Секция 17. Технические науки

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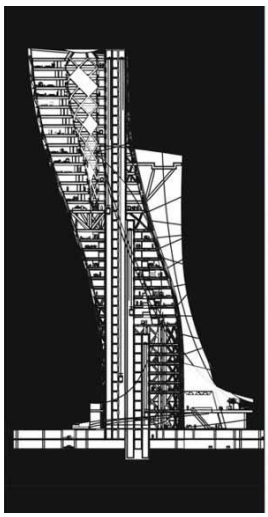
UNIQUE BUILDING STRUCTURES OF "CAPITAL GATE"

Dubai is known for its architectural projects, but now the neighbouring city of Abu Dhabi can exceed all its achievements. It is mainly connected to the «Capital Gate». Skyscraper with the largest slope in the world, which contrary to the laws of gravity deviates from the vertical axis 5 times more than the Leaning Tower of Pisa in Italy. To build this construction it was required striking and outstanding engineering solutions, which may alter the canons of skyscrapers construction.

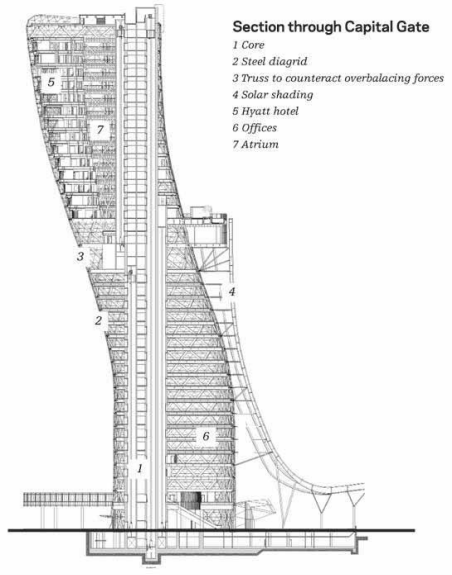


The tower rising out of the ground at 160 meters forms the angle of 18º with the vertical axis. The difficulties of this project begin on the first day. Upper floors are outside of the foundation line at 33 meters. Because of this appear a huge forces, which aimed to pull the foundation of the building out of the ground. The work begins with the foundation, located deep underground. [1]

On the one hand, the weight of the building pushes it deep into the ground, on the other hand, it pulls it out of the ground because of the great overhang. In order to eliminate this effect it must be set almost 400 concrete

piles, which perform two different tasks. The first half of piles from the side of the slope transmits the load, which appeared because of the overhang, into the ground. The other piles on the opposite side are set deeper till the rocky foundation. They prevent action of tensile forces, aimed to pull the building out of the land. Also there is mounted on the piles a thick concrete slab reinforced with steel, which evenly distributes the load of the building on them. [1]

When the foundation is ready, it is built an overground part of the building, but because of the great inclination its construction will be different from the usual skyscrapers. As a rule skyscrapers are based and lean on the central core, but in this case it would crack and be toppled over. Usual skyscrapers are built around a narrow vertical core which directs the weight of the building to the ground. In this case the usual core would not be strong enough and it would be bent up to dangerous levels. [1]



Weight of the overhang tends to pull the core breaking the concrete apart. The first part of solution: to build a core with a curvature in the opposite direction from the building inclination. During the construction process the growing weight of the building will straighten the core. Concrete which must be stretched by the weight of overhang, now will be strengthened by compression.

The core was built using formwork resettable technology. Firstly it is made a dense grid of steel rebar. Then around it is set the formwork in the form of the core; steel grid is poured by concrete. Then it is possible to rise up the formwork and repeat the same operation. As concrete will fill 4 meters there are set a few bars and the formwork is raised to the next level with the help of hydraulics. [1]

Core strength will increase in the process of straightening. But the central core itself is built with inclination and reinforced with a large amount of reinforcement can not stop the force of gravity in overthrowing the Capital Gate. It was used the post tensioning technology: in the walls of the core was placed additional reinforcement, and then it was stretched. When the concrete is poured to the desired height, it is stretching the stressed elements passing through the wall. It is done by tension mechanism. This way is so effective that after tension the core will be able to stand under the load. Additional reinforcement will not let it to be broke. [2]

For the next tension of the core through concrete vertically pass 146 steel reinforced elements. The length of one element is 20 meters. They pass through 5 floors of the building, covering each other for maximum strength. Tension of reinforced elements counteracts the action of traction force, which appears because of the huge overhang, and prevents the destruction of concrete. [2]

Long reinforced element is raised to the top of the core. Builders lower the steel reinforcement in the channels pre-made in the core due to its own weight. When the reinforced element is set on the place, it's both ends are fixed. Now on the every reinforcement is set a lifting jack and it is tensed. The steel reinforced element is stretched to a certain level and then it is possible to continue concrete pouring. The outer part of the building it is a covering which

can be presented as an eggs shell. Egg is capable of withstanding an enormous stress, because the shell evenly distributes the acting forces. It allows the egg to be thinner and its inner space increases. The shell is very thin, but very strong. In one experience there were laid 170 eggs, covered by peace of rectangular glass, and then began to lay on the top the load in the form of cinder blocks. Every of block has weight in 15 kg; there was put 31 blocks. Then the load crushed eggs. By the way eggs bear the weight more than 450 kg. The principle of eggshell in Capital Gate is represented as a diagonal lattice. Diagonal lattice – a great grid of steel wrapped around the core. Steel beams connected to joint and form cruciform sections. 720 unique sections form thin, but incredibly strong diagonal lattice. Together, these cross-shaped sections evenly distribute the forces on the walls of the building. [2]

The next step – to put the glass facade on the tower. Glazing was also a big problem. It was necessary to glaze the building by the cost effective flat glass frames. Here helped ancient Greek geometry – to obtain a curved shape it was used usual straight triangles. 26 thousand triangular frames was used for the facade. As the core of Capital Gate becomes straight in the process of building and will not stop moving until the construction is completed. [2]

Usual glass facades are designed for minimal movement in case of wind and temperature action; but in order not to break the glass and not to let water get into the building these panels are designed to move up to 30 mm. Light atrium allows the light of heaven to penetrate deep into the building. It passes through a half of building's height, that's why in the bottom it is very narrow and gradually expands in the form of a large funnel. This deep aperture helps to reduce the weight and minimize the stress. Covering should not have any holes;

it must entirely consist of reinforced concrete for distribution of forces. These forces must be diverted. Revolutionary solution – internal steel lattice, copying external diagonal grid. The inner frame in the form of a funnel transmits the loads of 18-storey building on the foundation and on the core. But the load is extremely high for such a small area. Not to let atrium force in the walls of the core it is need an additional concrete protection; solution – 6 giant steel bars which reinforce the connection with the core wall. [2]

In the end, the technologies, used in the process of construction not only impress by its technological side, but also from the ecological side: the glasses used in the construction block the sun's rays. Because of this technology the cost of electricity consumption decreases, especially on conditioning.

References:

1. Francis D.K. "Building Structures", New Jersey 2014.
2. Killory K. "Details in Contemporary Architecture", London 2007.