Bulgarian Journal of Agricultural Science, 27 (No 3) 2021, 625–630

Construction of green roofs and walls, hanging gardens and water cascade for an extension between the Alvar Aalto Museum and The Museum of Central Finland

Yanko Aleksandrov

University of Structural Engineering and Architecture "Lyuben Karavelov", 1373 Sofia, Bulgaria
E-mail: yanko.aleksandrov@live.com

Abstract

Aleksandrov, Y. (2021). Construction of green roofs and walls, hanging gardens and water cascade for an extension between the Alvar Aalto Museum and the Museum of Central Finland. *Bulg. J. Agric. Sci., 27 (3)*, 625–630

Integration of architectural forms into the environment requires appropriate selection of elements to achieve environmental sustainability and balance. Green roofs and walls, gardens and water cascades, as an integral part of the exterior and interior, are the main components used for the extension of between the Alvar Aalto Museum and the Museum of Central Finland. The transfer of environmental faults (mogs) in advantage (medium of heating or cooling after its liquidation), has been contributed to this. Other innovation solutions with combinations are integrated in The enlargement project between knowledge and new technical features allowing the use of: – solar energy for heating the internal three floor extension through "flooded balloons" with warm air, located on the roof; – the space closed between the two double umbrellas of the windows for making a warm air and the following discharge in the space of the expansion of two museums; – as a pipe net with different thicknesses and lengths of pipes filling the role of a sunny energy collector.

These innovative solutions provide a positive technical effect greater than or at least equal to the known world level.

Keywords: new solution; green roofs; gardens; water cascade; extension; Alvar Aalto Museum; Museum of Central Finland

Introduction

Creating new solutions without an inventive step or with an inventive step is essential to achieving original architectural creativity. The theory of innovative steps was developed by the author in his dissertation work "Innovative solutions with inventive step for elements to be used for the construction of chambers of storehouses and refrigeration warehouses" and is applicable to objects of all kinds: buildings, structures, technologies, details, interior spaces and other building elements.

This theory is described in a BJAS publication: "New solution – cultivation of soft fruits and vegetables in a super skyscraper in Hong Kong (Aleksandrov, 2018a) and was applied in the design of an arcology skyscraper in Hong Kong; in the container skyscraper project in Mumbai, India (Aleksandrov, 2018b) in the skyscraper in Kunming (Aleksandrov, 2020).

The theory of these steps was applied by Alexandrova (2011) in creating patents for inventions, too. For example: Patent BG66192 (B1) – 2011-12-30; „Solar energy application for hot water residential supply and air heating in a modular medical unit (operation theatre) in extreme situations".

Integrating green roofs, gardens and water cascades with other technical features that are part of innovative step-by-step solutions, such as solar air and water heating systems, whose tubular network covers the facade on all sides, or converting fog after condensation into plant irrigation agent in the interior, (Aleksandrov, 2018b), or collection of warm air in floor through “flooded balloons” create positive technical effect. This positive effect makes the architectural solution in a highly competitive product on the building market.

Geometric characteristics of the shape, its articulation, repeatability like, their arrangement, rotate, twist or translation combined with the latest building technologies, construction and new building materials lead to new aesthetic effects. Unusual combinations between technical features which are impossible and functionally useful, with formation of a new type, invite the environment with unique architectural works.

The greenery of the interior of the connection between the two museums is an integral part of the green system. “All green areas united in a green system as a whole, with development rules and norms, determine the integrity of the system of the development plan.” (Vlasarev, 2019).

Elastic sheaths are a practice in protecting the walls from panels of refrigerators. Transparent elastic sheaths are also widely used in the exterior of buildings (Aleksandrov, 2018b).

Their stretching on spatial structures or on tensegrity structures leads to an unexpected aesthetic effect and to a radically different form of emotional impact. In the specialized literature special attention is paid to the tightness and stability of tensegrity structures: the stiffness of tensegrity structures (Guest, 2011); stability of an elastic cytoskeletal tensegrity model (Lazopulos, 2005a); stability of an elastic tensegrity structure (Lazopulos, 2005b); the theory of basic tensegrity unit stable forming (Luo et al., 2017); geometrical stability analysis of cable-strut tensile structures (Luo, 2000).

Philosophy of the designs (Figures 1-10)

Design is an ever-evolving object and a way to understand the world and how one can change it. The work of Alvar Aalto is the cosmic intelligence of the universe. “The City Hall Building (Sainatsalo Town Hall (Finnish: Säynätsalon kunnantalo) has been accepted as the most important building that Aalto designed in his career (Weston, 1993); (Sainatsalo Town Hall) from Wikipedia, free encyclopedia 2019). Simple and laconic shapes, interpreted in brick and glass, contrast between dense and transparent parts, create a distinctive architectural appearance. The imprint of this striking style in the extension of the two museums is sought in its power. This power is reflected by the linear vortices modeled on the surface in front of the two inputs of the extension. Architecture, as a specific mental activity, is reflected in the design decision as a consistent and continuous information flow, reflected by the play of light and water vibrations in the water cascade, which penetrates the interior of the extension.

Essential details of the design (Yanko Aleksandrov, Liudmila Aleksandrova, Magdalena Mihaylova)

This is an international architectural competition for an extension between the Alvar Aalto Museum and the Museum of Central Finland, 2015.

The design makes an emphasis on several factors, crucial for the improvement and sustainable integration in the environment:

- Protection of the existing greenery and further development of inner green spaces, green walls and suspended ceilings;
- Collection of rainwater in special vessels and its use for irrigation of the inner greenery and for supplying the inner water source;
- The functional connections on several levels with the Alvar Aalto Museum and the Museum of Central Finland represent pathways with fluorescent covering;
- Sensors indicating the level of illumination of the inner spaces and controlling the fluorescent radiation of the pathways as well as the lighting and color shades of the water sources;
- Luminous railing of the two pathways, which connect the museums;
- A concise architectural image of soft forms, facilitating the perception of the outline from different points of view, whereas the forms in the plan are restricted by the configuration of the façade structures of the two museum buildings.

Inner walls of the cylindrical structure of the design

- The walls are static; – The walls of the cylindrical structure serve as screens to be used for projecting illustrations relating to the exhibitions in the Alvar Aalto Museum and the Museum of Central Finland;
- The walls are made of multi-layer electronic wallpapers with an integrated system for remote control allowing to demonstrate the visitors various stages in the creative work of Alvar Aalto;
- The images shown on the walls are dynamic;- The images shown on the walls can be easily changed and set in motion; – The images shown on the walls can move in various directions, e.g. from top to bottom, clockwise, etc. (Figures 1 and 2).

Fig. 1. General view of the extension between the two museums

Fig. 2. Situation of the extension between the two museums

The ceiling (Figures 3 and 4)

All floor levels have a suspended ceiling made of perforated transparent covering allowing for various plants to be integrated into its structure, thus serving as a natural extension of the green walls, whereas the roots of the plants are placed into pre-fabricated vessels.

Plants suitable for landscaping the interior of the extension of the two museums (Creeping and twisting plants, 2019[1]).

The use of hanging plants is recommended; of creeping plants on a grill of wooden anchorages, too, and Celosia Twisted Red, Cockscomb, because of its bright red color,

[1]https://www.sciencefocus.com/nature/how-do-climbing-plants-climb/

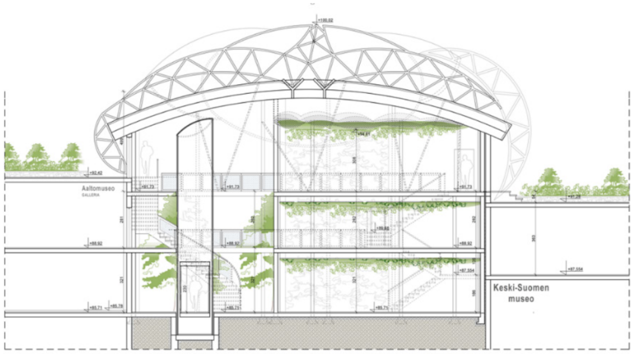

Fig. 3. Section B-B of the extension between the two museums

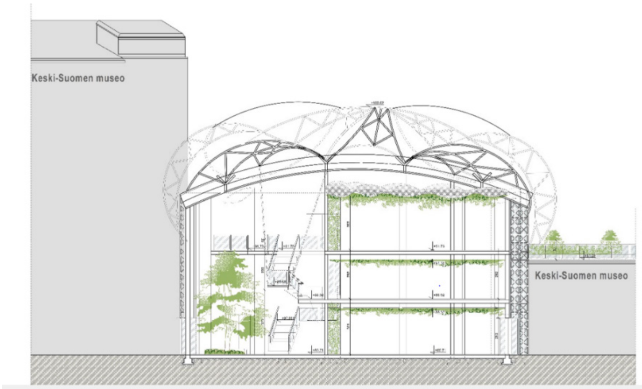

Fig. 4. Section A-A of the extension between the two museums

is well suited to emphasizing the green carpet of evergreen non-flowering plant species. “Adored for its fascinated red flowers, Twisted Red Celosia’s velvety, ruby blossoms are twisted with deep curly edges (Figure 5). “(https://sugarcreekgardens.com/product/celosia-twisted-red-cockscomb/)

Inner space of the extension

Two elevators with transparent casing ensure the unrestricted access to all levels of the connection, including the access of disabled persons and there is also a freight elevator. The height of the inner space is adapted to the height of the existing trees.

There are five entrance connections to the extension structure overall, two of them are situated in the eastern façade at ground level, one of them is situated in the western façade at ground level as well as two entrances to the roofs of each museum (one connecting with the roof of Alvar Aalto museum and one connecting with the roof of the Museum of Central Finland). Two pathways connect the two museums at different levels. The upper pathway represents a bridge, hanged on suspension ropes. These suspension ropes are

Fig. 5. Hanging plants; (https://palmibg.com/palzqshti-uvivni-rasteniq)

connected with the columns of the glazed façade as well as to the closest one of the four carrying arcs. The lower pathway connects directly via a bridge structure the second floor of the Museum of Alvar Aalto and the second floor of the museum shop, whereas the bridge structure leans partially on the floor plate of the shop (Figure 6).

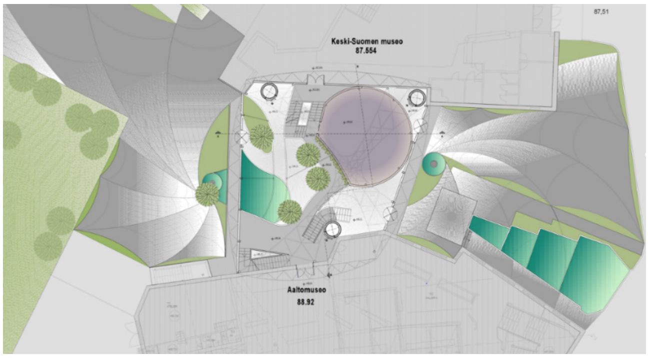

Fig. 6. Second floor plan; (on a level + 87.554 / + 88.92)

Museum exhibits, thematic exhibitions and museum shop

There are three floor levels in the museum extension situated in the cylindrical volume structure, which has its own carrying column framework and an elevator with a transparent casing. At the second floor level will be situated the storage space for the exhibition materials and the technical room, according to the project requirements. Over the third floor level is placed a corrugated suspended ceiling, resembling the wavy forms, present in many works of Alvar Aalto. The suspended ceiling plates will be perforated in order to allow the planting of greenery. At the second floor level next to the pathway a green wall will be built. All three floor levels can function entirely independent in case of need (Figure 7).

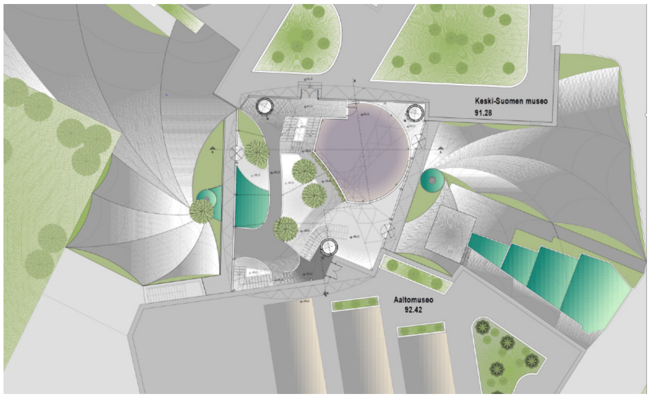

Fig. 7. Third floor plan; (on a level + 91.28 / + 92.42)

Constructional solution

The constructional solution is realized as hall cover – two pairs of inclined arcs are situated asymmetrically over the inner space. The arcs are made of wood and have a Y-shape of their cross section to allow for the gutter that will drain the roof construction to be placed. Between every two adjacent arcs are situated convex triangular shapes for the upper lighting. These convex shapes are made of rods.

A tensegrity-structure has been integrated in the solution – this structure leans on the arcs ad the terrain simultaneously and is situated in front of the glazed vertical surface of the walls, which have their own proper carrying construction with columns. In front of the tensegrity-structure and the four walls there is a transparent covering. This transparent covering and the glazed surface of the walls is conductive to the creation of a hot- house effect, which heats up the air inside. There are four dome-shaped elements with irregular integrated in the tensegrity-structure. The irregular dome-shaped elements are made of double-layer transparent polyketone, reinforced by transparent carbon fibers, whereas the two layers are connected by ribs. Over them are situated transparent thin photovoltaic coverings, allowing the accumulation of electricity to serve the needs of the extension. As well, the combination of the arcs and the tensegrity-structure allows the penetration of natural day- light in the inner space.

Pavement

The pavement is made as arc-shaped forms with central kernels, situated in front of the eastern and western facades of the extension respectively. On the roof, four oval-shaped "flattened balloons" hold warmer air. The balloons are of different sizes and are located above the upper illumination and are fixed to its construction (Figures 6, 7and 8).

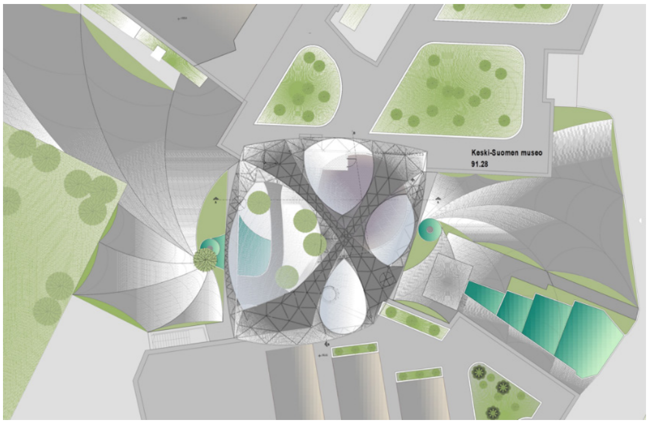

Fig. 8. Roofing plan of the extension between the two museums

Façade elements

There are oval application elements on both the eastern and the western façade which serve as advertisement installations where various information regarding the exhibitions of each one of the museums is displayed, i.e. monthly programs, exhibition highlights, etc. (Figure 9).

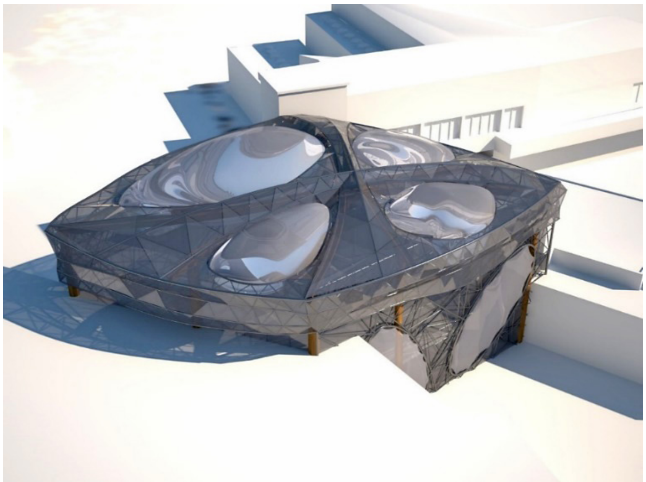

Fig. 9. Top view of the extension between the two museums

Under a double awning in the space of two forms formed by a double umbrella, a larger fan is forced into the outside air for heating by the sun's rays, which is subsequently fed through the nozzle into the inner space through a nozzle, which opens automatically at a fixed pressure level (Figures 9 and 10). In the skyscraper of containers for Mumbai, India, such fans are installed in the facade shell (Aleksandrov et al., 2018b). The smaller fan injects fog on a tubular radial mesh connected to a ring, which distributes the condensed fog by means of circulating pumps over a tubular network behind the transparent facade sheath. This radial pipe network encircles the building on all sides as a "circulatory" system whose branches are of different diameters and lengths. In addition to the distribution function, the network also performs a carrier function for the transparent facade sheath. At the floor, the network is connected to a lower circulation loop to drain the water droplets over the water cascade.

„Tensegrity structure is a new type of spatial structure system and is composed of discrete bars and continuous cables. Figure 10 shows examples of common single-layer tensegrity structures" (Yang, et al., 2020[2]). Tensegrit structures are preferred in the implementation of modern lightweight solutions of facade walls due to their smaller mass. „The lightweight nature of the structure is studied using the force-density relationship between the components, and the optimal structural parameter relationship is obtained when the structure has the lightest mass" (Yang, et al., 2020[2]).

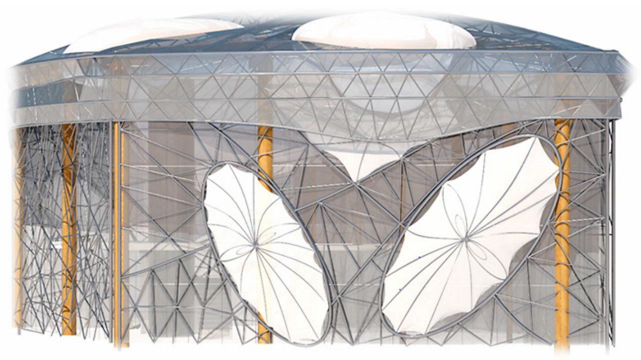

Fig. 10. Eastern facade

Conclusion

The green roofs and walls, the hanging gardens and the water cascade create a natural connection to the environment of the extension between the two museums. Unexpected combinations of known and new technical features, subject to new connections, turn the mist after condensation into a means of drip irrigation for hanging gardens, and warm air in the "flattened balloons" of the roof as a means of maintain-

---

[2] Journal of Aerosp. Technol. and Manag., 12, e2620. https://doi.org/10.5028/jatm.v12.1118

ing the thermal comfort of the interior of the extension. The linear vortices, modeled on the surface in front of the two inputs of the extension, make a strong mark on the overall solution.

The conceptual innovative design, developed as a unity of building technology, construction, building material, function, form and modern innovative technologies for energy self-sufficiency, reveal the contemporary vision for the expansion of the two museums. The material forms of this extension interpret the spirit of Alvar Aalto's creativity, an earthly projection of the aerospace of an new architectural industry, a projection that has left a clear mark on 20th-century architecture.

References

Aleksandrov, Y. (2018a). New solution – cultivation of soft fruits and vegetables in a super skyscraper in Hong Kong. *Bulg. J. Agric. Sci.*, *24(1),* 151–157.

Aleksandrov, Y. (2018b). New solution – Cultivation and storage of soft fruits and vegetables in chambers of the "containers" type with positive temperatures (Container Skyscraper, Mumbai, India). *Bulg. J. Agric. Sci.*, *24(2),* 326–334.

Aleksandrov, Y. (2020). New solution – fluorescent fish aquariums located in building elements and furnitures of the skyscraper Kunming, China. *Bulg. J. Agric. Sci., 26 (2),* 332–338.

Aleksandrova, L. (2011). Liudmila Aleksandrova. Patent BG66192 (B1) – 2011-12-30, Solar energy application for hot water residential supply and air heating in a modular medical unit (operation theatre) in extreme situations. Classification international F24J2/42; cooperative: Y02E10/40. www.espacenet.com

Guest, S. (2011). The stiffness of tensegrity structures. *IMA J. Appl. Math. 76(1),* 57- 66.
https://doi.org/10.1093/imamat/hxq065

Lazopulos, K. (2005a). Stability of an elastic cytoskeletal tensegrity model. *Int. J. Solids. Struct., 42(11-12),* 3459-3469. https://doi.org/10.1016/j.ijsolstr.2004.11.008

Lazopulos, K. (2005b). Stability of an elastic tensegrity structure. *Acta Mech., 179(1-2),* 1-10. https://doi.org/10.1007/s00707-005-0244-0

Luo, A., Liu, H., Skelton, R. & Che, S. (2017). The theory of basic tensegrity unit stable forming. *Chinese J. Mech. Eng., 53(23),* 62-73. https://doi.org/10.3901/JME.2017.23.062

Luo, Y. (2000). Geometrical stability analysis of cable-strut tensile structures. *J. Zhejiang Univ-Sc., 27(6),* 608-611.

Vlasarev, D. (2019). Functional – aesthetic role of the green system in industrial areas. First ed., Sofia, ISBN 978-954-331-106-4, Avangard Prima,100.

Weston, R. (1993). Town Hall, Säynätsalo, Alvar Aalto. London: Phaidon Press Limited.

Yang, H., Liu, R; Luo, A., Liu, H. & Li, C (2020). Force density relation and lightweight modeling of single layer tensegrity structures. *Journal of Aerosp. Technol. and Manag., 12,* e2620. https://doi.org/10.5028/jatm.v12.1118

Received: April, 30, 2020; *Accepted:* December, 23, 2020; *Published:* June, 2021