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New forms for the development of agricultural product silos farms produced in arcology skyscrapers

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Abstract

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Possibilities for growing, storing cereals and producing products from them to feed the inhabitants of the «arcological» non-scraper were considered. They have been reviewed the silos in tall buildings of this type of "arcological" skyscrapers, as a new opportunity for the development of silo farms. In this connection, various forms of a new type of silos are described: horizontal silos; prefabricated container silos; inclined silos in horseshoe-shaped hollow elements; multifunctional "floor" silos; floor» silos with a height of one, two or three floors or with the height of an entire building. Constructions of the refrigerator-type containers for fruits and vegetables are given. Ways of producing the aqua products are described.

Described/used under invention patents: BG№ 111440A and BG66716B1 – System for individual or combined use of rainwater and hot waste water on each floor of a skyscraper; BG№111651A and BG№66823B1 – Movable refrigerating chamber for positive temperatures; BG№111658A and BG№66742B1 – System for solar heating of a cold room with positive temperatures.

*Keywords***:** new forms; development; silage farms; agricultural production; "arcological" skyscrapers

Introduction

Silage farms are an integral part of the structure of the so-called "arcological" skyscrapers. In the structure of these skyscrapers, apart from floors for living, working, recreation and areas for growing agricultural products – wheat, corn, as well as spaces/areas for growing fruits, vegetables, as well as vegetable gardens – are provided. Food production in the "arcological" skyscraper occupies an essential place in its structure. The term "arcology" combines architecture and ecology and was proposed by the architect Paolo Soleri in 1969. Then this architect tries to combine construction with environmental philosophy. (https://bgnes.bg/news/pogled-v-b-deshcheto-shche-zhiveem-li-nakoga-v-sgradi-gradove/) "... Especially the grain-processing plants can be arranged in the urbanized environment of the production areas in the settlements near the big consumer" (Vlasarev, D., Romanova I., Hristov V. (2023).

It should be taken into account that the "arcological" skyscraper is an element of the settlement and its inhabitants are a relatively large consumer of agricultural produce, both of fruits and vegetables, and also of aquatic products, which requires the development of their own production areas at the height of the building. This will greatly reduce the transportation costs of growing agricultural produce in the structure of this building, once, and secondly, it will also reduce the cost of transporting this produce to the production area of the settlement. Territorial planning for buildings and complexes of the food industry and agriculture (Vlasarev, 2014) is a prerequisite for considering the "arcological" skyscraper as a complex complex of areas – residential, office, recreation areas, as well as production areas for growing and storing agricultural produce, and fruits and vegetables, too.

It is quite possible that some functional units of the food industry are also located in the structure of the "arcological"» skyscraper. Medical care is also an integral part of the

specialized activities in this type of skyscraper to get a complete complete cycle for the needs of the residents. In this regard, «Application of solar energy for domestic hot water supply and air heating in a modular medical unit (operating room) in extreme situations» is particularly useful. (Patent BG66192 (B1) – 2011-12-30) (Alexandrova, 2011). The structural safety of the "arcological" skyscraper is closely related to its earthquake resistance, and this safety is guaranteed by the relevant regulatory documents (Tsvetkov, 2020). Prefab one-story buildings made of reinforced concrete elements can be used for construction on the roof areas of the "arcological" skyscraper, for example, to serve agricultural needs (Tsvetkov, 2019). Current architectural-constructive solutions of agrarian buildings (Mancheva-Velkova & Tsvetkov, 2017) may become an integral part of the "arcological" skyscraper. Special attention in specialized literature is paid to aquatic products, which in the expanded format of large-scale "arcological" skyscrapers occupies an important place. (Vlasarev, 2013) The evolution of industrial buildings is illustrated in "Industrial Architecture News" (Mancheva-Velkova & Tsvetkov, 2020).

Materials and Methods

The specialized literature discusses the characteristics of silos ((http://maxstone-bg.com/portfolio/) Silos are a type of building for permanent and long-term storage of agricultural produce, aggregates and others (Figure 1).

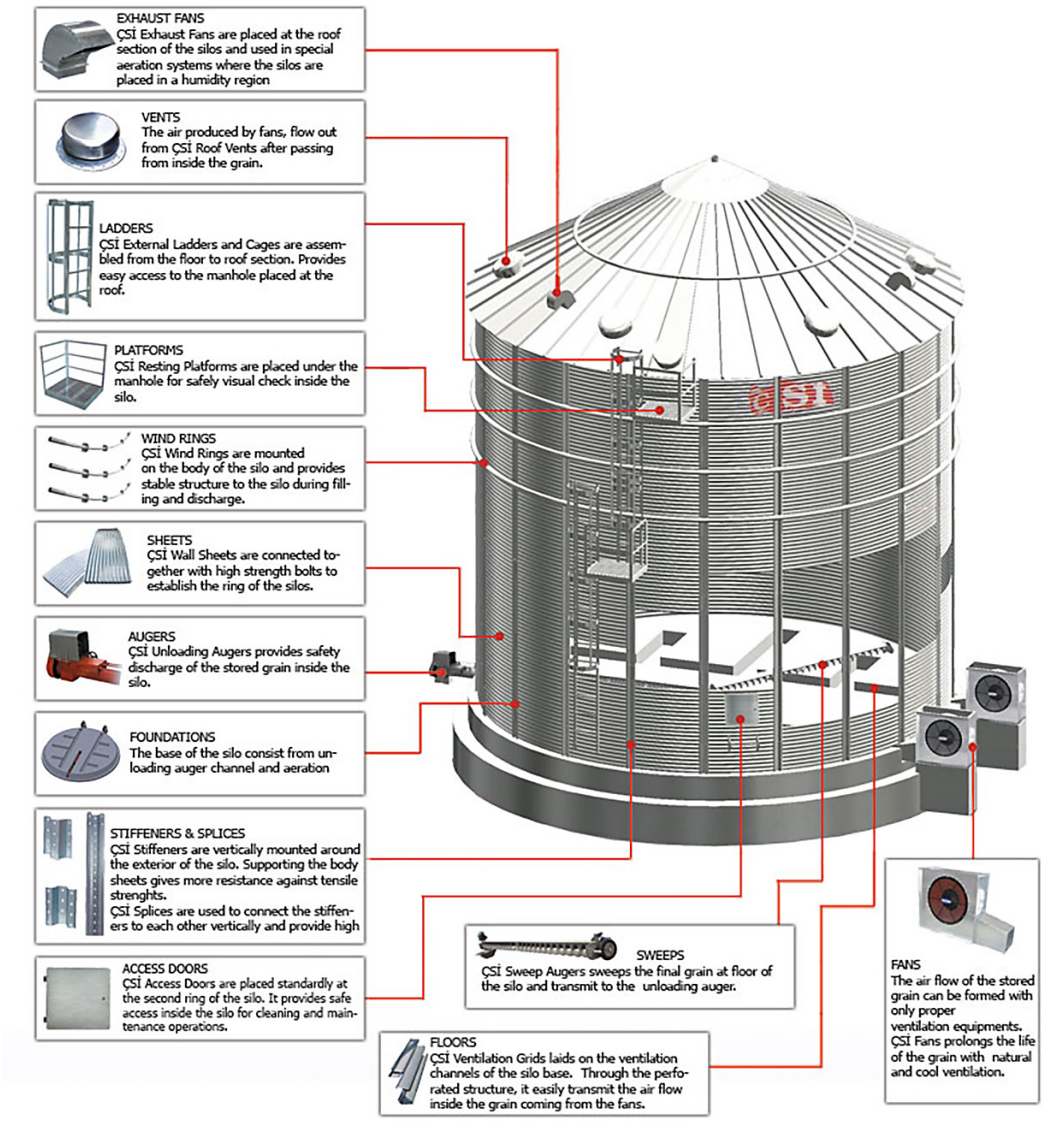

Fig. 1. Parts of a silo (http://maxstone-bg.com/portfolio/)

In practice, silos with a flat bottom, silos with a conical bottom, feed silos for livestock farms are used. (Figures 2, 3 and 4) Thermal control of grain in silos is essential.

Capacity of silos. Flat bottom silos have a capacity of 50 to 1000 t in different diameters and heights. Flat bottom silos range between 4.62 m and 26.60 m in diameter and with different diameters and heights from 50 to 1000 t. Conical bottom silos have a capacity of 1 to 1250 t. Fodder silos with a conical bottom for livestock farms – from 4 to 21 t. Quality Geomet 321 A coated bolts are used for the silos.

Fig. 2. Silos with metal construction
(https://elgroup-pleven.com)

Fig. 3. Construction of silo farms. Full mechanization
https://agrosalon.bg/mashini-za-zarno/Izgrazhdane-na-silozni-stopanstva-pylna-mehanizatsiya-oferta-9259.html?slink=agro-tehnika&page=

Attached bolts are isolated with epidyem washers. To provide sealing and insulation at the point of connection of the two sheets, the insulating tape (mastic) is used. The galvanized sheet covering of flat bottom silos consists of 350 g/m^2 or 450 g/m^2 galvanized sheets. The silos are designed in Eurocode 1-4, Eurocode 3-4-1 standards. (https://agrosalon.bg/mashini-za-zarno/Izgrazhdane-na-silozni-stopanstva-pylna-mehanizatsiya-oferta-9259.html?slink=agro-tehnika&page=)

Requirements for silos. Strong construction, roof load capacity, high snow load capacity, high wind and earthquake resistance, advanced technology to keep control. Air condition-

Fig. 4. Grain silos with conical bottoms
(https://www.google.com/search)

ing and grain cooling systems, grain level systems in the silo, control systems are used. Seed and packing lines, fruit dryers, seed decontamination machines are required. And more – grain dryers, grain cleaning machines, machines and equipment for grinding fodder and building fodder workshops.

Equipment of the silos. Silo equipment includes: elevators, redlers, rubber conveyor belts, manual and electric valves and gates, walkways, elevator towers, structures for forwarding silos above unloading, etc. (https://agrosalon.bg/mashini-za-zarno/Izgrazhdane-na-silozni-stopanstva-pylna-mehanizatsiya-oferta-9259.html?slink=agro-tehnika&page=)

Lines. Cleaning and screening lines, grinding lines, dosing and micro-dosing lines, mixing lines, pelletizing lines, packing and bulk loading lines, conveyors; spare parts for already existing old granaries. When selecting silos, the following are important: – technological requirements; – economic exploitation; – the quality of the resulting dry product, etc. Choosing the right grain dryer for drying is related to many factors. (https://agrosalon.bg/mashini-za-zarno/Izgrazhdane-na-silozni-stopanstva-pylna-mehanizatsiya-oferta-9259.html?slink=agro-tehnika&page=)

Modern Solutions for Underground Silos as Well

Adaptation for residential functions of an abandoned missile silo used to load intercontinental ballistic missiles (Figures 5, 6 and 7) https://it.dir.bg/tehnologii/silozat-kakvo-znaem-za-nay-dalbokiya-bunker-na-bogatite. It concerns an abandoned missile silo designed for operation in extreme conditions. "The 15-story bunker Survival Condo has its own vegetable gardens, mini mall, swimming pool, theater, library, school, gym, sauna, climbing wall, expensive liquor bar and 12 apartments for up to 75 people. He even has a prison ward, and in his warehouses there is water and canned food, enough for at least 3 years. The stocks are constantly renewed and are always fresh.

Waste Management

It occupies an important place in the operation of tall buildings. Characteristic of the "arcological" skyscrapers is the separate collection of different types of waste, their transportation and processing in order to form a new type of product and its application. Part of the food waste can be collected according to new waste-free technologies, by grinding, heating, drying and evaporation at high temperatures. In ground powder form, they are used to fertilize plants.

Results and Discussion

In the tall buildings of the "arcological" skyscraper type, an important place is occupied by the territories for growing agricultural products, which are extremely important for feeding the inhabitants. The storage of this production takes place in silos that must be adapted to the structure of this skyscraper. The various new forms of silos are closely related to the norms for their design. Depending on the needs of the residents and the areas available in the building, different planning schemes for the placement of the silos can be proposed.

Fig. 5. 15-story underground skyscraper. The scheme of the bunker
Photo: Survival Condo. (https://it.dir.bg/tehnologii/silozat-kakvo-znaem-za-nay-dalbokiya-bunker-na-bogatite)

Silos in high-rise buildings of the "skyscraper" type

Horizontal silos, such as storage farms (Figure 8)

"Horizontal" silos are like a freight train of tanks with different purposes, the tanks being tightly connected to each other. "Horizontal" silos, such as storage farms for bee products honey, fruit, bee pollen, wax, honeycombs, are provided in a skyscraper, as an independent bottom penultimate floor (Aleksandrov, 2020b). Through opening wings located in the shell of this type of silo, stored products are selectively accessible.

Fig. 6. Survival Condo gardens can provide always fresh vegetables
Photo: Survival Condo (https://it.dir.bg/tehnologii/silozat-kakvo-znaem-za-nay-dalbokiya-bunker-na-bogatite)

Fig. 7. Beach underground. The pool imitates a tropical beach. Photo: Survival Condo.
(https://it.dir.bg/tehnologii/silozat-kakvo-znaem-za-nay-dalbokiya-bunker-na-bogatite)

Fig. 8. Horizontal silo of four cylindrical segments
(https://www.vesdor.bg)

With the help of practicables, suitable for transporting bee families in hives, both their elevation and the elevation of the finished product from the warehouse of the "horizontal" silo to the upper last floor, accessible from the roof areas and located above it, is ensured (Aleksandrov, 2020b).

At low temperatures, the bee families are collected and stored in the storage farms of the «horizontal» silo with these practicals, and when collecting for grazing, they are taken out/ taken out with the same practicals to access plantations with honey products: rapeseed, linden blossom, thyme and others , located on the roof terrace of the «arcological» skyscraper or next to the plants from the environment (Aleksandrov, 2020b). Hives have wheels and stoppers for ease of transportation.

Horizontal silos – way of implementation

Pipes, the spaces of which are decided on at least two levels – the first level ensures the transportation of the product to a free place on a movable rubber conveyor belt; the free space is a place to store the product and it is located on the second level, above the level of this bar; with the help of a mobile crane, the product is lifted from this conveyor belt and left for storage in a free space of the second level; access is provided to both levels to control production, both when moving on the first level and when storing the product on the second level.

Access to both levels is via transport corridors which are internal and external. The internal ones are for charging and control. External ones are for selective access to a certain type of product. In this way, through doors-valves, the selected product is directly removed from the second level – for example, by weight, specific taste, smell and other characteristics. For this purpose, doors/valves are provided, through which, after opening, access is provided to select a certain pre-stored product for transport to the buyer.

The removed products are taken by freight elevator to the roof for transport by cargo drones, to the floors for internal operation by the residents or to the basement and ground floors for transport to the commercial network by ground transport.

Prefab container silos

– Silos for storing grains, flour, are included in containers located in close proximity to the production area at the height of the building (Aleksandrov, 2018b) Containers can be mounted on a grid, with the grid located in a protective casing. If necessary, this shell can also be transparent;
– Inclined silos in horseshoe-shaped hollow elements (Figure 9);
– Containers are also located in U-shaped hollow elements surrounding the body/building of the Hong Kong skyscraper (Aleksandrov, 2018a), as well as in the lowest floors of a bamboo skyscraper in Singapore (Aleksandrov, 2019b);
– The section in figure 10 shows a two-story solution of the U-shaped elements bent around the body of the skyscraper. Each of the floors can be used to store a different type of cereal, for example. The pipes twisted at the top of the skyscraper were used to collect rainwater and warm waste water. With the help of circulation pumps, heat exchange is carried out along circulation loops for heating the rainwater used for irrigation of plant areas, vegetable and fruit gardens, agricultural production.

The temperature of the warm wastewater is used to heat the rainwater; (Registration No. 111440 and Invention Patent BG66716B1 – System for individual or combined use of rainwater and warm waste water on each floor of a skyscraper). The silos are moved outside the volume configuration of the "arcological" skyscraper (Figures 11 and 12). The silos at their base, on the field, are combined with water areas for growing aqua products and algae. Analogous water areas are located on the roof of the skyscraper (Figure 11).

The spherical bodies are surrounded by bent silos located externally on (2 plus 3 plus 5 volumes forming a Fibonacci sequence). The "arcological" skyscraper is made up of these three independent volumes (Figure 13). Through a network located above the bent silos and composed of thin pipelines, it is planned to load individual sections of these bent silos with cereals. Along the routes, these crops are dried. On the other network, located under the bent silos, loading is provided on a lower horizontal floor, for example, for planting with corn, wheat.

Cereals are produced in horizontal sections located on the roof and on the floors. Horizontal bent silos for agricultural products are arranged in a circle around the periphery of the first floor of the "arcological" skyscraper in the Singapore project (Figure 14). Special containers are provided to store fish products, water as well as sand products like sugar, table salt, types of spices in modular units/elements which are inserted in the skyscraper gardens (Aleksandrov, 2020c).

Multifunctional "floor" silos

The silos are designed as multifunctional functional units, the walls of which are transparent in the upper part (to form a greenhouse effect) and are used for growing agricultural products, for example wheat, corn). At the same

Fig. 9. Arcology Skyscraper, Hong Kong. Silos with different slope and variable crosssection (Aleksandrov, 2018a)

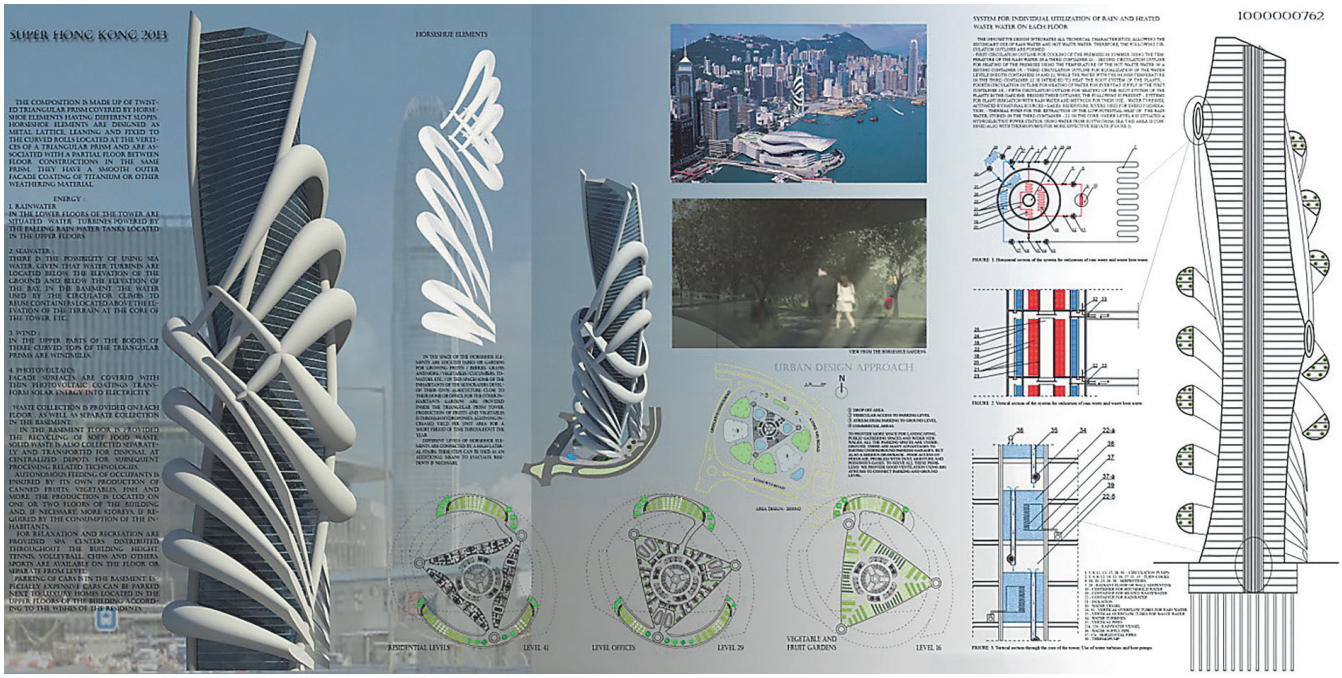

Fig. 10. Arcology Skyscraper, Hong Kong (Aleksandrov, 2018a)

Fig. 11. Arcology skyscraper, Mumbai, India. Silo with openwork metal structure (Aleksandrov, 2018b)

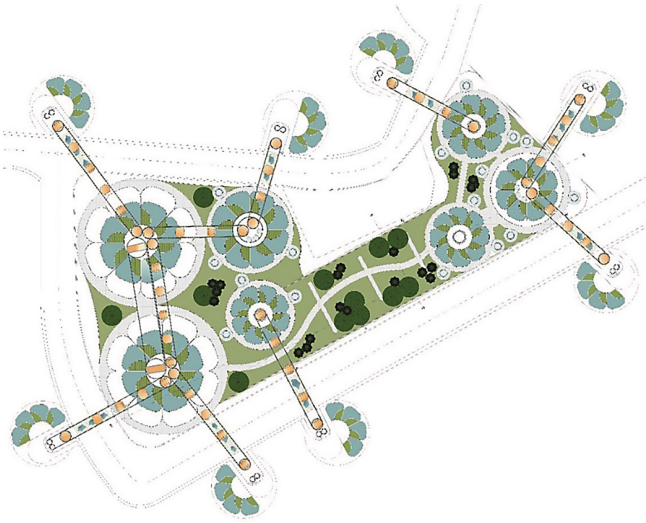

Fig. 12. Arcology skyscraper, Mumbai, India (Aleksandrov, 2018b)

time, their areas here may be larger in size than the areas of the other floors of the silo. In the middle floors of the silo is their processing and selection, and in the lowest part with solid walls, is the collection of processed products. This is followed by loading and vertical transport of this production to the mill, organized on a subsequent lower floor level.

On the floors located next to the field, the already packaged production of flour – white and black, as well as mixtures, which are ready for transportation to grocery stores from the urban territory of the settlement – is stored. Part of the production is intended for feeding the inhabitants of the «arcological» skyscraper (Figures 11 and 12).

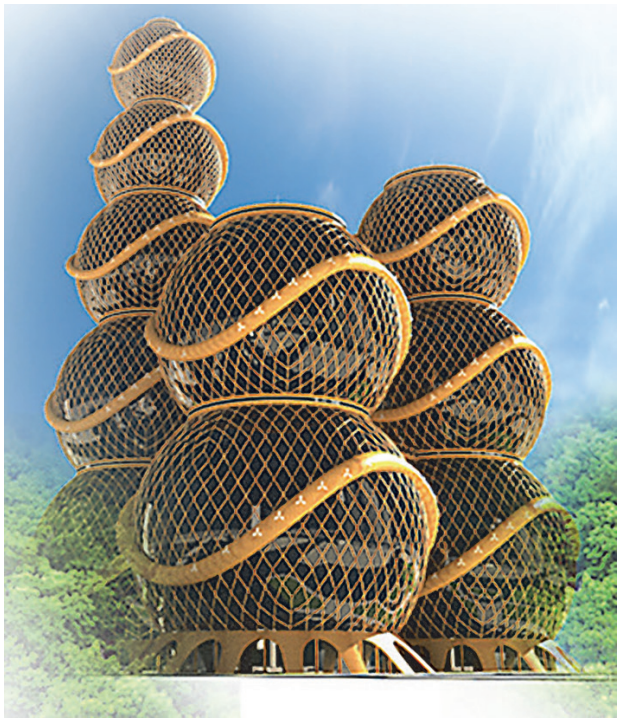

Fig. 13. Arcology Skyscraper, Singapore (Aleksandrov, 2020a)

"Storied" silos with a height of one, two or three floors

One-, two- or three-story "storied" silos are included in the spaces next to the container housing units in the Mumbai skyscraper (Aleksandrov, 2018b).

Storage farms in the form of vertical "story" silos are a means of bringing the food production/chain closer to consumers. Agricultural produce is grown on areas in the skyscraper, collected and processed in a separate floor level, and then stored in the corresponding floor silo (Aleksandrov, 2018b). Silos divided into floors with a pater noster elevator system for filling cassettes for storing specific products such as bee products: honey, fruit pulp, bee pollen, wax, honeycombs are provided in the skyscraper from Mumbai (Aleksandrov, 2018b).

Access to the storage "drawers" is by magnetic card for each user. In this way, there is an economy of useful area, of electricity, and at the same time a concentration of common activities in the skyscraper is realized. Consumption of packaged products is controlled using a computer program. Flat silos with a height of one, and in the case of maisonettes with a height of two or three floors, the silos being the height of these floors. According to the type of products, a selection is made and the corresponding positive refrigeration-technological mode is selected (for storing fruits and vegetables, root crops, etc.)

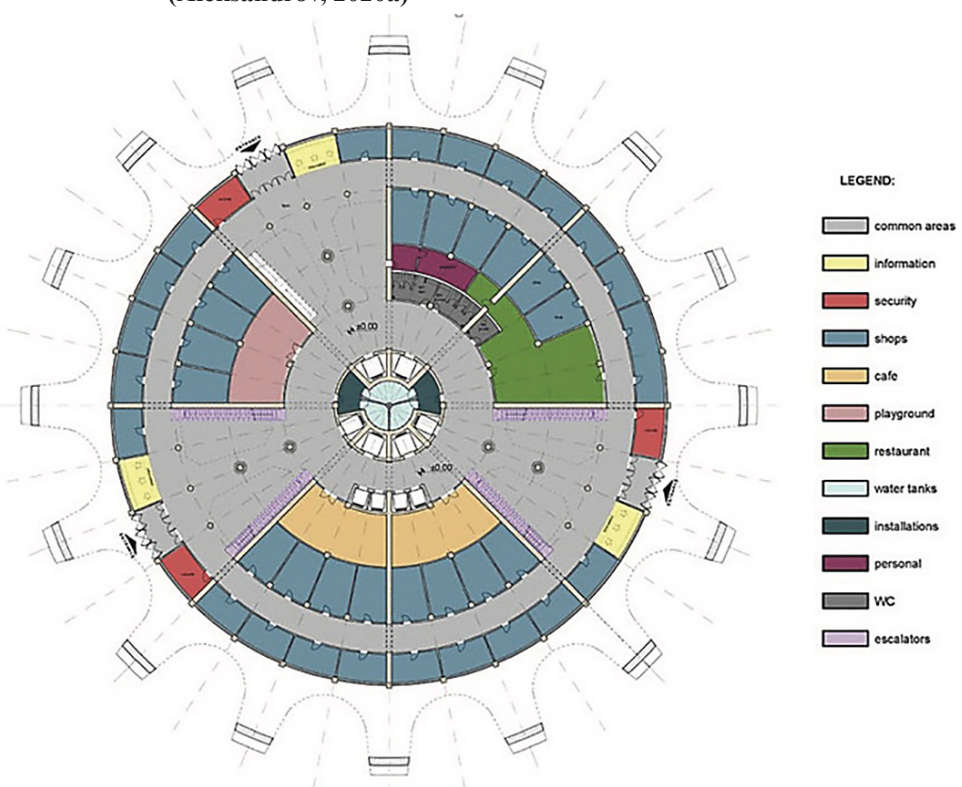

Fig. 14. Arcology Skyscraper, Singapore. Bent horizontal rings are located along the periphery of the ground floor (Aleksandrov, 2019c)

Bulk production, such as corn, wheat, seeds, flour and others, is transported by freight elevator to the upper end of the silos or with the help of cargo drones to the roof, and from there by the same freight elevator to this upper end.

Multi-story silos with building height

A horizontal circular silo at the base of the building is combined on both sides with two bent silos along its entire height. Wind generators are located on the outer shell of the two bent silos. The energy is also used to dry the grain, in the dryer for fruit collected from the orchards located in the core of the building, as well as to ensure a suitable microclimate (Figure 15).

Construction of the refrigerator type containers for fruits and vegetables

– Elastic protection against root impact on the walls is provided in a patented solution (Aleksandrov, 2017);
– innovative solutions with an inventive step (inventions and patented solutions) of chambers for storing fruits and vegetables according to the conditions of the specific unsolved tasks are given in chapter 6 of the NOVA publishing house of the USA (Aleksandrov, 2018c);
– "Transparent balloons" with a protective function are provided for closing the uppermost vertical silos (Aleksandrov, 2021). These balloons can also be installed laterally, if the silos are installed at one of the facades of the high-rise building, and at the same time they are double-skinned, with serving transport lanes located between the two skins.

Fig. 15. Arcology skyscraper. Kunming, China (Aleksandrov, 2020a)

Aqua products (Vlasarev, 2013)

- Aqua products are grown and stored in containers located on the ground floors of penthouses in the Kunming skyscraper (Aleksandrov, 2020a);
- Fluorescent algae are located in water containers in the elevator cabins and on the floors in front of the entrance to them (Aleksandrov, 2019a; 2019b);
- Aqua products are part of swinging aquariums in the Toronto skyscraper, (Aleksandrov, 2022) and the Mumbai skyscraper (Aleksandrov, 2018b);
- The aquariums are combined at the base with the silos of the "arcological" skyscraper. Mumbai (Aleksandrov, 2018b).

Transportation of overproduction from the skyscraper to other users

Produced products are transported to the roof terrace, adapted for the landing of cargo drones and to the ground floors of the skyscraper with storage farms for the selective storage of fruits, vegetables, aquatic products produced according to the plan for the distribution of the production cycle in the building and the area.

Conclusions

Silos in high-rise "arcological" skyscrapers are a new opportunity for the development of the future grain industry. Cultivating the produce within the structure of the skyscraper and storing it in bent and tilted horseshoe silos surrounding the body or bodies of the "arcological" skyscraper meets the production needs according to the architectural forms of the buildings.

New forms are proposed for the development of silo farms for agricultural production produced in "arcological" skyscrapers, where living, working, recreation environments are combined with the production and processing of food and products for the nutrition of the inhabitants. These forms of silos are suitable for new searches and solutions of "arcological" skyscrapers of different areas and technological schemes of performances.

Overproduction can be directed via cargo drones and

ground transport to the commercial network to reach the widest range of users in the population. It is also possible to exchange products between different "arcological" skyscrapers when meeting nutritional needs according to the needs of the residents. Future large cities of millions located in "arcological" skyscrapers will pose new tasks to solve, such as separate collection and treatment of waste,water supply for domestic and drinking needs, obtaining energy through artificial osmosis (salting with sea salt and mixing with fresh rainwater), transport – cargo and light, with drones – taxis, specialized medical care, growing algae at home, dryers for fruits and vegetables, areas for sports needs, indoor tourism in the complex with suitable areas for climbing, water sports, hiking and others.

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