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NEW SOLUTION – CULTIVATION AND STORAGE OF SOFT FRUITS AND VEGETABLES IN CHAMBERS OF THE "CONTAINERS" TYPE WITH POSITIVE TEMPERATURES (CONTAINER SKYSCRAPER, MUMBAI, INDIA)

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Abstract

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Two types of containers have been used in the construction of a skyscraper. The first type is intended for inhabitation. Each home consists of three containers, situated on one floor or of six containers, situated on two floors. Along the height of the building two residential floors are followed by one or two floors, made of the second type of containers, which represent refrigeration chambers, used for cultivation and storage of soft fruits and vegetables. Each chamber is divided in two parts. The first part of the chambers is used for cultivation of soft fruit and vegetables, whereas the second part represents a storage space with positive temperature (2-12°C). This storage space meets the specific technical requirements, including an inert gas medium, if the latter is a prerequisite for the storage of fruits and vegetables.

The positive temperature is achieved by the direct penetration of sunrays in the first part of each chambers as well as the solar system for water heating with at least two circulation pumps.

There are two circulation outlines – first, which include a solar energy collector, situated inside the transparent fibers of the "cobweb" structure on the south façade of the skyscraper, whereas the second outline is formed by the hollow transparent elements 11, 12, 13 of the chambers intended for cultivation and storage of soft fruits and vegetables. In both the first and the second outline, the heat-carrier is set in motion by their own circulation pumps.

Key words: cultivation; storage; soft fruits; vegetables; chambers; containers; positive temperatures; skyscraper

Introduction

In the dissertation of the author are reviewed innovative solutions with inventive step, which focus on the chambers, intended for storage of fruits and vegetables, situated in autonomous buildings of the warehouse type (Aleksandrov, 2014). The combination of innovation design of buildings without inventive step (Aleksandrov, 2017a) and the innovation design of constructions and details with inventive step (Aleksandrov, 2017b), which are an undivisible part of these buildings allows to achieve a high level of competitiveness of numerous design solutions.

In an innovative arcology skyscraper in Hong Kong, the cultivation of soft fruits and vegetables is realized in horseshoe-like hollow spaces, which are supported by the kernels of a twisted triangular prism, the latter representing the main high body of the skyscraper (Aleksandrov et al., 2013). The chambers for storing fruits and vegetables can be situated on specially built floors, which are equipped with refrigeration installations, meeting the special requirements for humidity, temperature, gas medium, etc. (Aleksandrov et al., 2013).

In the case of single volumes with transparent covering is achieved a hothouse effect, combined with a solar system for water heating which uses rainwater, stored in special water tanks (Aleksandrova, 2011). These volumes are intended for exploitation in extreme situations (Aleksandrova, 2009).

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Various examples for buildings made of containers exist, whereas the containers are situated side-by-side or over each other (Woods, 2015). A prominent example for a high-rise building made of containers has been built in Mumbai (Ganti, 2015). Another building made entirely of containers is developed by NBRS (Duffin, 2015). However, in all mentioned solutions there are no chambers of the "container" type, specifically designed for cultivation and storage of fruits and vegetables in autonomous refrigeration environment. The energy self-sufficiency of these container buildings requires the use of passive and active systems for solar heating as well as the integration of new materials. The proportions of the used materials (Ching, 2014) are of high importance for contemporary technologies in the area of energy effectiveness.

In the container skyscraper (Figure 1 and 2, and Table 1) designed for Mumbai, India the cultivation of fruits and vegetables can be realized in the first part of the chambers of the "container" type which have transparent elements (Figure 3). The fruits and vegetables are then stored in the second part of the same chambers. The maintenance of the temperature regime in both parts is achieved with the help of the hothouse effect, combined with the solar systems for water heating (Aleksandrov et al., 2015). These chambers of the "container" type (Figure 3) are situated on different levels immediately under or over the floors with containers, which are intended for inhabitation (Fig 1).

Fig. 1. Exemplary container, adapted for inhabitation
(Competition brief. Steel city – Container Skyscrapers, Mumbai, 2015)

Patented Invention Bg 111651/09.12.2013. A Moveable Cold Storage Chamber for Positive Temperatures

Transparent angular two-plane elements are used for the direct lighting of the floor and the ceiling of the refrigeration chamber, the penetration of solar beams is directed by sunblinds, which are controlled by sensors (Aleksandrov, 2013a).

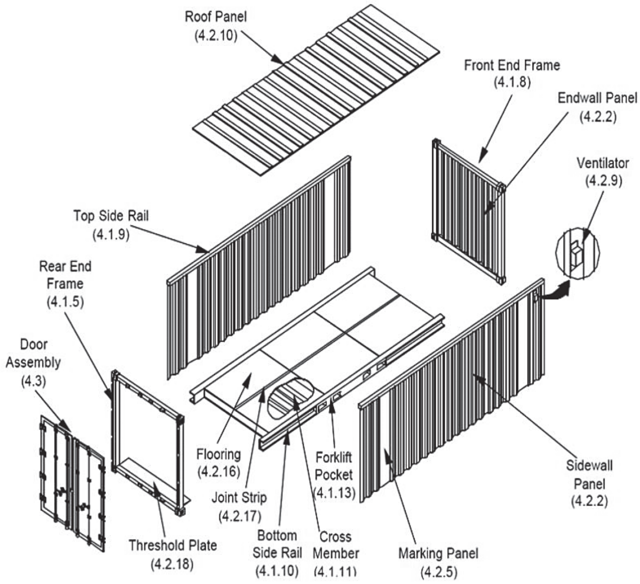

Fig. 2. Details of an exemplary container
(Competition brief. Steel city – Container Skyscrapers, Mumbai, 2015)

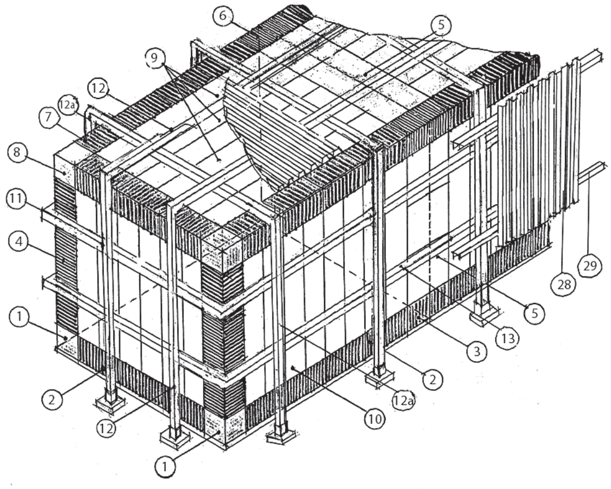

Fig. 3. Refrigerator for fruits and vegetables. General view. „Moveable cold storage chamber for positive temperatures". BG111651(A) (Aleksandrov, 2013a)
(1,8) three angular planar elements; (2,7) two planar elements; (3,6) „T"-shaped angular member; (4) the vertical angular of two planar elements; (9) not transparent ceiling panels; (10) not transparent wall panels; (11,13) the inner side of the guides; (12a) the inner side of the transverse frames; (12-a) transverse transparent frames; (11,13) inside transparent guides

Table 1
Dimensions of containers

		20′ container		40′ container		40′ high-cube container		45’ high-cube container	
		imperial	metric	imperial	metric	imperial	metric	imperial	metric
external dimensions	length	19′ 10 ½″	6.058 m	40′ 0″	12,192 m	40′ 0″	12.192 m	45′ 0″	13,716 m
	width	8′ 0″	2.438 m	8′ 0″	2.438 m	8′ 0″	2.438 m	8′ 0″	2.438 m
	height	8′ 6″	2.591 m	8′ 6″	2.591 m	9′ 6″	2.896 m	9′ 6″	2.896 m
interior dimensions	length	18′ 8 13/16″	5.710 m	39′ 5 45/64″	12.032 m	39′ 4″	12.000 m	44′ 4″	13.556 m
	width	7′ 8 19/32″	2.352 m	7′ 8 19/32″	2.352 m	7′ 7″	2.311 m	7′ 8 19/32″	2.352 m
	height	7′ 9 57/64″	2.385 m	7′ 9 57/64″	2.385 m	8′ 9″	2.650 m	8′ 9 15/16″	2.698 m
door aperture	width	7′ 8 ⅛″	2.343 m	7′ 8 ⅛″	2.343 m	7′ 6″	2.280 m	7′ 8 ⅛″	2.343 m
	height	7′ 5 ¾″	2.280 m	7′ 5 ¾″	2.280 m	8′ 5″	2.560 m	8′ 5 49/64″	2.585 m
internal volume		1,169 ft^3	33,1 m^3	2,385 ft^3	67.5 m^3	2,660 ft^3	75.3 m^3	3,040 ft^3	86.1 m^3
maximum gross weight		66,139 lb	30,400 kg	66,139 lb	30,400 kg	68,008 lb	30,848 kg	66,139 lb	30,400 kg
empty weight		4,850 lb	2,200 kg	8,380 lb	3,800 kg	8,598 lb	3,900 kg	10,580 lb	4,800 kg
net load		61,289 lb	28,200 kg	57,759 lb	26,600 kg	58,598 lb	26,580 kg	55,559 lb	25,600 kg

Competition brief, Steel city - Container Skyscrapers, Mumbai, 2015

Three flat corners are filled with the external transparent layer (1-a), an inner dense layer (7), as in layers (7) shaped the first vertical zigzag channel (7-a) and the second horizontal zigzag channel (7-b), whereas in the channel (7-a) there is a heirloom layer (6), and the zigzag shaped element (6) is fixed to the thick layer (7) with the connector (4), (7) and behind this layer (6) are located in the thin heating coils (3-b) and between the outer transparent layers (1-a) and the inner dense layer (7) is a transparent thermal insulation (2), whereas in its transparent walls (2) are shaped confined spaces, as at least half of these spaces are filled with energy accumulation composition, and a T-shaped three-flat corner is filled with external vertical transparent layer (5), and the other two layers (1-a), and (7) are dense, such as in the layer (7) shaped the first vertical zigzag channel (7-a); and the second horizontal zigzag channel (7-b), as in the channel (7-a) is a heir loom layer (6), and zigzag shaped element (6) is fixed to the thick layer (7) with the connector (4) as in the sewers (7-a) and behind this layer (6) are located in the thin heating coils (3-b), and by the same layer (6) are located on thicker heating coils (23), such as to the left of the layer (1-a) are located other vertical curved channels (7-b), and the two flat corners (on the external walls of the enclosure) are filled with outdoor transparent layer (1-a) as in layers (7) shaped the first vertical zigzag channel (7-a) and the second horizontal zigzag channel (7-b), as in the channel (7-a) is situated here (Figure 4, 5).

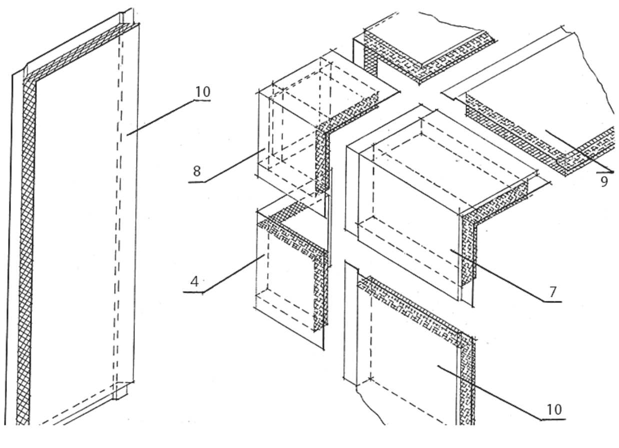

Fig. 4. Refrigerator for fruits and vegetables. The basic elements. „Moveable cold storage chamber for positive temperature". BG111651 (A) (Aleksandrov, 2013a)

Functioning of the Solar System for Water Heating

Inside the hollow transparent elements 11, 12, 13 circulates a heat-carrier, set in motion by a circulation pump. Inside the internal separation wall between the two premises of the chamber, the external hollow elements are connected with outside tubular serpentines 22, 24, situated at its both sides. A second circulation pump returns the heat-carrier to the outside hollow transparent elements 11, 12, and 13. At least two circulation pumps are situated in one of the two parts of each chamber, at the beginning and at the end of the internal tubular serpentines. Thus, the heat-carrier circulates inside the *first circulation outline,* situated behind the transparent "cobweb" at the south façade of the skyscraper.

The *second circulation outline includes the fibres of the vertical "cobweb" structure, situated in front of the containers at the south façade of the skyscraper.* The fibres of the transparent "cobweb" represent tubes filled with heat-

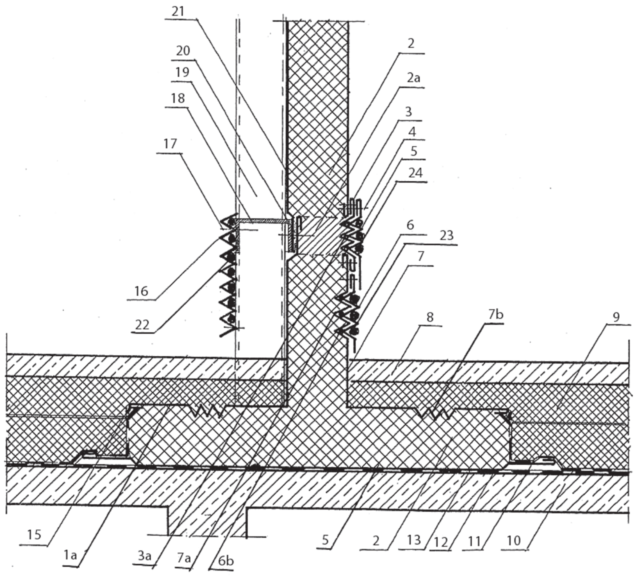

Fig. 5. Refrigerator for fruits and vegetables. „T"-shaped joint

The separation wall between two parts of an exemplary chamber of the "container" type for cultivation of fruits and vegetables in its first part and their storage in its second part „System for solar heating of cooling chamber with positive temperatures" BG111658 (A) (Aleksandrov, 2013b)
(1-a) external transparent layer; (2) transparent thermal insulation; (3-b) thin heating coils;
(4), (17) connector; (5) "T"-shaped three-flat corner; (6) zig-zag shaped element; (7) inner dense layer; (7-a) first vertical zigzag channel; (7-b) second horizontal zigzag channel; (21) external vertical transparent layer; (23) thicker heating coils

carrier, which form a solar water collector, connected with the help of circulation pumps with the tubular serpentines 22, 23, 24, 3-a, situated in the lower part or the separation wall between the two parts of each chamber. The heat-carrier represents purified rainwater, mixed with antifreeze liquid (if the system is to be installed in areas with low temperatures). The temperature in the two premises of each chamber is controlled by various sensors. In the container for inhabitation, which are combined with chambers for cultivation of soft fruits and vegetables, positive temperature is maintained with the help of the external hothouse effect, occurring in the south façade covering, the internal hothouse effect, occurring inside the containers and chambers themselves as well as the two circulation outlines. *A third circulation outline* for heating of the "cobweb" type can be installed as a hung ceiling in the premises for inhabitation (Figures 6, 7).

Fig. 6. Container with dimensions 6058 x 2438 x 2591 mm, adapted for inhabitation (Aleksandrov et al., 2015)

Fig. 7. Third circulation outline for heating, whereas a transparent internal "cobweb" structure is placed on the ceiling of containers with dimensions of 6058 x 2438 x 2591 mm, adapted for inhabitation (Aleksandrov et al., 2015)

The Conceptual Design (Figures 6 - 16)

This project has been created as a result of unity of compositional, functional, archtectural, technological, ecological and other characteristics of innovative character. The main living unit has an area of 90 m² and is formed by 6 containers, with dimensions of 6058 x 2438 x 2591 mm. (Table 1) Located on two floors, two of the containers are

Fig. 8. Container skyscraper. Mumbai, India (Aleksandrov et al., 2015)
The transparent “cobweb” structure creates a hothouse effect in front of the south facade of the skyscraper

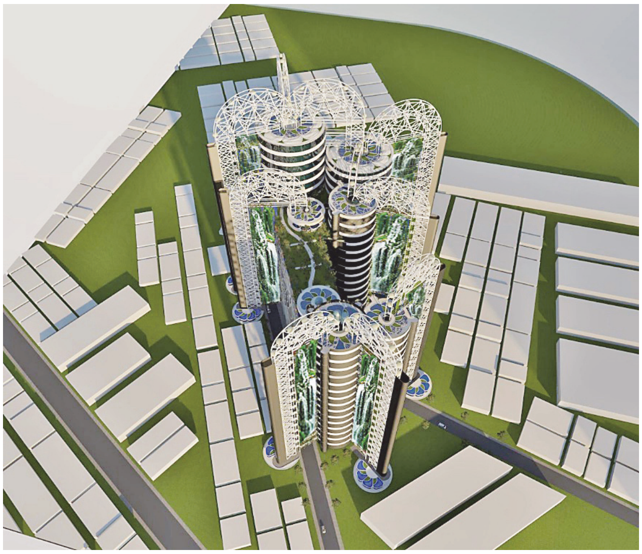

Fig. 9. Container skyscraper. Mumbai, India (Aleksandrov et al., 2015)
Interactive outside walls with waterfalls installed on them combined with vertical pipes with different transverse section for the flowing of rainwater. On ground level, there are also various areas filled with water

adapted for use as entrance halls, with stairs and bathrooms with shower. The contemporary appearance of the building is achieved by the fusion of attractive approaches, (using the elliptical caterpillar to form raised cabins, with the help of gears and chains) transportation of inhabitants and visitors to the round bodies intended for living and sport activities as well as the original elevating technology that lifts the floor

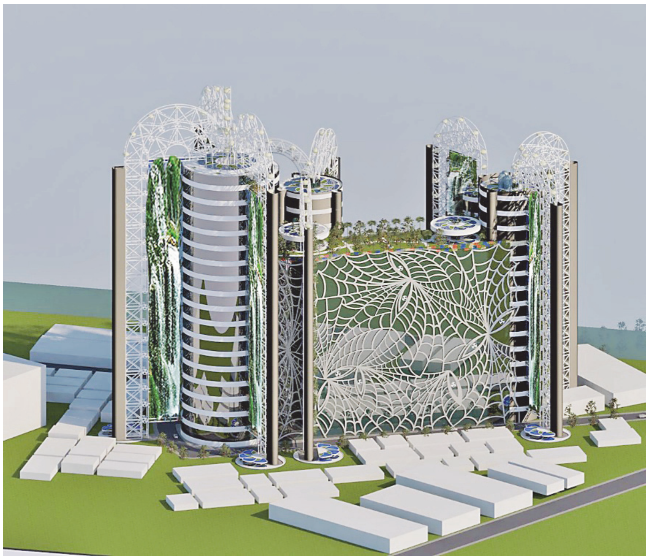

Fig. 10. Container Skyscraper. Mumbai, India (Aleksandrov et al., 2015)
The residential floors and the floors intended for cultivation of fruits and vegetables can be accessed by oval panoramic gondola lifts and internal elevators

Fig. 11. Plan of ground level (Aleksandrov et al., 2015)
Freight elevators transport all containers to their respective places in the skyscraper

construction (with or without containers) to the relevant elevation level. Wind turbines are situated under the cabins. As well, there is a vertical park, composed of flower gardens and “swinging” waterfalls, whereas the waterfalls are enveloped by a transparent tissue made of polyketone, reinforced by carbon fiber. The façade that has a replaceable skin-like covering can be both colorfed or transparent, made of polyketone reinforced with carbon fiber. Its segmenting resembles

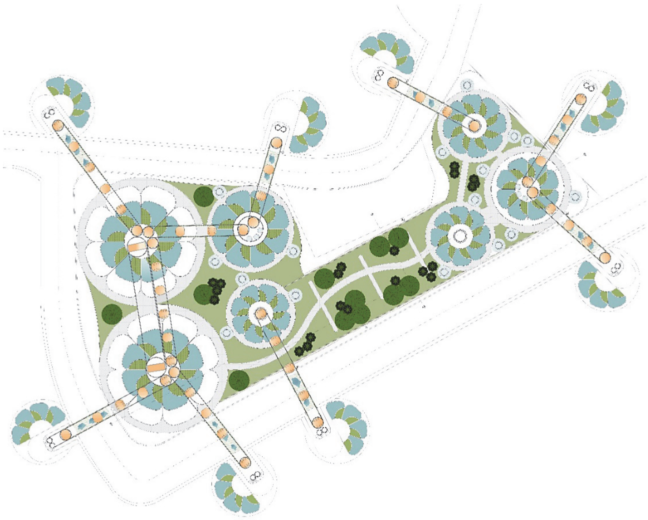

Fig. 12. Roof plan (Aleksandrov et al., 2015)
The water areas and gardens can be accesses with the help of oval cabin elevators

Fig. 13. Plan of Residential floor with living rooms (Aleksandrov et al., 2015)
Rotating rings and pathways transport the containers, which are adapted for inhabitation and the chambers of the “container” type, which are intended for cultivation of fruits and vegetables to the respective floors for mounting. Two aquariums are hung to the floor plates in order to extinguish vibrations in case of an eartquake

butterflies with outstretched wings, whereas there are small wind turbines in its structure which are used to supercharge mist which condenses in special tanks and is used for irrigation of the internal gardens thereafter.

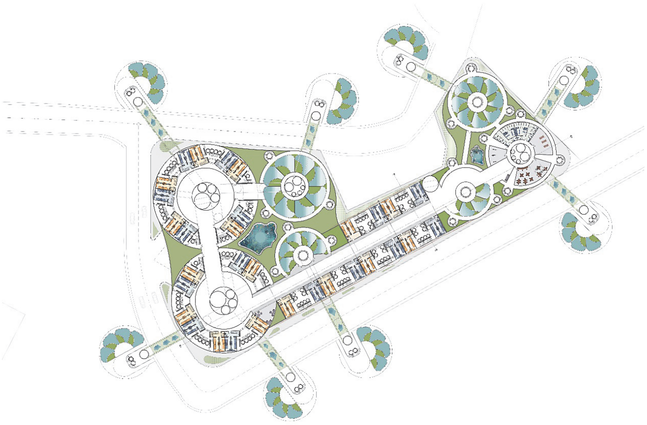

Fig. 14. Plan of residential floor with bedrooms (Aleksandrov et al., 2015)
The bedroom floor is connected with the living room floor by an internal staircase, siuated in a separate container

The suspended ceiling in the containers is formed by using the same skin-like covering. In this covering there are two pairs of wind turbines at different levels along the height of the facade.

Energy sources

The production of electricity for operational use in the building is ensured by:

– Wind turbines located in the “butterflies”;

– Water turbines powered by rainwater;

– Photovoltaic coatings;

– Solar air heating systems, warm air resulting from the greenhouse effect (occurring behind the space formed by the transparent suspended façade) that is than pumped by fans into the interior space of the cores containing the stairs and the elevators in the parallelepiped volume or in the spaces of the peripheral cores containing stairs and elevators, which service the round bodies where living and recreational modules are situated.

Composition

It includes seven round bodies and a parallelepiped with a rectangular base. In the left part of the plan there are two large round bodies with containers for residential use and two round bodies with smaller dimensions for relaxation and sport activities forming rotating swimming pools; above or below the pools are located changing rooms, saunas and massage or spa centers. The round structures for recreational use (along the height of the building) can be alternated with luxurious homes

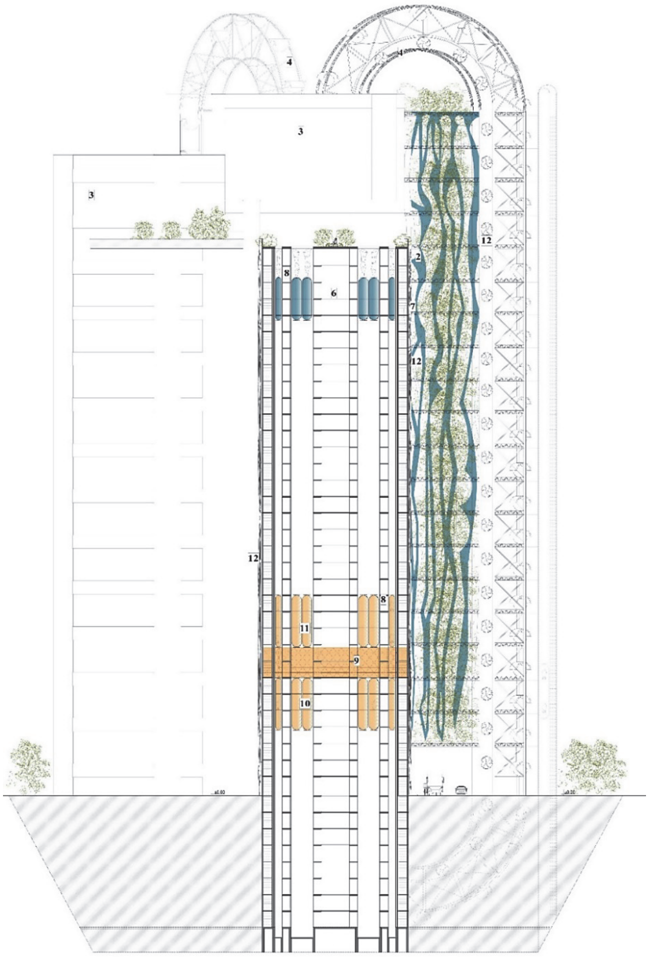

Fig. 15. Description of the positions on section A-A (Aleksandrov et al., 2015)

1. Vibration extinguisher (a "swinging" aquarium) 2. A "swinging" waterfall 3. Rotating water ring 4. Elliptic cabin elevator 5. Mobile ring for electric cars and containers 6. Mobile pathway 7. Suspended soft "butterfly" façade covering with integrated micro wind turbines 8. Cross-beam-structure walls, connected trough stiff joints to their adjacent floors or floor slabs 9. Mobile shuttering platform 10. Pushing three-story construction elevators 11. Pulling three-story construction elevators 12. Wind turbine

made of containers of two 90 m^2 floors with individual garden or water area. On the right side there are three other round structures for recreational use also with rotating pools. Two of those can be used (at specific floor levels) for luxury design utilization – the two floored housing containers with single garden or water area each. In the parallelogram are located containers for living. Directly beneath the levels with housing containers are situated the parking areas, schools, medical care, shopping areas, a rooftop greenhouse, etc. A warehouse for storing fruits and vegetables, grown in the greenhouse is located below the ground level. Soft waste goes through secondary treatment in the underground level, then, in processed form, it is used to fertilize the park and the plants in the greenhouse. Solid waste is collected in containers and then transported to landfills for storage and further technology processing according to its type.

Function of the Structural Cores

In the central cores of the round bodies (intended for residential use) are located the shafts, used for passing through the cabins, with approximate dimensions of 3.60 x 3 m. Those shafts belong to the oval wheel providing external access to the round structures for residential and recreational use. In addition to these shafts, there is a shaft for a big elevator (at least 6.60 x 6.60 m) in those cores, for transporting up and down the containers in need of replacement or for easy access to the residents' electric cars, stored in the garage with the help of an Automated vehicle storage & retrieval system (AVSRS). There is also a staircase and an elevator servicing the residents.The walls of the shafts are perforated to achieve equalization of the air pressure. To produce additional energy, there are wind turbines located in the perforated openings.

Installation Operations for the Elevator-Lifted Floor Slabs and Floors

First is mounted the top floor or the two top floors with a greenhouse located on top of them.

To their central core, using slabs are stiffly connected other peripheral cores, containing one staircase and two elevators; with the aid of these elevators, seven below and seven above, a round framework platform with a mounted container placed on it is pushed.

Note: All slabs and containers on the framework platforms are assembled on the ground level. The round structures where the recreational/sport areas are situated are made by using one central and several solid cores, containing a staircase and elevators.

Communications

All round fixtures are connected directly - through external cabins, hung on elliptical caterpillar-like raise with the help of gears and chains, allowing access to each floor.

Evacuation

Evacuation of the residents of the parallelepiped structure: by using 1 staircase and 8 elevators located in each core of each of the structures; these elevators lead to different areas - the garage levels, commercial areas, medical

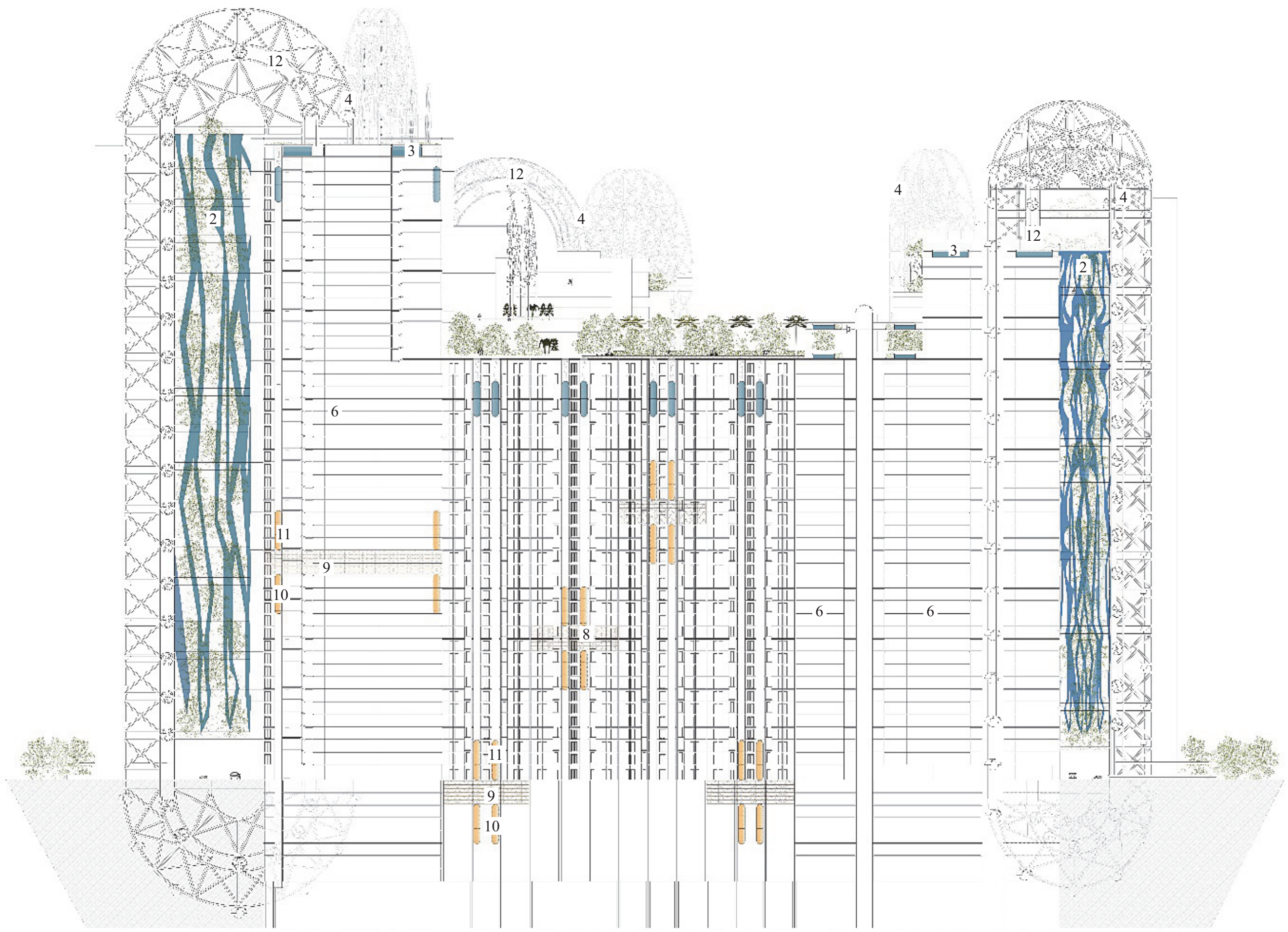

Fig. 16. Description of the positions on section B-B (Aleksandrov et al., 2015)
Vibration extinguisher (a "swinging" aquarium) 2. A "swinging" waterfall 3. Rotating water ring 4. Elliptic cabin elevator 5. Mobile ring for electric cars and containers 6. Mobile pathway 7. Suspended soft "butterfly" façade covering with integrated micro wind turbines 8. Cross-beam-structure walls, connected trough stiff joints to their adjacent floors or floor slabs 9. Mobile shuttering platform 10. Pushing three-story construction elevators 11. Pulling three-story construction elevators 12. Wind turbine

centers, kindergarten, the rooftop greenhouse and others. The evacuation of the residents of the round bodies is realized by using the peripheral cores, which also contain stairs and elevators; evacuation zones are located on every eight floor. These areas can be reached by stairs and then by evacuation elevators, thus one can get to ground level.

Conclusion

The project creates comfortable conditions for living and recreation, providing fast elevators operating by individual subscription, parking near the housing unit, commercial areas, medical services, kindergartens and various types of activities and facilities. This constructive solution meets the housing needs of underprivileged people and integrates them by making modern living standards affordable to them. In skyscrapers, the cultivation of fruits and vegetables as well as their storage on the areas situated directly above the containers adapted for inhabitation contributes in a unique way to the improvement of the living environment as fresh produce is available on site. The surplus of fruits and vegetables can be stored in the container chambers, situated in the northern part of the transportation corridor, and be sold to third parties. The internal spaces of the skyscraper, used for cultivation of fruits and vegetables eventually become an integral part of the urban environment.

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