a wooden model for the building of the Third International. The new headquarters of this international communist organization, at that time the tallest building in the world, was to be built in St. Petersburg. In fact, the project was a visual embodiment of a communist utopia. The building was to become a monument that stood out from all others. If it had been built, it would certainly have become one of the wonders of the world, but an overly ambitious design prevented its implementation. The 400-meter-high building consisted of two interconnected metal spiral structures. Four different geometric figures
were suspended from it, each rotating at a different speed around its own axis. The lowest, cube-shaped building was dedicated to the legislative body and made only one rotation during the year. It was planned to hold large gatherings, congresses and conferences there. The pyramid-shaped building above was intended for the executive bodies. It made one rotation per month. The third, cylindrical building in height was to house the information center, publishing house, printing house and other services with an agitation-propaganda function. The cylinder would make one rotation per day. The highest, hemispherical figure made one rotation in one hour and was presumably dedicated to artists and art workers (Fig. 1).

According to the author's idea, the tower was to become a symbol of the reunification of humanity, which was divided during the construction of the Tower of Babel, and in its design, constructivist, it would be built entirely from locally produced materials. In capitalist countries, such high-rise buildings were faced with marble, ivory and other expensive materials. Tatlin wanted to create the tower with the main elements of Soviet

industry (iron, steel, glass, etc.). It was of great importance to the working class, because at that time everywhere, including in the field of art, they wanted to establish a new and clearly socialist identity. Tatlin's tower was unique because the construction concerned the entire socio-economic class of people. Although it was not implemented, it still made such a strong impression that it is still a source of inspiration for architects.

Fig. 1. Model of Tatlin's Tower

2. Main part

The world's first residential house that rotates around its own axis was built in 1935 in the village of Marcelli, near Verona, Italy. Tatlin's idea was implemented almost 15 years later by the Genoese engineer and investor Angelo Invernizzi, who built a rotating private house with the help of famous engineers and architects. It was built in the style of modernism and during a period of great interest in the use of solar energy. The building is also known as the "Sunflower Villa" because its fruits are always directed towards the sun (Fig. 2). From an engineering point of view, the building is a masterpiece of rationalism and futurism. The building consists of two parts. The first part is a three-story reinforced concrete support platform with a diameter of 44 meters. Inside it is a rotating axis, and on the surface there is a green courtyard, where three circles of railway tracks are made. The second part is movable. It is a two-story building. Its two rectangular parts are connected to each other at an angle of 900, with a 40-meter-high tower in the middle. The supporting part of the tower is built of a metal frame, and here, as in the building, bricks and reinforced concrete are also used. From above, the object resembles a large and slowly moving sundial. Its weight is more than 1,500 tons and movement on the tracks is carried out in both directions by 15 locomotive wheels and a 3-horsepower electric motor. The moving part takes 9 hours and 20 minutes to rotate 3600 degrees, or its speed is 4 mm/s. Currently, this building houses a museum.

Fig. 2. The first rotating house

After this object, many more rotating houses were built around the world at different times, and there are even more ideas and projects for their embodiment. Among such buildings, several deserve special attention for their original engineering solutions. One of these is the three-story house of architect Ralph Disch in Freiburg (Germany), which was built in 1994. The house that follows the sun was named after the decorative plant "heliotrope". The flowers of this plant change

their position during the day in the direction of the sun's movement, that is, they always look at the sun. This building was built taking into account this principle. In addition, it is interesting that the house rotates using solar energy. Which is generated by 6.6 kW of solar panels located on its roof. It is worth noting that the panels, whose total area is 56 m2, generate 5-6 times more electricity than is needed to fully power the house. Therefore, it is also considered an ecological building. The panels also move freely along with the movement of the sun, which allows for maximum accumulation of electricity, and the movement of the house itself creates a certain atmosphere for the residents. It should also be noted that the windows of the house are double-glazed, which has high thermal insulation properties and has the ability to control the climate (Fig. 3).

Fig. 3. "Heliotrope" in Freiburg

The idea of creating absolutely ecological buildings is relevant not only for residential, but also for public buildings. In particular, the solution of the "Heliotrope" - a rotating house was used by the same architect when developing the "Heliotrope" hotel project, which was supposed to show a wider scope of the use of kinetic construction. And possibilities. Unfortunately, due to lack of funds, it could not be implemented.

A two-story house with 4 duplex-type residences built on Prince Edward Island in Canada is very interesting due to its simple solution. It makes one full turn around its central axis throughout the day. Its rotation almost completely repeats the principle of movement of a children's carousel. For this, first, a circular pool-like underground structure was built from monolithic reinforced concrete, and then a rotating frame from steel profiles was arranged in its internal space. This frame is actually the foundation of the building, on which two floors were built using light metal structures (Fig. 4).

Fig. 4. Rotating foundation

Fig.5. Around the Sea"

According to the authors of the project, this is the only apartment building that rotates with an elevator, and all rooms in the building necessarily face the ocean. In addition, this structure required not only precise calculations, but also furniture and accessories are arranged

with pre-calculated fastenings. In order not to restrict the movement of the house, communications were laid in its central part. In order to ensure the best possible view around, the windows and doors of the building have wide frames, and the second floor is equipped with a circular balcony. Therefore, the building fully corresponds to its name. "Around the Sea" means "around the sea" (Fig. 5).

In 2004, a rotating private house was built on a mountainside in San Diego (USA), with unusually good views. It was designed by the Johnstons, a couple who live there, who did not have a special architectural education. The base of the kinetic structure of the house is a cylindrical base, made of a metal frame with movable and stationary platforms. The movement is carried out by an electric motor. Since it is hot in California, the facade is made of black tinted glass. The movable platform is the floor of the living area of the house, and 8 bearings are enough to move it. Using a conventional remote control, it is possible to adjust the speed of rotation of the building, one full revolution is carried out, the fastest movement is carried out in 33 minutes. The building has a circular balcony and all communications, elevator and entrance door are located inside its cylindrical axis. A two-car garage is located on the first, immovable floor of the building (Fig. 6).

Fig. 6. Rotating house in San Diego

Many more examples of low-rise rotating houses can be cited, which are found in different countries of the world. Modern architects, creating a new project, always try to make specific changes to make it different from standard types of buildings. One of such features is high-rise rotating buildings, which, along with the architectural solution, are interesting for their rotational motion. The most difficult thing at this time, based on the laws of physics, is to ensure the stability of the floors moving asynchronously around the axis of the building (Fig. 7).

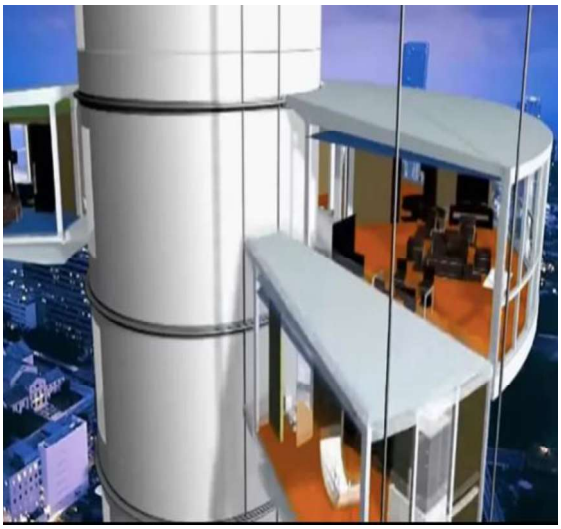

Fig. 7. Floor connection

Most of the low-rise buildings built earlier were completely rotary. In the case of separately movable floors, the architectural and constructional solution is also supplemented by ensuring their functionality. This requires an individual engineering approach in each particular case. Therefore, along with the names of the authors of such objects, i.e. architects, the creators of the rotating mechanism are also indicated. One of the first such high-rise buildings was built in 1991 in Curitiba, Brazil, whose architect is Burno de Franco, and the design of the rotating device was created by engineer Alan Holtzman. This building is considered the first complex in the world where the floors can rotate independently of each other. The building is

15-story. The first four floors are stationary, while the remaining eleven can completely independently make one rotation around the central core, where all communications and nodes are concentrated, in 60 minutes (Fig. 8).

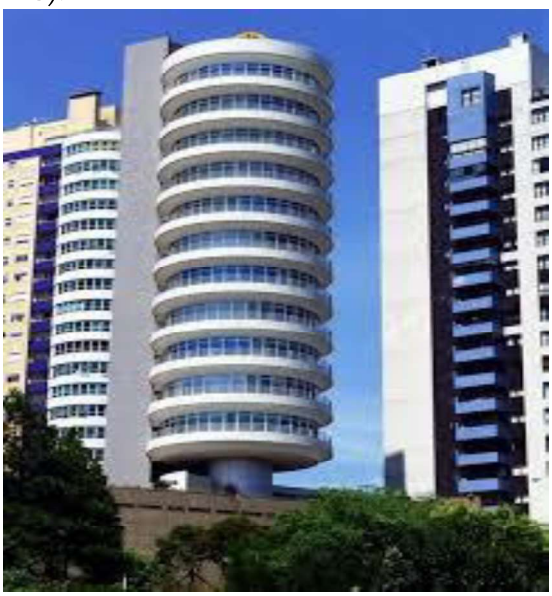

Fig. 8. Rotating house in Brazil

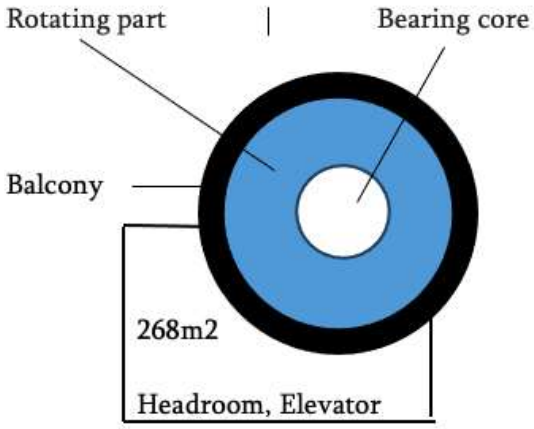

Fig. 9. Rotating Part

The complex is located in the city center, in an elite area. The cost of the apartments is much higher than the cost of ordinary apartments, since their owners receive not only apartments, but also the ability to change the view from the windows at their own discretion. There is only one elite apartment on each floor, where prominent citizens of Brazil live. Such a decision was made with the view that in the case of several apartments, there could be major misunderstandings regarding the rotation of the floor. Therefore, the total area of the floor is 268 m2. All conditions for comfortable living are created in the apartments. In addition, more than 30 m2 is occupied by a large terrace with a panoramic view. Communications pass through the central core here too and there are sewers. And the fixed part houses the entrance, stairwell, elevators and a number of other auxiliary storage rooms (Fig. 9).

The most important object among the rotating buildings is the "Rotating Tower" (rotating tower) 80-story skyscraper (height 420 m) under construction in Dubai. All floors rotate independently in both directions and complete one revolution in 90 minutes. The building is constructed around a central, monolithic reinforced concrete cylindrical core, with individual sectors of the floors suspended (Fig. 10).

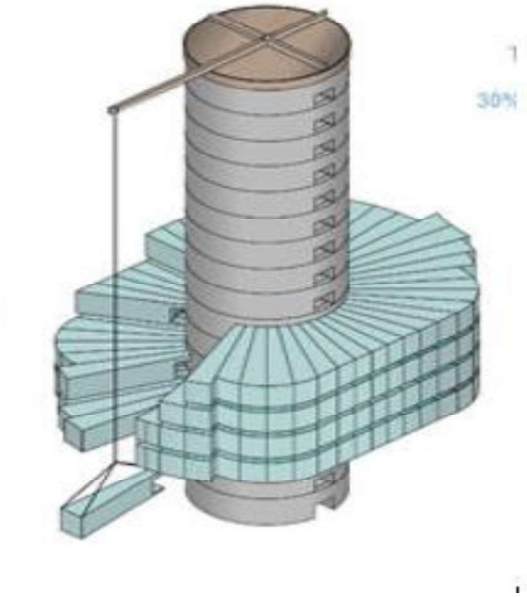

Fig.10. Connecting the sectors

The lower 20 floors of the building will house offices of well-known firms and companies. The next 15 floors will be

devoted to a six-story hotel. The remaining 45 floors are apartments with pools and greenery, the price of which is incredibly high. The staircase, elevators, entrance, and communications are in the central core. There are wind turbines between the floors, which will generate much more electricity than is needed for consumption. In addition, the configuration of the floors is such that as a result of their free rotation, the facade of the building will always be different, making it truly incomparable. Figure 12 shows several such facades of the building obtained as a result of the rotation of the floors.

Conclusion

1. The idea of rotating buildings has been around for more than a century. The first such building was built in 1935 in Italy, where a museum is now located. Since then, mainly low-rise buildings have been built, which rotated around their axis, in most cases, using a carousel-like structural solution;
2. The most difficult is the structural solution of a rotating building, when it is necessary to ensure the movement of floors in both directions, completely independently. All such cases individually require the creation of special rotating systems, which is always interesting. The first such rotating high-rise building was built in Brazil in 2001, where 11 rotating floors were suspended around a central metal axis;
3. Currently, the construction of a 420-meter-high, 80-story rotating house in Dubai is nearing completion. Its floors are suspended and installed on a central core using prefabricated sectors. The floors are configured in such a way that their movement constantly changes the facade of the entire building, which makes this building unique.

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