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Tensegrity Structures

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Abstract*— The development of spatial constructions since the second half of the 20th century took place simultaneously through several complementary processes: affirmation of new materials with experimental-theoretical confirmation of their properties, referential for certain elements of architectural and construction objects; development of methods (theory) of computational verification of structural elements and their assemblies. Development of appropriate software that accelerated the budgeting process, with the possibility of quickly checking a large number of solution variants; the realization of individual architectural and construction objects (in economically strong parts of the world) which by their appearance have become new symbols of cities (and entire nations), and as such – an inspiration for others; innovative work of creative individuals who are able to anticipate the near or distant future with their ideas (theories, patents) based on the assessment of the present moment (the state of any science, philosophy, practical action); the introduction of computers into architectural design (first as an effective 'aid' in drawing architectural plans, and later also in the process of 'imagining' and designing architectural forms. A special discipline, 'computer-aided design', is established in schools of architecture. Once the needs of people (scientific expeditions in different climatic conditions, for example), life in conditions of natural disasters, life in war conditions, imposed special requirements for certain architectural programs (limitation of physical dimensions, speed of construction, assembly-disassembly-repeated use, possibilities of transportation to the desired location, materialization, cost of construction, material recycling).*

Keywords*— Tensegrity Structures, Buckminster Fuller, Kenneth Snelson.*

I. INTRODUCTION

The development of spatial constructions since the second half of the 20th century took place simultaneously through several complementary processes:

a) Affirmation of new materials (reinforced concrete, steel, aluminum, laminated wood, synthetic materials) with experimental-theoretical confirmation of their properties, referential for certain elements of architectural and construction objects [1,2,3,4,5,6,7, 8,9,10,11],
b) Development of methods (theory) of computational verification of structural elements and their assemblies. The development of appropriate software that accelerated the calculation process, with the possibility of quickly checking a large number of solution variants [12],
c) Realization of individual architectural and construction objects (in economically strong parts of the world) which by their appearance have become new symbols of cities (and entire nations), and as such - an inspiration for others [13],
d) Innovative work of creative individuals who are able to anticipate the near or distant future with their ideas (theories, patents) based on the assessment of the present moment (the state of any science, philosophy, practical activity) [14,15,16,17,18, 19,20,21,22,23,24,25,26,27],
e) Introduction of computers in architectural design (first as an effective 'helper' in drawing architectural plans, and later in the process of 'imagining' and designing architectural forms. A special discipline, 'computer-supported design') is established in schools of architecture.

In the past, people's needs were determined (scientific expeditions in different climatic conditions, recreational stays in nature, mobile exhibitions, mobile art and entertainment events, periodic gatherings for religious and cult reasons, construction work on strategic infrastructure and energy projects far from any settlements), life in conditions of natural disasters, life in war conditions imposed special requirements for certain architectural programs (limitation of physical dimensions, speed of construction, assembly-disassembly-multiple use, possibilities of transportation to the desired location, materialization, cost of construction, recycling of materials).

The enormous popularity of sports, and especially its manifestation through world and regional competitions (Olympic Games, world championships, continental championships), requires arenas with large capacities for spectators, and more recently arenas that are not only covered, but completely closed and conditioned [14].

The industrial and modern era from the end of the nineteenth and the beginning of the twentieth century introduced new values into private and social life, which are still being generated [13]:

- think quickly, decide quickly, act quickly (all summed up in the maxim 'time is money'),
- profit is a measure of success (the lower the input, the higher the output gives the 'minimax' effect),
- recognize the real needs of a large number of people (or invent needs and impose them on a large number of people as their real needs, and at the same time 'be the first',
- to be able to do something that no one else can do ('be a record holder'),
- be present as much as possible in public media (means 'to be someone'),
- to possess something that others do not have (means 'to be exceptional')...

Architecture is the framework of life and as such a more or less legible image of both the individual man and his narrower and wider collectivities.

The term 'Tensegrity' appeared at the beginning of the second half of the 20th century. Regardless of its immanent attachment to constructions (in architecture, construction, everyday objects of use), it is a product of the totality of human activity in the first half of the 20th century [2,15,20,21].

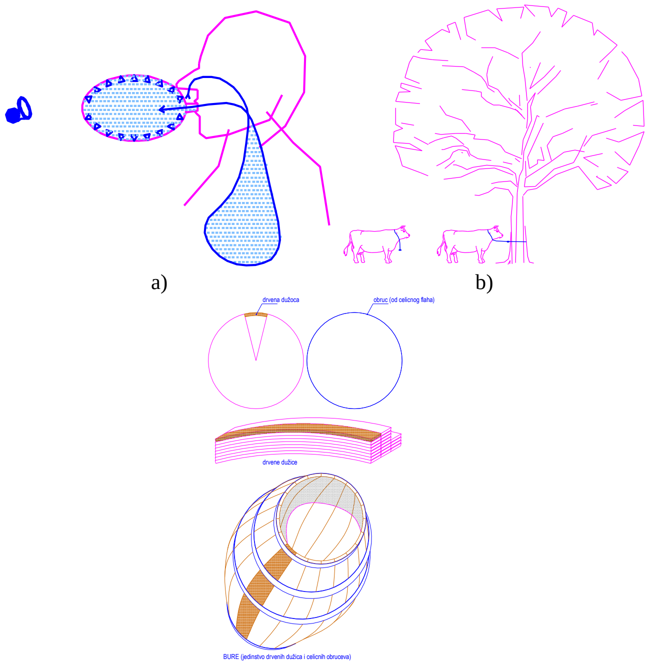

Figure 1. Examples of tensegrity constructions in everyday life: a) 'crumpled' and inflated balloon, b) free-bound animal, c) wooden strips and steel hoop (wooden barrel)
Source: Author (Drawings, 2007)

II. Tensegrity structure

Etymologically, the word 'Tensegrity' was created by the integration of the terms[1] 'Tensional' and 'Integrity', and could most simply be understood as 'unity of tension' (Figures 1,2).

No term in architecture (in construction and in many spheres of practical human activity), from the middle of the 20th century until today, has been subject to as much interpretation as the term 'Tensegrity'. More than that, even today there are debates about who is the author of this term and who first made[2] the 'Tensegrity structure'.

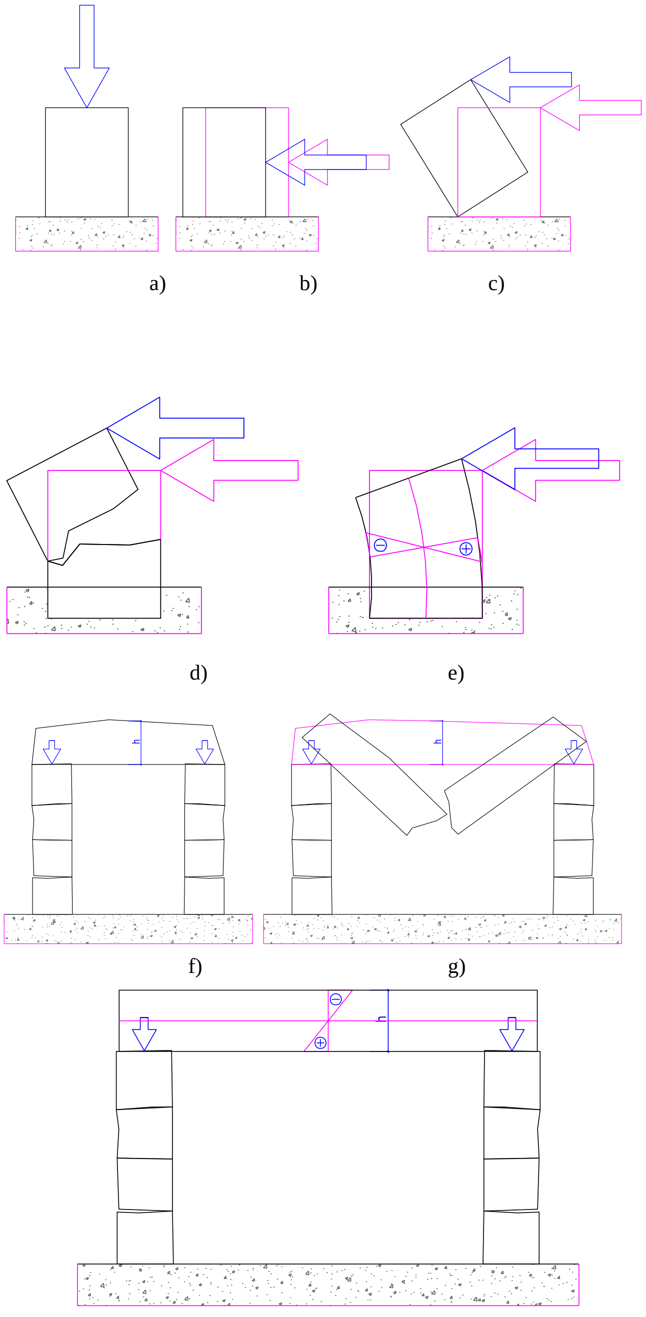

Figure 2. Understanding (and 'searching' for tensegrity constructions in architecture (building)
Source: Author (Drawings, 2007)

In fact, the essence of the term 'Tensegrity', in a purely technical as well as in a philosophical sense, is present in architecture, in man's everyday life and actions, in nature at every step (Figures 3,4), as the basic essence of the existence of things[3].

[1] Tensional, English: tense, tension. Integrity: English: integrity, unity.

[2] The builder of the first 'Tensegrity structure' is considered by many to be the sculptor Kenneth Snelson, and his sculpture 'Needle Tower' (1968), the first built 'Tensegrity structure'. Himself pressed by the controversies surrounding this issue, Snelson, at the request of Mr. R. Motro, gave a written interview for the International Journal of Space Structures, November 1990, in which he described in detail the history of the 'Tensegrity structure' issue. In this interview, Snelson attached an excerpt from a personal letter (dated 12/22/1949) sent to him by B. Fuller, in which Fuller himself confirms Snelson's originality:

..."In all my public lectures I speak of your original demonstration of the advantages of discontinuous and continuous stressed construction; - the emergence of a prototype construction, ready reproduction, which, deftly incorporated into basic structures, can accelerate the spontaneous goodwill and understanding of mankind. The event was one of those an event "happened", but it demonstrates how important events happen where the atmosphere is most favorable. If you had demonstrated this structure in front of an artistic audience, it would not have impressed them in the way it did me, who was in search of such a structure in energy geometry. That you were excited about what came next shows how important the faith of colleagues is in what you do. The name Ken Snelson will become known as the name of a true pioneer of realized good life and good will".

Source: http://www.grunch.net/snelson/rmoto.html, Accessed: 12.21.2022.

[3] The Universe was created on the principle of 'unity of opposites': day-night, hot-cold, positive-negative (atom structure). Man's value system is based on distinguishing opposites: good-evil, moral-immoral, rich-poor. Hegel's dialectical idealism is based on the opposition of thesis-antithesis, where

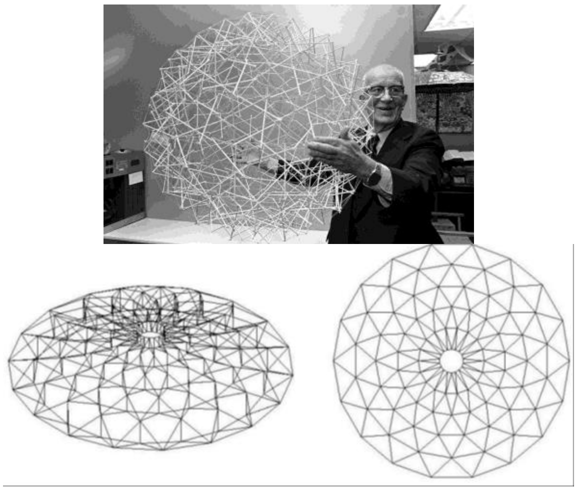

Figure 3. Some Tensegrity structures by R.B. Fuller
Source: https://www.pixelandtimber.com/consilience, Accessed: 12.20.2022.
https://pure.tue.nl/ws/files/46913415/749437-2.pdf, Accessed: 12.20.2022.

Figure 4. Tensegrity structures in the living world of nature
Source: https://prezi.com/3s9hhg5ubj7o/tensegrity-in-nature-amp-architecture/?frame=44c69bdfd04d5664c49a39b822d61a9d17cc1f54
Accessed: 12.20.2022.
https://prezi.com/3s9hhg5ubj7o/tensegrity-in-nature-amp-architecture/?frame=c8f172be54d19012b61fa5137d2ac2e855a41ab6
Accessed: 12.20.2022.

By looking at the list and content of the patents[4] of the American inventor Richard Buckminster Fuller, by reviewing the realized structures that he designed, one can get an insight into the extent to which he was dedicated to the search for new principles of construction, design and materialization both in architecture and in everyday life.

Fuller explained the term 'Tensegrity' as "Synergy between compression and tension". 'Synergy' implies a 'system' made up of components that, in the unity of pressure and tension, stabilize each other, in a new quality [21].

R.B. Fuller's thought is famous: "Don't fight forces. Use them! Although it has a philosophical-universal depth, it is the best guide for understanding 'Tensegrity structures'. Tensegrity constructions (structures) are the ultimate 'pure solutions' of a system (form) whose elements (components) with their best properties are arranged within the system in a way that makes the maximum possible contribution to the unity of the system. Each component of the system is at the same time independent by its specific properties and an indispensable part of the system, without which the system would fall apart[5]. Each tensegrity construction (by definition)

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synthesis is their unity, with new attributes. Korean traditional philosophy is based on the Ying-Yang opposite.

[4] Complete list of R. Buckminster Fuller's patents (28 patents, 1927-1983):

1. Stockade (Building Structure) June 28, 1927 , U.S.A. Patent No. 1,633,702
2. Stockage (Pneumatic Process) June 28, 1927, , U.S.A. Patent No.1,634,900
3. 4D House April 1, 1928 , U.S.A. Patent No. 1,793
4. Dymaxion Car December 7, 1937 , U.S.A. Patent No. 2,101,057
5. Dymaxion Bathroom November 1940 , U.S.A. Patent No. 2,220,482
6. Dymaxion Deployment Unit (sheet) March 7, 1944 , U.S.A. Patent No. 2,343,764
7. Dymaxion Deployment Unit (frame) June 13, 1944 , U.S.A. Patent No. 2,351,419
8. Dymaxion Map January 29, 1946 , U.S.A. Patent No. 2,393,676
9. Dymaxion House (Witchita)
10. Geodesic Dome June 29, 1954 , U.S.A. Patent No. 2,682,235
11. Paperboard Dome April 14, 1959 , U.S.A. Patent No. 2,881,717
12. Plydome September 22, 1959 , U.S.A. Patent No. 2,905,113
13. Catenary (Geodesic Tent) November 24, 1959 , U.S.A. Patent No. 2,914,074
14. Octet Truss May 30, 1961 , U.S.A. Patent No. 2,986,241
15. Tensegrity November 13, 1962 , U.S.A. Patent No. 3,063,521
16. Submarisle (Undersea Island) March 12, 1963 , U.S.A. Patent No. 3,080,583
17. Aspension (Suspension Building) July 7, 1964 , U.S.A. Patent No. 3,139,957
18. Monohex (Geodesic Structures) August 3, 1965 , U.S.A. Patent No. 3,197,927
19. Laminar Dome August 31, 1965 , U.S.A. Patent No. 3,203,144
20. Octa Spinner March 17, 1965 , U.S.A. Patent No. Case No. - 349.021
21. Star Tensegrity (Octohedronal Truss) November 28, 1967 , U.S.A. Patent No. 3,354,591
22. Rowing Needles (Watercraft) August 17, 1970 , U.S.A. Patent No. 3,524,422
23. Geodesic Hexa-pent May 14, 1974 , U.S.A. Patent No. 3,810,336
24. Floatable Breakwater February 4, 1975 , U.S.A. Patent No. 3,863,455
25. Non-symetrical Tensegrity February 18, 1975 3,866,366
26. Floating Breakwater January 30, 1979 , U.S.A. Patent No. 4,136,994
27. Tensegrity Truss June 17, 1980 , U.S.A. Patent No. 4,207,715
28. Hanging Storage Shelf Unit March 22, 1983 , U.S.A. Patent No. 4,377,114

Source: https://www.bfi.org/about-fuller/bibliography/patents/, Accessed: 12.21.2022.

[5] Let's consider this statement on the example of a barrel made of wooden strips:
wooden strips are elements of the system (barrel) that bear pressure, while steel hoops are elements of the system that bear tension. The number, shape (dimensions) of each length correspond exactly to the 'certain barrel'. By

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consists of elements that are exclusively pressed and elements that are exclusively tensioned. Compressed elements within the system are arranged in an extremely expedient discontinuity, while tensioned elements are in mandatory continuity. It is precisely the requirement of exclusive precision in the arrangement and task of its elements that makes tensegrity constructions so distinct and unique in the sphere of all possible constructions that they can be considered the very essence of 'constructing in space'.

omitting only one string, it would not be possible to assemble the barrel (that is, by breaking out only one string from the finished barrel, it would fall apart). Steel hoops hold the strings "together", in a purposeful system (barrel). By tearing the hoop, the strings stop being 'together', the barrel falls apart (Figure 1).

The ultimate precision of tensegrity constructions is easiest to understand by analyzing 'classic structural assemblies'. Let's take for example an element that is exposed exclusively to pressure. If a specific requirement is placed before that element (to accept and transmit a certain intensity of vertical force), then we will look for material with which that element will fulfill the requirement. A material with a higher compressive strength will be more effective than a material with a lower compressive strength. It is understood that the selection of materials with higher strength will result in smaller dimensions of the element that we requested.

If we consider an element that is exposed to a force, then cases can happen: that the element under the influence of the force (because of its mass) remains in its basic position or that it slides on its surface. If the element is exposed to force, then it can happen that it remains in the basic position (because of its mass), or it can fall over. if the element is anchored in the base, then under the action of the force it can remain in its position, or be broken. Fracture will occur if the element does not have adequate tensile strength. If we build the element from material with low tensile strength, then we will have to use more material, and the element will have to have larger dimensions.

It is similar to the case of a simple beam: if the element in the structural position of the beam is made of material with low tensile strength, we will have to use a lot of material (the dimensions of the beams will be large). If we increase the load on such a beam, or its span, it will break. If we want to keep the dimensions of the cross-section of the beam and its span (for the same load), we must use material with higher tensile (bending) strength to make the beam.

All major architectural traditions (for example, Mesopotamia, Ancient Egypt, Ancient Greece, Rome, Maya, India, Burma...) used stone as a basic building material, and due to its low tensile strength (from 1.5 to 5 MPa), the structural elements of buildings are were robust.

The bow is, in a certain sense, a tensegrity construction: the use of small elements (relatively high compressive strength and low tensile strength) to overcome large spans is possible thanks to the very shape of the bow, where the height of its arrow is the height of the 'imaginary' beam on which is a "mirrored" bow. However, the arch causes lateral thrust in its supports, which in the solutions of old architectural traditions accepted heavy, massive structures. By using braces (anchored to the arch supports) to accommodate these forces, the arch would come even closer to the essence of tensegrity constructions.

Reinforced concrete is basically a tensegrity structure where the carrier of compressive stress is (continuous) concrete, and the carrier of tensile stress is steel reinforcement (for concrete, the compressive strength is from 10 to 60 Mpa, the tensile strength is from 1.5 to 5 Mpa, while steels of this strength range up to 700 Mpa, for steel cables up to 2500 Mpa).

In a word, all structural elements in architecture and construction are to a certain extent doubly load-bearing (bearing both pressure and tension-bending). The difference in the amount of material used in the full sections of a structural element to the 'trajectory of their tensegrity efficiency' most often appears as 'ballast' (forced excess) that burdens the structure.

It is very important to underline here that architecture is an extremely complex discipline that should necessarily strive towards tensegrity constructions. Some elements of its structure, in addition to the constructive ones, also have a number of requirements that are very often mutually contradictory.

(See from the same author: Hadrovic, A. (2008), Bioclimatic Architecture, searching for a path to the Heaven, North Charlston, SC, USA, Booksurge).

III. Selected Realizations of Tensegrity Constructions

'Needle Tower' (1968), is a sculpture designed by Kenneth Snelson (1927-2016), exhibited in the statue garden of the Kröller-Müller museum in the Netherlands. The tower is a unique structure that cannot be compared to anything that man has made up to that time. From the base of the shape of an equilateral triangle (whose side is 6 m), a composition of aluminum tubes-rods and stainless steel cables rises to a height of 30 m. Aluminum tubes-rods (rigid components of the structure) are in discontinuity, in their ends connected to each other with cables, in continuity. The swaying of the tower in the wind adds even more to the impression of its unreality (Figure 5).

Snelson's sculptures 'Sleeping Dragon' (2003), (Figure 6) and 'Dragon' (2003), (Figure 7) leave a similar impression on the observer.

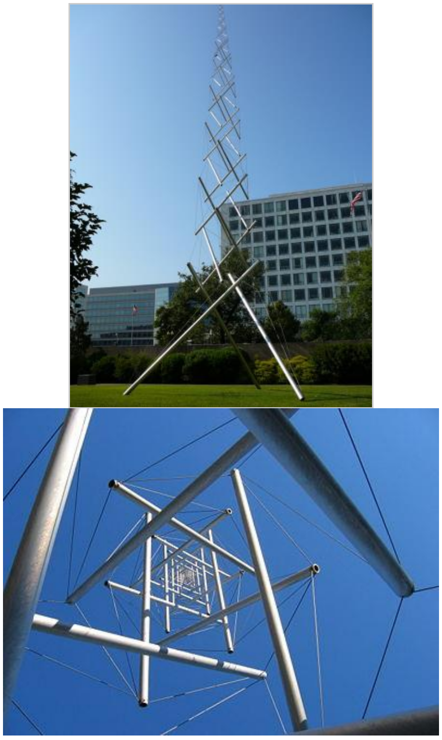


Figure 5. Needle Tower, 1968 (Kenneth Snelson, sculptor)
Source:http://www.waymarking.com/gallery/image.aspx?f=1&guid=8938514f-097f-498e-b512-b2e990372a72, Accessed: 12.20.2022.

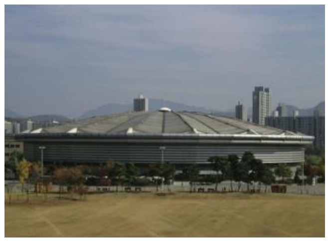
Figure 6. 'Sleeping Dragon', 2002-2003 (Kenneth Snelson, sculptor)

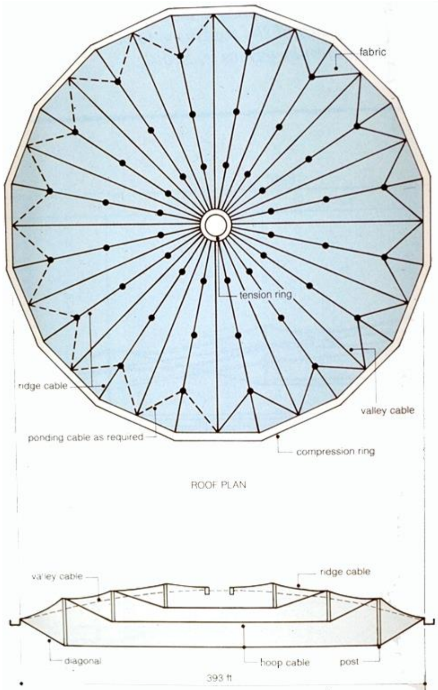
Source: http://kennethsnelson.net/sculptures/outdoor-works/sleeping-dragon/, Accessed: 12.20.2022.

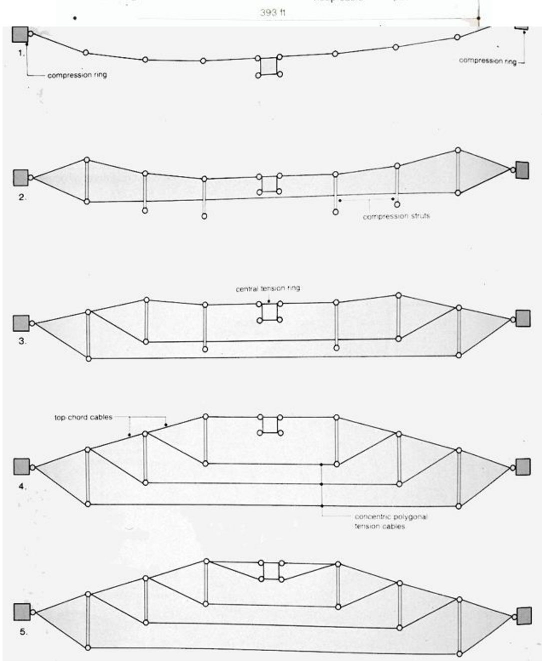
Figure 7. 'Dragon', 2002-2003 (Kenneth Snelson, sculptor)
Source: http://kennethsnelson.net/category/sculptures/outdoor-works/, Accessed: 12.20.2022.

'Olympic Fencing and Gymnastics Arenas', Seoul, Korea (1984-1986), the work of the architectural group Space Group of Korea (designer David Geiger), is the first building in the world whose roof structure was realized as a "tensegrity structure". The basis of the arena is a circle with a diameter of 120 m, along the edge of which there are reinforced concrete columns. The Tensegrity dome is 29.40 m high. The columns are connected by a strong reinforced concrete ring at its tops, which is the anchor point for the steel cables, which form the 'dome' in a completely new way. Here the construction of the 'dome' consists of a network of cables placed radially (as meridians) and horizontally (as parallels), following the contour of the tensegrity dome. The network of cables in a convex position is maintained by elegant steel rods supported by the circular contour of the horizontal cables, by the levels of the horizontal cables. The rods are the rigid components of the tensegrity dome, which rest on the intersections of the spanned primary cables (in the radial order of the base of the dome) and the circular cables, row by row along the height of the dome.

Seen from the outside, the roof of the 'Olympic Fencing and Gymnastics Arenas' in Seoul looks like a dome made of classic corrugated arches. This geometry of the roof is realized by the well thought-out design of the trajectories of the cable network: meridionally placed cables that threaten the tops of the steel rods from the circular perimeter reinforced concrete ring to the crown of the dome determine the upper edge of the 'fold'. On the tops of the steel rods supported on the same horizontal cable, steel cables (which follow the routes of the circularly placed cables in their horizontal projection) are suspended, the deflection of which is defined by the meridianly placed cable which, on one side, is anchored in the perimeter reinforced concrete ring, and on the other side, suspended o the ring in the crown of the roof (The ring in the crown of the roof of the tensegrity dome is a practical solution for connecting meridional cables). These meridional cables define the lower edges (bays) of the folds of the tensegrity dome. The roof shell itself (covering) is made of a stretched membrane (glass fiber canvas coated with silicone), (Figure 8).







Base and cross-section of the roof construction Phased roof raising

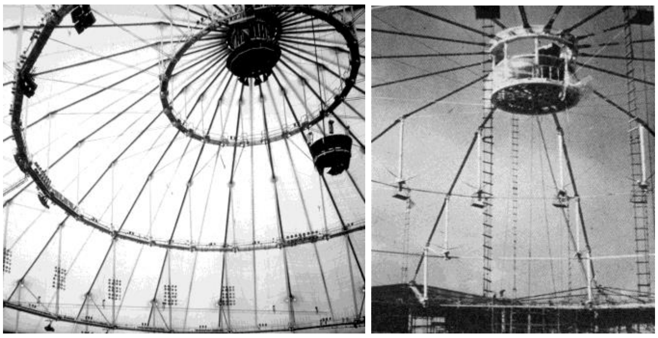


Figure 8. 'Olympic Fencing and Gymnastics Arenas', Seoul, Korea, 1984-1986 (Architects: Space Group of Korea, Constructor: David Geiger)
Source:Google Earth, Accessed: 12.20.2022.
http://en.structurae.de/photos/index.cfm?JS=53607Architectural Record, Septembar 1988, Accessed: 12.20.2022.
http://www.columbia.edu/cu/gsapp/BT/DOMES/SEOUL/1018-18.jpg, Accessed: 12.20.2022.
http://www.columbia.edu/cu/gsapp/BT/DOMES/SEOUL/sol-22a.jpg, Accessed: 12.20.2022.

'Redbird Arena', Illinois State University, Illinois, USA (1985-1988), the work of architect Paul Kennon (constructors David Campbell and David Geiger), is the construction of an elliptical base (whose combined diameters are 90 and 77 m) on which tensegrity is constructed a dome with a height of 24.34 m. The construction is similar in all respects to the construction of the 'Olympic Fencing and Gymnastics Arenas' in Seoul. The specificity of the tensegrity dome 'Redbird Arena' is the sharp lines in its outer contours, which were achieved by using only one horizontal cable (and thus one row of steel rods) in its construction. The roof covering is a stretched membrane (glass fiber cloth coated with PTFE foil), (Figure 9).

Figure 9. 'Redbird Arena', Illinois State University, Illinois, USA, 1985/1988 (Architect: Paul Kennon, Constructors David Campbell and David Geiger)
Source:Google Earth, Accessed: 12.20.2022.
http://www.panoramio.com/photos/original/2230200.jpg, Accessed: 12.20.2022.
http://en.structurae.de/photos/index.cfm?JS=53615, Accessed: 12.20.2022.
http://en.structurae.de/photos/index.cfm?JS=53614, Accessed: 12.20.2022.

'Tropicana Field (Suncoast Dome)', Saint Petersburg, Pinellas County, Florida (1989), by architects HOK Sports Facilities Group (constructor Geiger/KKBNA), is an arena-roofed circular stadium (diameter 209 m) with a capacity of 43,000 seats (Figure 10). The construction is similar in everything to the construction of the 'Olympic Fencing and Gymnastics Arenas' in Seoul.

Figure 10. 'Tropicana Field (Suncoast Dome)', Saint Petersburg, Pinellas County, Florida (1989), (Architects: HOK Sports Facilities Group, Constructors: Geiger/KKBNA)
Source:Google Earth, Accessed: 12.20.2022.
http://en.structurae.de/photos/index.cfm?JS=53752, Accessed: 12.20.2022.
http://www.panoramio.com/photos/original/9354723.jpg, Accessed: 12.20.2022.
http://www.panoramio.com/photos/original/5096812.jpg, Accessed: 12.20.2022.
http://www.panoramio.com/photos/original/9354745.jpg, Accessed: 12.20.2022.

The specificity of this dome is its rotation along the tangent at the base, along the vertical plane, which means that its edge reinforced concrete ring does not lie in a horizontal but in an oblique plane. This achieves the dynamism of the architectural form of the dome and the building as a whole. (A similar effect was used by Foster&Partners at the 'Scottish National Arena').

The 'Georgia Dome', Atlanta (1990-1992), the work of architect Scott W. Braley (constructor Matthys P. Levy), is the central arena of the Olympic Games held in Atlanta in 1992.

The roof of the arena has a base in the shape of an ellipse, the final dimensions of which are 240x210 m. Unlike the tensegrity domes realized up to that time, this dome does not have a dotted line, but rather a line. The network of primary and secondary cables is arranged like a sophisticated geometric pattern, with targeted aesthetic effects. The roof covering is a stretched membrane (glass fiber cloth coated with PTFE foil) through which plenty of natural light (during the day) reaches the interior of the arena, i.e. artificial light (at night) illuminates (Figure 11).

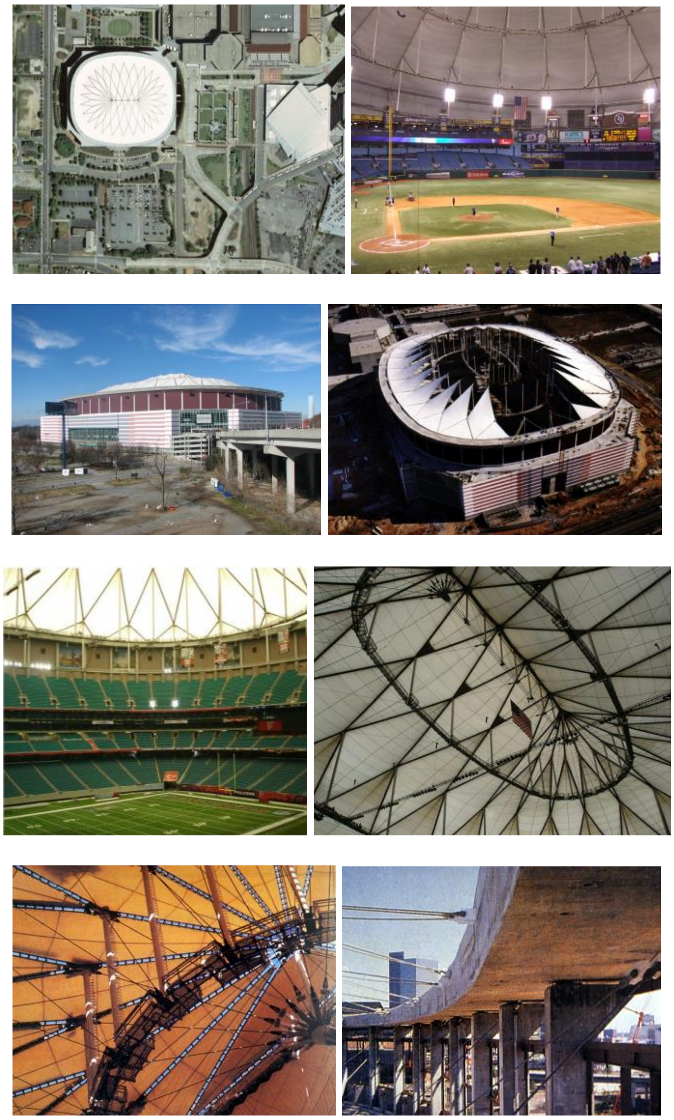


Figure 11. 'Georgia Dome', Atlanta (1990-1992), (Architect: Scott W. Braleya, Constructor: Matthys P. Levy)
Source:Google Earth, Accessed: 12.20.2022.
http://www.panoramio.com/photos/original/1024128.jpg, Accessed: 12.20.2022.
http://en.structurae.de/photos/index.cfm?JS=74447, Accessed: 12.20.2022.
http://www.columbia.edu/cu/gsapp/BT/DOMES/GEORGIA/geo-03.jpg, Accessed: 12.20.2022.
http://www.columbia.edu/cu/gsapp/BT/DOMES/GEORGIA/geo-05.jpg, Accessed: 12.20.2022.
http://www.columbia.edu/cu/gsapp/BT/DOMES/GEORGIA/geo-21.jpg, Accessed: 12.20.2022.

'Sony Centre', Berlin (1993-2000), the work of the design group Murphy & Jahn INC (Constructor Ove Arup&Partners USA), is a complex located in the historic center of Berlin, on Posdamer Platz.

The 'Sony Centre' was designed as a 'Kulturform', a new form of culture, which includes a covered square. The base of the roof of the square has the shape of an ellipse (whose combined diameters are 107 and 83 m). Along its edge, a strong ring, a steel spatial lattice support, is constructed as one of the primary segments of the complex roof structure. Steel beams are hung from this support, on which, eccentrically in relation to the ellipse of the base, the central pylon (a specially designed steel spatial grid support) is supported. The primary steel cables are suspended from the circular end of the central pylon, on the one hand, and the marginal steel spatial lattice support, on the other, which, together with the network of secondary cables and stretched canvas, form a tent-like roof structure. (The roof area is 5250 m^2). The roof covering is a stretched membrane (glass fiber cloth coated with PTFE-foil-teflon), (Figure 12).

Figure 12. 'Sony Centre', Berlin, 1993-2000 (Architects: Murphy & Jahn INC)
Source:Google Earth, Accessed: 12.20.2022.
https://franks-travelbox.com/en/europa/deutschland/potsdamer-platz-in-berlin-deutschland/, Accessed: 12.20.2022.
https://www.lookphotos.com/en/images/71132017-Interior-of-the-Sony-Center-in-the-evening-Potsdamer-Platz-Berlin-Germany
Accessed: 12.20.2022.

'Bifid Tension Dome', Marina Seca, Barcelona (2004), the work of the architectural group Guri & Casajuana (constructors ARQINTEGRAL (Ch.García-Diego & H.Pöppinghaus) with J.Llorens), is similar to the Sony Center in Berlin built as an exhibition space managed by the "Barcelona Forum of the Cultures".

The object has a circular base with a diameter of 20 m. The strong perimeter ring is at a height of 6.7 m, from which 24 radially distributed primary steel cables are suspended, which support horizontal cables and vertical steel columns, in the already described way of constructing a tensegrity dome. The roof covering is a stretched membrane (glass fiber cloth coated with PVC foil with Fluotop T2 layer), (Figure 13).

Figure 13. 'Bifid Tension Dome', Marina Seca, Barcelona, 2004 (Architects: Guri & Casajuana, Constructors ARQINTEGRAL (Ch.García-Diego & H.Pöppinghaus) with J.Llorens)
Source: https://www.tensinet.com/index.php/projects-database/literature?view=project&id=4255, Accessed: 12.20.2022.

IV. Conclusion

The word 'Tensegrity' was created by the integration of the terms 'Tensional' and 'Integrity', and could most simply be understood as 'unity of tension'. No term in architecture (in construction and in many spheres of practical human activity), from the middle of the 20th century until today, has been subject to as much interpretation as the term 'Tensegrity'. More than that, even today there are debates about who is the author of this term and who first made the 'Tensegrity structure'.

Like all 'great truths' that man has discovered in nature throughout history, 'Tensegrity structures' have their roots in nature, in its 'living world' (Figure 4). Also, 'Tensegrity structures' were not created ('discovered') at one moment ('date'), but were generated from the very beginning of human history.

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