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Skyscraper with vertical clusters consisting of modules that can be adapted for agricultural needs and other specific activities (education, medical care (COVID-19) and sports

Yanko Aleksandrov

University of Structural Engineering and Architecture "Lyuben Karavelov", 1373 Sofia, Bulgaria
Corresponding author: aleksandrov@vsu.bg

Abstract

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Specific points within the scope of the article's topic are covered, including: cluster definition, clusters in urban planning, vertical clusters, cluster modules, construction schemes and construction systems using the cluster modules. Completed vertical clusters are indicated as the subject of the article.

Innovations are given and a rationale is made for building vertical clusters in skyscrapers. Vertical clusters and cluster initiatives are examined. The vertical clusters in urban planning are described. Cluster boundaries are indicated.

The multifunctionality of signs – vertical clusters revealed by the similarity and self-similarity of the forms, as well as by the proportions of the building material – is considered.

A patented innovative solution with inventive step is reviewed (Patent number BG 66716 – "Systems for individual or combined use of rainwater and hot wastewater on each floor of a skyscraper"). "Floating" and "flying" skyscrapers as future forms of urban cluster development in the environment are examined. "Floating" and "flying" cluster forms are described as a possible answer to the future economic needs of society.

Mixed vertical clusters are analyzed according to the different functions of their floors meeting the needs of economic development programs. Various possibilities for functional independence of vertical clusters have been revealed (e.g. education, medical care and sports).

Medical clusters are considered within the scope of vertical clusters which can be used for the protection of the population in extreme situations (e.g. during COVID-19) as well as for offering general and specialized medical care.

The recommended cluster module sizes for use for agricultural needs and other purposes are given in tabular form. A special place is dedicated to the tensegrity structures as an element of clusters as well as the possible future trends for development of such structures.

Keywords: skyscraper; vertical clusters; modules; agricultural needs; specific activities

Introduction

Clusters occupy a central place in the organization of the resources of settlements. They are a powerful economic factor for regional development.

Term definitions

"Cluster is a union of several uniform elements, which can be considered as an independent unit possessing certain properties" (Wikipedia).

"Cluster (urban planning) is a territorial formation in

the metropolis, set apart as a relatively autonomous unit and providing its residents with a full range of urban functions (residential, administrative business, commercial, entertainment, recreational)".

The vertical cluster is a vertical territorial floor formation within the artificial material environment of the arcology skyscraper.

The cluster module is a repeatable autonomous unit within the arcology skyscraper, providing the residents with a relative completeness of a range of activities, their management, functional diversity and operation. The cluster module is distinct, pre-structured set of known and new urban functions, providing a fulfilling lifestyle for the inhabitants of the arcology skyscraper.

Construction, construction schemes and construction systems using the cluster modules

The construction is a fundamental moment in the realization of the artificial material environment. Concrete structural schemes are preferable when mastering the space in the arcology skyscraper. Their combination with load-bearing walls, such as earthquake washers, are a mandatory point in their construction. Large construction wheelbases are preferable, as they allow unhindered placement of furniture or equipment elements on industrial or agricultural sites. Blocked axes in skeletal construction systems are preferable when performing the supporting skeleton of the clusters. The three-dimensional clusters characterize the shape formation, and the two-dimensional clusters give an idea of the dimensions of the functional-planning solutions of the clusters. The arcology skyscraper is a complex of activities, developed primarily in the space of grid structural structures with skeletal and mixed structural schemes of vertical clusters, whose structural schemes have preferred concrete dimensions of the center axes of the supporting elements.

Material and Methods

Theory of clusters

The economic potential of clusters is highlighted as a specific form of cooperation (Oxford Research, 2008, Barsoumian et al., 2011; Slavova et al., 2018). "Clusters are a form of "self-organization" that offer competitive advantages" (Slavova et al., 2018, p.18). As well, industrial clusters and industrial cluster analysis are closely reviewed in the work of Stimson (Stimson et al., 2006). The thesis of the joint development of clusters and entrepreneurial activity has been developed as a possible powerful impulse for the economic prosperity of various regions (Delgadoa, M. et al., 2010).

Theory and practice regarding the cluster concept are developed in policy planning documents with examples from Latvia and Northern Cyprus (Garanti, Z. et al., 2014). The effect of the industrial cluster from the point of view of system dynamics is clarified as a kind of technology (Lin, C. et al., 2006). Moreover, horizontal and vertical cluster development are considered integral parts of territorial development and regional organization.

The subject of consideration in this article are the completed vertical clusters in the field of urban planning in the form of tall buildings of the arcology skyscraper type. They are intended not only for living, working and recreation but also for agricultural purposes – growing corn, wheat, buckwheat as well as fruits, vegetables and spices. In these clusters, floors for education, medicine, sports, etc. can be integrated in order to meet the needs of their residents. Service transport – air and ground – occupies an important place in the exchange of agricultural products. Food production occupies a fundamental place in the arcology skyscraper. The raw materials for this production are obtained by cultivation inside of the arcology skyscrapers.

Innovation

Various aspects of innovative solutions are discussed in the author's work (Aleksandrov, Y., 2021).

Arcology skyscrapers, as a new architectural structure, have a significant distinguishing feature – they represent clusters shaped by modular forms with their own construction which is subject to the modular coordination of their dimensions (Aleksandrov, Y., 2023). Innovative solutions with an inventive step are an integral part of the theme of this article.

Rationale for building vertical clusters in skyscrapers

Within large metropolitan cities, due to the lack of urban areas to form horizontal clusters, it is necessary to seek and explore other ways of developing in height using vertical clusters. A suitable way to solve the problem is a skyscraper with a structure of similar clusters, developed on the basis of modules of different sizes. Cooperation between different cluster owners remains in place, with self-organization aimed at discovering and using common financial resources according to project goals.

Vertical clusters

Vertical clusters create opportunities for communication of various activities with the help of technical means for vertical communication – elevators, ramps, stairs, escalators. Another important opportunity to connect with the outside world is modern transport drones, which are used to transport both raw materials and finished products.

A cluster initiative

Regarding the structure of the skyscraper, the cluster initiative researches, searches and creates a choice of technical solutions for each cluster both as a building and as a cluster. Their new shapes and sizes are tailored to the functional needs and technological features of their design tasks.

Vertical clusters in urban planning

Concrete floor clusters are grouped in height (3 + 5 + 7 volumes) (Figure 1). They are connected to each other by inclined connections for communication between the volumes. These connections – corridors, ramps, escalators – are also suitable for evacuation in the event of a fire in any of the connected volumes (Arcology Skyscraper, 2013). In the arcology skyscraper, the management of the vertical clusters can be concentrated independently in one volume, which can be positioned and deployed in different locations of the structure. According to the territorial separation and the purpose, different types of activities from the field of education, medical care and sport activities can be grouped in these concrete floor clusters (Velodrome Skyscraper, 2015). After being cultivated inside of the arcology skyscraper, the agricultural crops (wheat, corn, buckwheat), fruits and vegetables are stored in silos and containers which are also situated inside the skyscraper (Aleksandrov, Y., 2018c).

Fig. 1. Concrete floor clusters grouped and developed in height (Arcology Skyscraper Hong Kong, 2013)

Cluster boundaries

Cluster development is within the arcology skyscraper. Direct transitions from natural terrain forms – rock formations, forest hilly areas, to vertical floor clusters through covered galleries and corridors are also possible. In this way, some of the clusters merge with the environment. The integrated environment, located immediately next to the twisted part of the skyscraper and functionally connected to it (in principle, both next to us, but not with us) is a new design impulse towards a unique interpretation of the form of the stretched vertical cluster along the height of the twisted part of the building.

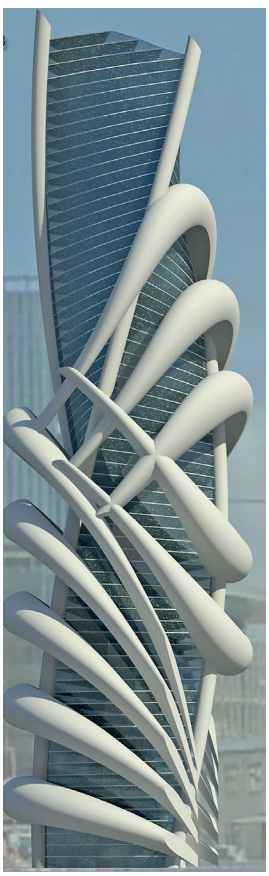

Fig. 2. Complete and prominent cluster in the field of urban planning. A skyscraper in Hong Kong

The development of the cluster is limited within the construction spot. The twisted form represents a group of bent U-shapes with variable cross-section (Figure 2). They are suitable for growing and storage in modular containers of agricultural produce, spices, fruits, vegetables, dried fruits, dried mushrooms and vegetables, spices. The vertical cluster can represent a type of stretched spring with an irregular shape, located outside the building, but within the scope of the building with other functions (Aleksandrov, Y., 2018a). Specialized medical care can also be sought in the space of

the highest U-shape, for example for treatment of COVID-19 and other forms of illness requiring isolation, or in the space of the lowest U-shape, where designated place for first aid is formed.

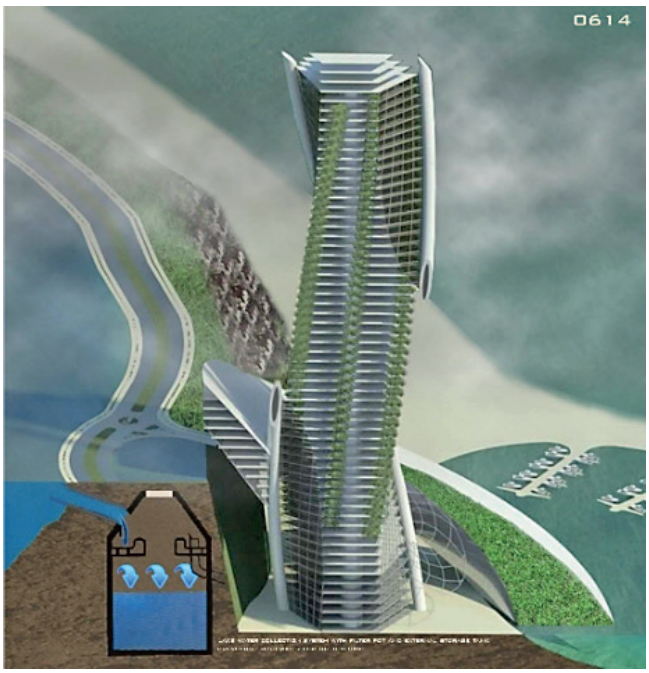

Fig. 3. Completed cluster in the field of urban planning. Skyscraper. EVOLO 2013 design competition

Fig. 4. Similarity of spread feathers in two rhythmic rows in dark and light brown

Fig. 5. Similarity in the shape of feathers in two rhythmic rows and in black and white

Direct insertion of a complete self-contained cluster is done, representing a twisted skyscraper in the environment, for example, a reservoir-dam at a higher level and a lake or sea at a lower level (Figure 3). Seasonal fruits are grown on the sloping roof of the low body – blackberries, raspberries, strawberries, spices, etc.

Results and Discussion

Multifunctionality of signs – vertical clusters revealed by similarity and self-similarity of forms. Building material proportions

The twisted skyscrapers have an innovative design which is achieved through the repetition of similar and self-similar forms, such as, for example, the feathers of birds spread out when they fly (Figures 4 and 5).

Repetition of identical floor forms twisted around the axis of the core of the skyscraper are shown in figure 3. There is a combination of an artificial material form with two significant natural factors – a dam and a lake or another natural body of water – a sea or an ocean.

At the tops of the plan, there are twisted one-dimensional ones, along which the rainwater flows to water collection vessels located in the core of the skyscraper. Water from the lower floors of the cores is pumped to the top floors of the skyscraper. The author has patented an innovative solution with inventive step – Patent number 66716; Systems for individual or combined use of rainwater and hot wastewater on each floor of a skyscraper (Aleksandrov, Y. et al., 2018). Vertical clusters need corresponding innovative technical solutions for technological services which are a determining factor in the formation of the building structure. Details occupy an important place in the formation.

Theoretical scientific research is accompanied by modern architectural solutions of "floating" and "flying" skyscrapers. In "floating" skyscrapers, vertical aquaculture production clusters under and above water are integral to the modern service of their inhabitants (Figure 6).

"Flying" skyscrapers are twisted structures with a central base with a fixed-landing and take-off core at the pointed

Fig. 6. Futuristic underwater skyscrapers made of ocean trash. (Dezeen, 2015)

bottom. Their shuttle-shaped shape with twisted ribs allows for a gentle flow of wind when moving through the air. The "flying" vertical clusters are moveable urban planning units in the aquatic environment dotted with numerous green islands (Figure 7). An autonomous lifting force detaches them from the earth's gravity, guides and ensures their movement in the environment.

Fig. 7. "Flying" skyscrapers by Vincent Callebaut Architects (Home Designing, 2010)

"Floating" and "flying" cluster forms

According to Figure 8, the production area is moved to the immediate vicinity of the completed cluster from the sphere of territorial organization and urban planning. The Skyscraper for London is adapted to a floating type for aquaculture production.

One half of the building is for living, and the other half is for growing fruits, vegetables, algae, providing food products for the residents. The building is filled with a soft facade shell, allowing the wind to flow around its shape. In the lower floors of the clusters, rotating rings are provided, with work offices located on them.

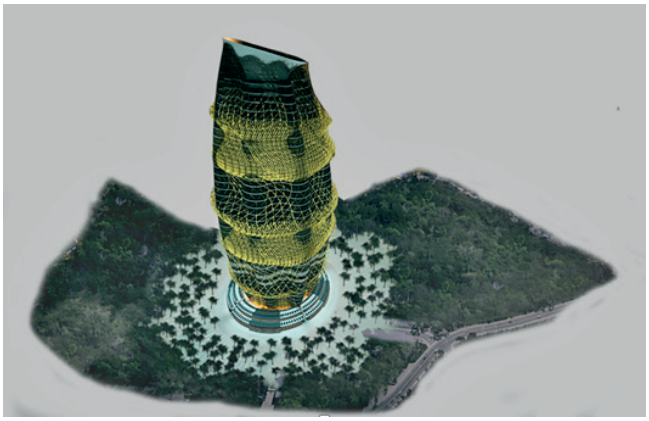

Fig. 8. Growing crops – olive forest, on a floating platform. The storied vertical clusters are hidden behind a soft facade shell (London Skyscraper, 2013)

Combining different forms of living with ways of eating according to the "next to us, but not quite with us" principle develops a new approach in the development of the vertical cluster. Their design changes episodically according to the requirements of the residents. The wall elements are of an assembled-detachable construction – columns and a folding soft partition wall made of transparent material, rolled up in a roll when disassembling. The new design is selected from the catalog and ordered to the manufacturer for replacement. Stability is ensured by the underwater part of the skyscraper, which includes enough floors for balance and for the production of aquatic products – algae, mussels, shrimps (Aleksandrov, Y., 2018d).

Mixed vertical clusters

Another possibility is related to the decomposition of the cluster into floor spaces for radically different functions – alternating two residential floors, for example, with two floors for agricultural needs in order to obtain food products. Or with floor spaces for production of food industry products.

Near Vienna, a residential complex was built on the area of an abandoned airport, where the main place is occupied by the so-called "shared affordable housing" with common kitchens and common spaces for living – communication about interests, children's play, quiet sports – chess. The aspiration is for a high density of construction of the complex of 5–7 floors, which in the case of construction with high-rise buildings will reflect a dense construction with vertical

clusters with different contents of the floors according to the function. Multi-story vertical modular clusters will be located per unit of built-up area.

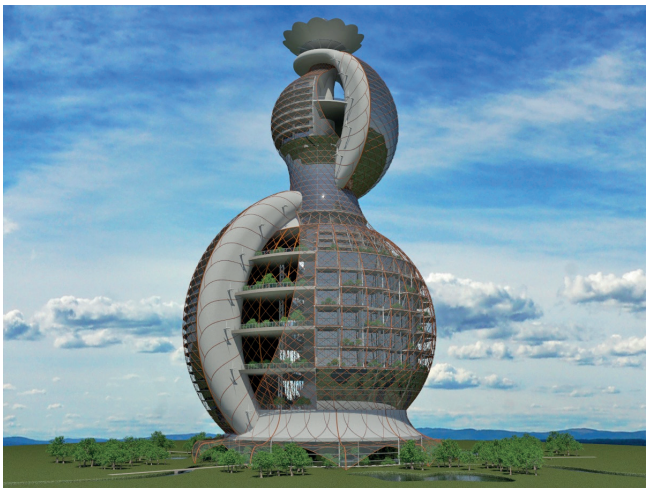

Fig. 9. Skyscraper, Kunming, China. Completed high-rise building-skyscraper cluster in the field of urban planning (Kunming Skyscraper, 2013)

Possibilities for functional independence of the vertical cluster

An example of a synthesis of activities in the field of the living environment, a work environment integrated with the production of fruit from own floor orchards, a vegetable greenhouse located in a smaller volume under the skyscraper cap, an environment for daily recreation in a fitness center located in the terraced gardens or next to them, as well as silos for storing agricultural produce. Cereals, such as corn, wheat, buckwheat, are stored in different compartments of the two oppositely located silos in a bent shape with variable width (Kunming Skyscraper, 2013).

A complete curved convex photovoltaic surface located on a facade, dissected by horizontal one-dimensional ones of different lengths and with equal one-dimensional ones located between them. The convex surface is framed by two bent thick one-dimensional ones of different thickness. There is a complete technical facility of the cluster – a building with modern innovative technologies. Wind turbines for generating electricity are mounted on the bent shape with variable pitch. On the roof, on the cap, there is a steam generator for obtaining hot water for domestic needs, and a wreath of parabolic reflectors is formed on the periphery (Aleksandrov, Y., 2020).

In the lowest horizontal part, there are fruit storage and cold storages, whose cold chambers are adapted to the refrigeration-technological modes of operation – for positive temperatures from plus 2° C to plus 12° C – for fruits and vegetables, for medium temperatures from -15° C for eggs and low-temperature refrigerators from -25° to -35° C for fish and meat.

Fig. 10. Vertical cluster – building. Skyscraper in Kunming, China (Kunming Skyscraper, 2013)

Professional educational clusters

Vocational secondary education is aimed at current and future cluster activities. Their sizes are selected according to the purpose and educational goals – botany, biology, chemistry or other disciplines, and are intended for professional service of the cluster groups in the structure of the skyscraper.

Fig. 11. Independent educational cluster of 6 planning modules (Africa Modular Schools, 2015)

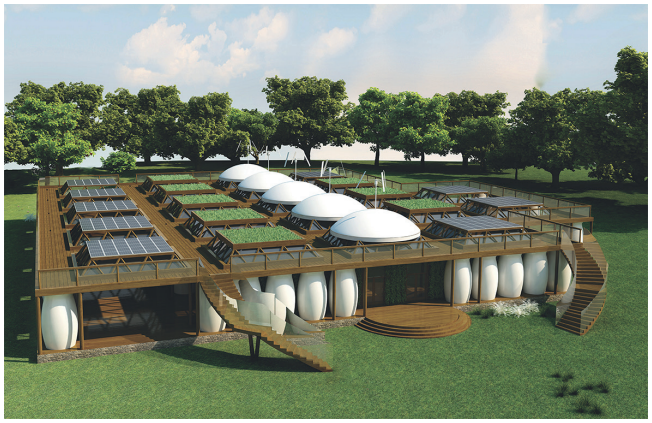

Fig. 12. Self-contained educational cluster of 22 planning modules located on the roof of the skyscraper. Test field of 9 green modules on the roof of the cluster (Africa Modular Schools, 2015)

Certain modules of specialized schools are located in a park environment on the roof of the skyscraper (Africa Modular Schools, 2015). Module sizes are variable (Figure 11 and 12, and Table 1).

The technical solution of the educational cluster modules should allow the assimilation of the educational initiatives with appropriate living comfort – air temperature and humidity, direct sunlight and in the depth of the premises, too. Interactive curtains and common shared spaces without desks and headboards with free choice position of the learners' bodies are used when learning the learning material (Figure 14). Since the cluster modules are located on the roof, the inclusion of water collection vessels in them allows the water to be used for drip irrigation of plants, as well as for sanitary and domestic needs (Figure 13).

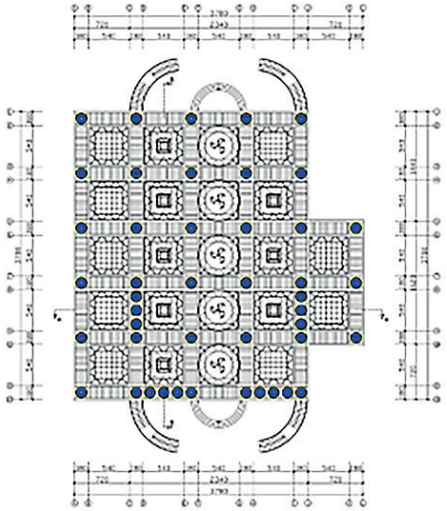

Fig. 13. Agricultural clusters on the roof of the skyscraper, made of modules with dimensions (180 + 540 + 180) of (180 + 540 + 180) cm

Fig. 14. A new interactive learning format under flowering vegetation, as part of a professional education cluster (Berlin School, 2017)

Medical clusters

Self-contained medical clusters are necessary with a very large population of arcology skyscrapers. They are specialized in treatment and recovery according to established norms for the management and management of medical care. Integration with sports procedures and sports grounds on respective floor levels leads to the creation of sports centers. Physiotherapy for medical purposes, massages according to Eastern recognized recipes will lead to rapid recovery of the body of the residents practicing the relevant restorative procedures.

The minimum required areas for operating theaters and operating blocks are discussed in the work of (Aleksandrova, L., 2016; Aleksandrova, L., 2009). These areas are an integral part of the independent medical clusters. "New innovations" are a factor in the development of a high degree of competitiveness of technical solutions and affect the quality of the living environment for living in the arcology skyscraper. Using natural energy sources for medical purposes, for example solar energy, is essential to obtain warm water and air for the needs of operating theaters and operating blocks especially in extreme situations, too. In this connection, patent BG66192 (B1) – 2011-12-30 was developed; "Solar energy application for hot water residential supply and air heating in a modular medical unit in extreme situations" (Aleksandrova, L., 2011).

Specialized clusters for veterinary medicine

Corners and areas located in the arcology skyscraper are provided for the treatment and rehabilitation of the pets of

Table 1. Preferred dimensions of the cluster space implementation modules

No	Axial distance between columns at the water vessel	Distance between columns of two adjacent vessels	Sample application	
			Main purpose of the cluster	For other purposes of the cluster
1	2	3	4	5
1	180 x 180 cm	540 × 540 cm	For growing spices, mushrooms in the basement of two-story modules	For primary schools, botanical kindergartens, FIG
2	180 x 180 cm	630 × 630 cm	For growing soft fruits and vegetables, storage of niche products in food located in the basement of two-story modules	For interactive schools without class- rooms, FIG
3	180 x 180 cm	720 × 720 cm	For a larger number of bee families	For medical purposes in case of pandemic
4	Note	Depending on the needs of each case, the dimensions can be changed every 30, 60, 120 cm.		

children and adults. It is proposed that they be located in a multi-story park environment. There are separate zoos on the garden floors, too. The height of the floors is adapted to the size of the zoo animals.

Use of the modules for agricultural clusters for other purposes

The dimensions of the module, consisting of four water vessels, where each vessel is located between four columns is a constant quantity, and the distance between two adjacent vessels is a variable. The dimensions are subject to the modular coordination used in construction (Table 1).

Tensegrity – the structure, as an element of the cluster

An artificial material environment was created using tensegrity – a structure composed of 7 rods with a net stretched over them. It is suitable for greenhouses-gardens, tourism-tents and for other forms with a free configuration, such as cages for exotic animals from the field of zoology (non-poisonous and dangerous). Important are the sizes determined by the functional purpose of the clusters – for growing fruits and vegetables, rare species of plants and others (Figure 15). Tensegrity – structures are executed on the floor slabs of the vertical cluster – primary basic unit. The technical implementation includes a combination of rigid one-dimensional forms (rods) with thin one-dimensional ones (strings or threads) of the network stretched over them. Threads have limited extensibility. When covered with thin transparent zippers or skins, an autonomous microclimate is created in a closed space under the net.

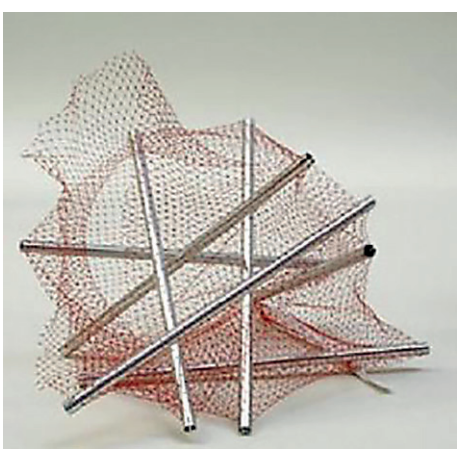

Fig. 15. Tensegrity – a structure of 7 rods with a network of thin strings or threads stretched over them

Possible future trends of development of the tensegrity structure

In modern or future implementations, it is envisaged that the rods are traffic arteries of inclined escalators, and the strings and filaments of the network, when properly oriented, are local paths, or streets and squares in another dimension and another scale.

At the entrances and exits of the hollow rods, fans are provided to blow filtered air, as a freshener of the interior spaces. The fans are located in funnels fixed to the inlet and outlet of each rod. Stiff rods have cavities, which are mechanized paths for rectilinear movement in different directions at different inclinations. These are escalators, driverless taxis, tram closed routes with automated opening and other future ways of movement. Openings for the exits and entrances of the drinkers are provided along the bars.

Of particular importance is the connection with the taxi drones to transfer from one type of air transport to a new specific ground one, which in this case is presented as rectilinear, but is in the area of the inner spaces of the rigid rods of the tensegrity structure.

It is obvious that in the field, under the skyscraper is the classic layout of the subway and subway stations. With the new solutions, areas can also be sought above the terrain, but with an appropriate choice of the structural scheme and the structural system for the placement of the construction elements necessary for the implementation of the arcology skyscraper.

In this regard, new construction technologies will be a factor in the materialization of the structures of each arcology skyscraper. The dimensions of the service territory predetermine the dimensions of the rectilinear rigid elements of tensegrity – the structure in the arcology skyscraper. Of course, air routes and connections for the movement of people, goods, medicines and other necessary attributes for the daily and normal life of the inhabitants are also possible.

An interesting example in this regard is a group of skyscrapers connected by circular, bicycle-wheel-type shapes, located at an angle to the core of the skyscrapers and connected to these cores by means of hollow horizontal spoke-type rods. Wind generators are located on the "spokes" (Figure 16).

Fig. 16. Skyscraper of vertical clusters spanned by circular "rings", carried by "spokes" and served by transparent elevators (Riga Skyscraper 2014)

Conclusion

The vertical clusters are with strictly fixed limits available within the artificial material environment of the arcology skyscraper. Their size depends on the functional purpose, the construction spot on the terrain, the location of the vertical clusters next to road infrastructure, next to water bodies, such as rivers, lakes, seas or oceans. After mechanical and chemical cleaning, the water from them can be used for drip irrigation of the floor vegetation located in the gardens.

"Horizontal" clusters develop within the framework of natural conditions and are created according to the characteristics of the territory – vineyard massifs, production of sunflower, corn, wheat (selected varieties), popular in the market for agricultural products.

Their boundaries are determined by the parameters of the natural sources – type of territory, water massif, vineyard massif, characteristics of the soil, temperature and humidity of the environment, annual sunshine.

The future transport should be in line with the latest trends for the development of the structure of the arcology skyscraper. High access to public transport with modern vehicles requires the development of appropriate infrastructure. In particularly large and expansive skyscrapers with internal courtyards or "cloud" openings (Zaha Hadid's Macao Hotel), landing pads for drone taxis, loading and unloading platforms for agricultural produce, as well as passengers should be considered. Medicines and to specialized medical personnel to provide urgent and rapid medical assistance.

In this regard, depending on the dimensions of the elements, the tensegrity structure allows free treatment of the spaces enclosed in them. Urban megastructures – megacities require modern policies for cluster management, where the arcology skyscraper of separate vertical clusters will have a particularly promising form of development. Clusters can be separated, as independent buildings, where each building carries a certain number of functions. If the clusters are separated, as concrete clustered floor volume modules, then they have different functions in the arcology skyscraper.

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