Modern Tendencies in Design of Public Spaces in term of Sustainable Development

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Abstract. The Flight of Fantasy is a multifunctional complex located on the territory of perspective development in Dubai, United Arab Emirates. The project was designed for the International Student Competition “MultiComfort House Students Contest” hold by Saint-Gobain ISOVER. The project was developed taking into account the standards of energy-efficient construction and sustainable development and meets all the requirements of the competition. This paper describes the main conceptual solutions adopted by the authors. Since Dubai has a tropical desert climate, it was necessary to protect all spaces from overheating in summer and to ensure the possibility of comfortable movement between apartments and public spaces. Also it was necessary to offer an optimal solution for residential spaces that meet all the needs of residents. The architectural concept should fit the modern trends of the city development and use innovative materials.

1. Introduction

Dubai is the largest and most populous city in the United Arab Emirates (UAE). Dubai has a tropical desert climate, Köppen classification Bwh, because of its location within the Northern desert belt. Summers are extremely hot and humid. The weather between December and March is warm and considered to be the most comfortable climatic conditions of the year. The Emirate of Dubai has experienced a rapid transformation. From a desert city with an estimated population of 10,000 in 1900, today it is a mega-city with a population of over 2.1 million people and between 8-10 million annual visitors.

Based on these conditions and world experience [1,2,3,4,5], we have developed an architectural concept and construction solution. In addition, the project involves the infrastructure of the complex, building services systems and technical equipment. The main characteristics meet the requirements of energy efficiency and multicomfort for newly built buildings. Compliance with these requirements was the main complexity of the project. In a hot climate it is necessary to solve other tasks, unlike widespread energy-saving techniques for buildings in a temperate climate. In these climate conditions, about 60% of the total energy consumed by the building spends on cooling. Therefore, it is necessary to take into consideration using renewable energy sources, and avoid overheating of the premises.

2. Architectural concept

Historically, the symbol of the UAE was the image of a falcon, on whose breast a dhow schooner was depicted [6]. The dhow is a traditional swimming device for pearl hunters. It was sails and waves that we were inspired of. The idea of waves pushed us to associations with a number of physical
Also we tried to make the architecture fit in the surrounding of the site and maximize the views to the waterfront and architectural dominant. Special focus was given on developing the sustainability dimensions as well as the comfort ones. As a result, we got the following semantic chain: waves - physical interaction of waves - interference of coherent waves (Figure 1).

![Figure 1. Architectural concept.](image)

Figure 2. Object visibility: 1 - above 5 floors (shown in purple); 2 - at the height from 1 to 5 floors (green).

The following architectural features of the object can be distinguished. The object consist from five five-storey blocks disposed in special order to compose ten-storey building. The first floor is of commercial premises, the remaining floors are residential. The apartments are designed for different segments of the population: young specialists, foreigners of different nationalities living and working in the country. About 10% of the apartments are designed for long-term rentals of up to 6 months for people involved in cultural events. The area of apartments is set to 50 - 70 sq.m. per person (according to the requirements of the development region). There are two machine rooms in the underground part
of the building: they are tidal energy turbine control center (TCC) and a cooling system engine compartment, as well as a two-storey underground parking for 500 cars. All traffic infrastructure is brought underground.

Figure 3. Visualization: 1 – the view of a complex from the water; 2 – the view of a complex from the city.

The dominant element of the complex is a glazed air-conditioned atrium, in which public, cultural and commercial premises and walking paths and recreation area, as well as walking paths and recreation area are located. On the roofs of the first and fifth sections there are a swimming pool, recreation area and a restaurant with the views to the waterfront, where the residents of the complex can spend their free time at any season. We provided for a spacious multicomfort atrium that unites the entire complex of five buildings into a single one following the modern methods of effective planning of smart functional and public spaces [7,8,9], as well as the requirements for creating a comfortable microclimate of development.
3. Construction solution

The main construction material of the object is reinforced concrete with fibre-reinforced polymer. The concrete was chosen self-sealing with a self-cleaning surface. Self-compacting concrete prepared according to the method supposed by Hiro Okamura (or analogs) [10,11], has a high plasticity, good adhesion to the reinforcement and does not require vibration. This effect is achieved, in particular, by the addition of a polycarboxylate. A self-cleaning surface that does not require finishing is achieved by the addition of titanium dioxide nanoparticles. Such concrete has high aesthetic qualities, and also triggers the decomposition reaction of many harmful bacteria on the concrete surface.

We use carbon fiber reinforced polymer as a fibre-reinforced plastic. Carbon fiber was chosen because of having the best strength properties [12]. Due to high average annual temperatures in the UAE, the reinforcement should be selected according to the expansion coefficient. Carbon fiber has value of this coefficient closer to concrete than steel, which provides the best grip.

4. Fire security

All reinforced concrete structures of the complex have a fire resistance limit of REI 120, which is provided by a protective layer and composition of concrete, as well as protective coatings. In our project, there are five special shelter rooms (one for each building). They are protected by layers of reinforced concrete and sheet refractory coatings. Their walls are able to withstand the onslaught of fire for two hours. Each safe area is equipped with an autonomous ventilation system. Sealed fireproof doors prevent the penetration of smoke. In safe areas, people can hide until the emergency services take control of the situation or their turn for evacuation approaches. The fire lift is designed to move 5,500 kg (50-60 people).

The early warning system works continuously, 24 hours a day. As soon as a smoke detector, a thermal sensor or an automatic water extinguisher is triggered, a powerful fan system is activated. They pour clean cool air into the building through refractory ducts. Fresh air displaces smoke from the stairwells, ensuring the safety of evacuation routes.

5. Insolation

Due to the location "from north to south," the walls with windows are located on the west and east sides, which provides the required insolation. Also we propose to use special automated shutters on all window openings to protect the premises from overheating.
6. Solar energy generation
The roof surface of the upper five-story sections is equipped with BenQ SunForte 333 PM096B00 solar panels. They are performed by reverse-contact technology, which allowed to obtain an output power of 333 watts with a confirmed efficiency of 20.4%. A total of 600 panels are supposed to be installed. The dimensions of one panel are 1559x1046x46 mm. The average generation of solar cells was calculated in special program, it is about 250 kWh / day. Monocrystalline silicon is used as the main material of the panels.

![Figure 5. Annual solar energy generation.](image)

Window are equipped with blinds also consisting of solar panels. Solar energy, collected during the day, is supplied to the electrolyluminous foil in the dark at night and provides lighting for the premises. This device allows the use of a large surface to collect sunlight. The smart house system allows to adjust the inclination of the collecting surface depending on the position of the sun, and thus improve the efficiency of the device.

7. Tidal energy
In the underground part of the building we arranged a reduced version of the Turbine Control Center, developed by OPENHYDRO and awarded several awards. CCT is designed to fix and control the energy output from tidal massifs and export it with the greatest efficiency to the network. It simplifies the architecture of the array, which requires only one submarine cable to exit: creating a transformation in the economy of tidal massif development, which increases the reliability and predictability of the entire energy supply system.

8. Artificial park
We propose to equip a part of the territory around the complex with artificial trees, in which there are solar batteries instead of leaves. This device is called "Sun Tree". The structure of the location of solar cells repeat the regularity of the leaves one discovered by Aidan Dwyer, which allows increasing the energy output in the summer by 20%, and in winter by 50%. Also, this design allows trees to take up less space and be more weather resistant than flat panel constructions on the roof.

Along with the "solar trees" it is proposed to establish Wind Tree. Recently several generators of this type applies in the form of a tree about 7 meters in height apply in north-west France. People who have already seen the device in action agree that Wind Tree has a certain artistic value. The creators of the wind generator were inspired by the leaves waving in the wind. The device uses tiny blades that are dispersed inside the artificial leaves. The blades rotate independently of the direction of the wind, while the wind farm is capable of generating electricity even at a minimum wind speed (about 2 meters per second).
9. Air-conditioning system
The air quality and the ventilation rate are considerable in common comfort. In our project we propose to use the cooling system of Alfa Laval, called SeCool [13] (with the corresponding additional products, including Maxi Cooling) using seawater. Sea water directly cools the plate heat exchanger of the chiller. Circulating fresh water is cooled in two VETs with gaskets and titanium plates and then used to cool the condensers of air conditioners.

The advantages of this system are that it does not consume fresh water, which is especially important in the zone of the Northern Belt of the Desert, where Dubai is located. Also demineralized water doesn’t lead to corrosion. The plant equipment is in contact only with non-aggressive and uncontaminated fresh water. Aggressive and clogged sea water is present only in the dismountable heat exchangers of the SECOOL circuit.

The only requirement to use such a system is the presence of a source of sea water nearby, which is performed on our site. The above mentioned system will be connected to the geothermal cooling network in the ground, which will reduce the maintenance costs of the complex.

9.1. Air-conditioning of underground premises
For the ventilation of underground premises, the Jet Trans Fans system is installed. It allows to remove exhaust gases at an increased rate and to control the operation of each fan individually. The number of cars in the parking lot is determined automatically using a CO₂ sensor. The system allows you to regulate the load and thrust of specific fans, reducing energy consumption in general, and can operate in a completely reversible mode.

10. Acoustic isolation
The most simple and effective way to protect against noise is to use of multi-layer frame sound-proof structures. Such designs provide the same protection from noise, as well as an additional built-up brick wall 10 times larger.

A structure in which there are two or more layers provides better sound insulation than one thick layer. We propose multilayered frame partitions consist of several alternating layers of rigid (dense) and soft (light) building materials.

11. Elevators
Ensuring the availability for low-mobility groups and creating a barrier-free environment is an imprescriptible feature of multicomfort. Our complex is equipped with OTIS Gen2 Life lift with a lifting capacity of 1020 kg, the maximum speed of which reaches 1.6 m/s. The components of the Gen2 Life compact elevator are installed inside the shaft and eliminate the need for a machine room. This saves construction costs and frees the area. When the elevator is operated, there is no need for harmful substances, due to so-called zero lubrication.
The optional Gen2 Switch technology provides up to 100 runs at the time of power failure. When powered from a single-phase 230 V network or from renewable energy sources, the system requires less installed power than a household microwave oven.

**12. Calculation result at MCD**

To calculate the amount of energy spent on the operation of the building we chose the southernmost section of the complex. The calculation was held out in a specialized program MultiComfortDesigner. The results obtained fully satisfy the energy efficiency criteria (Figure 7). Annual heating costs in the cold period are 13.24 kWh / m², and conditioning costs in the warm period are 5.68 kWh / m². Quite low indicators were achieved due to the fencing of the internal courtyard with a glass dome.

**Figure 7.** The artificial trees: 1 – Sun Tree; 2 – Wind Tree

**13. Conclusion**

The project of a multifunctional international complex, designed at the Ural Federal University, meets both the requirements for creating a microclimate in hot operating conditions with a significant reduction in energy consumption for these purposes, and preserving the traditions and modern development of such a multinational community as the city of Dubai and the United Arab Emirates.

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