Research Institute for the
Built and Human Environment

The International Built and Human Environment Research Week

4TH INTERNATIONAL POSTGRADUATE RESEARCH CONFERENCE IN THE BUILT AND HUMAN ENVIRONMENT

salford centre for research & innovation
in the built & human environment
an EPSRC funded centre

SCRI prize for most innovative idea awarded to

Cemil Atakara

POSSIBLE USES OF SMART MATERIALS IN THE DEVELOPMENT OF SUSPENDED GLASS SYSTEMS WITH PRESTRESSED CABLE TRUSS

C. Atakara , Y. Hürol
Faculty of Architecture, Department of Architecture,
Eastern Mediterranean University, Famagusta
cemil.atakara@emu.edu.tr, yonca.al@emu.edu.tr

ABSTRACT:Suspended glass systems with prestressed cable truss is one of the recent building systems which has affected the spatial characteristics of the buildings considerably. On the other hand, nanotechnology can be accepted as another development which has not affected the lives of people yet.Nanotechnology can be applied together with many systems, including building systems, in order to improve their characteristics. The research objective of this paper is to identify the improvements and positive effects in the structural and spatial characteristics of suspended glass systems when they are combined with nanotechnology.
Keywords: Cable truss, Nanotechnology, Suspended glass systems.

1.INTRODUCTION

The new science revolves around the creation of new materials on a sub-microscopic scale. Nanotechnology, which can safely enhance our lives, is already around us in the form of waterproof clothing and self-cleaning glass. The use of nanotechnology is viewed as a sign of the next industrial revolution. (Dalton, 2003)

Nanotechnology can be used in totally different products or in improving the possibilities of existing systems. The main focus of this paper is to discuss the possible improvements in the structural and spatial characteristics of suspended glass systems with pre-stress cable truss, (SGSPCT) through the use of nanotechnology.

SGSPCT is one of the recent developments in structural engineering and architecture. It enables the design of very transparent surfaces whilst using the least amount of structural materials. These systems are usually added to some other structural systems.

In this paper, the structural and spatial characteristics of SGSPCT, and the developments that have been achieved with the use of nanotechnology, are presented. In the later part of the paper, the possible effects of use of nanotechnology with SGSPCT is predicted.

It is concluded that if the suspended glass system with pre-stress cable truss using nanotechnology is applied to buildings, we may be able to grow buildings like we grow plants in tubs. Such fundamental changes do not only change the facade of the building functionally, aesthetically and structurally, but it also totally changes the spatial characteristics of the building. This will radically affect the spatial organization of the living spaces of the next generation.

2. STRUCTURAL AND SPATIAL CHARACTERISTICS OF SGSPCT

Today, with some of the astonishing breakthroughs that are being made in science and technology, the world suddenly does not seem so far out there. We live in a fluid and dynamic world. You come in and plug into your laptop; you work for a bit, and you move on to somewhere else. We need to create the dynamic spaces that will allow these interactions to occur.

New developments in technology create extremely transparent spaces with the use of the new types of cable truss systems. These systems can be described as suspended glass systems with pre-stressed cable truss (SGSPCT). (Atakara, 2002) The non-disturbed transparent facades and masses can be combined with the use of secondary structural systems, which are dependent on the main building structure. These systems are seen as unique structures, which actually combine a number of different structures in their bodies. All details have a structural role, including the glass surface. The glass surfaces, which started to have a more structural character, also help in the formation of the transparent surfaces and masses. (Rice P., Dutton H., 1995). Dematerialization became possible when the secondary structure, which is in between the glass and the main building structure, became much lighter, as is shown in Figures 1 and 2.

Suspended pre-stress cable structures usually combine an extension of main building structure, some tubular frames, cable trusses and the glazed assemblies as shown in figure 1 and figure 2. The cable trusses are placed on the transparent surfaces. The tubular elements form secondary structures between the transparent surfaces and the main building structure. Finally, the main building structure is the less transparent part of the building; it also supports the transparent parts

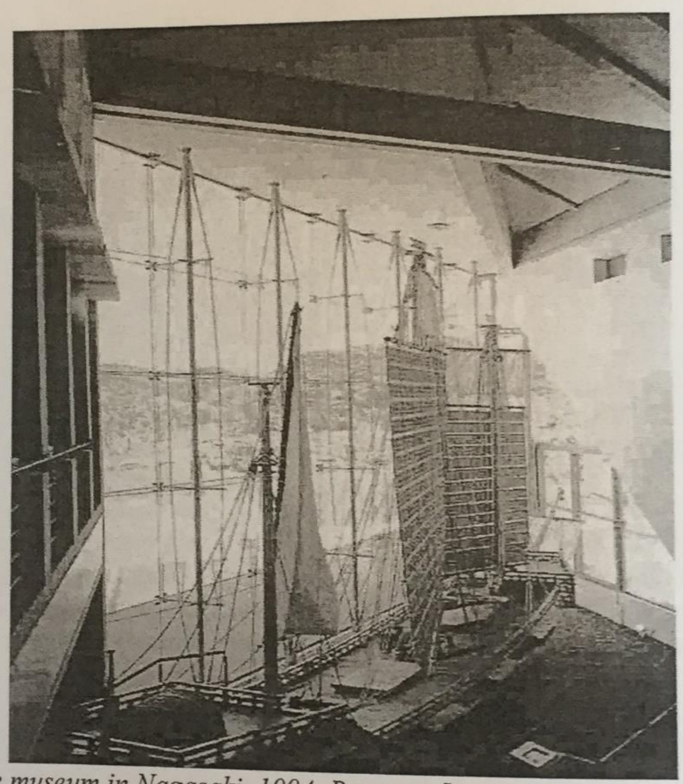

Fig. 1 The maritime museum in Nagasaki, 1994, Between floors system (Rice, Dutton, 1995).

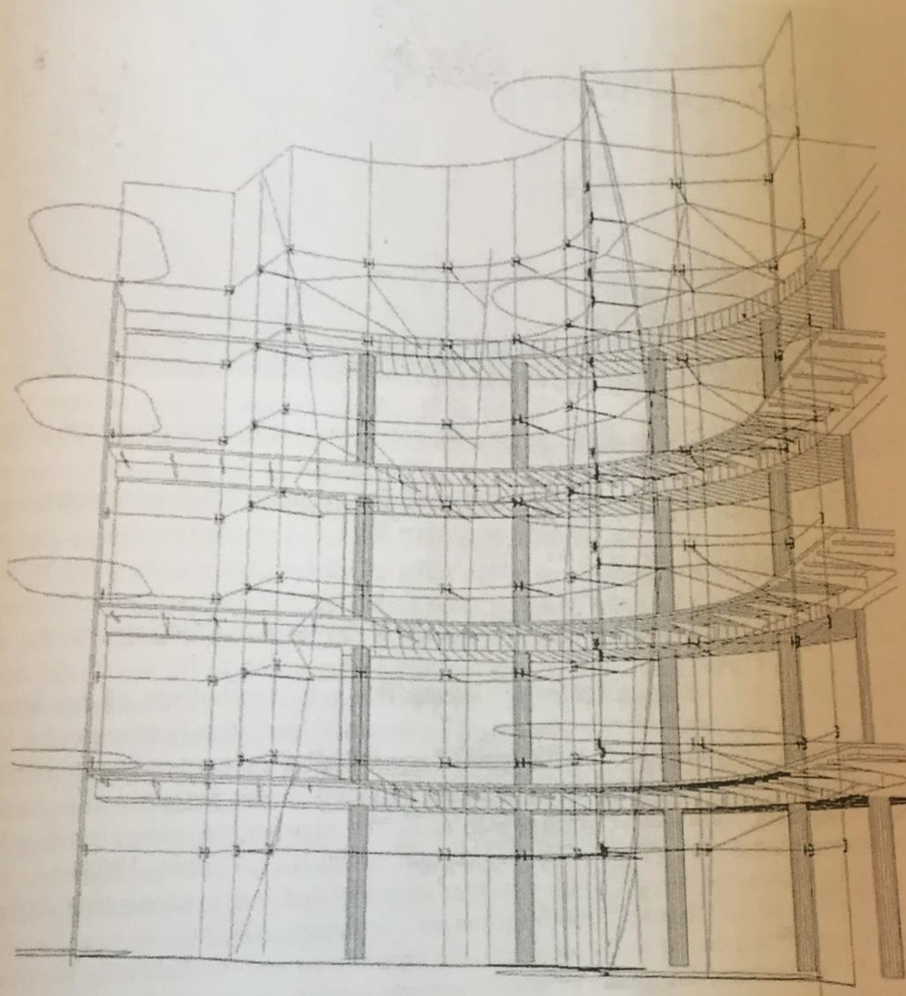

Fig. 2 Channel 4 Headquarters, London, 1994, Independent body (Rice, Dutton, 1995).

The relationship between the main building structure and the secondary structure can be used in the classification of different types of SGSPCT. The secondary structure might form a surface, which is between two floors of the main building structure as can be seen in Figure 3.c. The 3D secondary structure might span a distance between the main building structure and the transparent surface as is seen in Figure 3.a. Finally, the 3D secondary structure might be integrated with the main building structure, as in Figure 3.b.

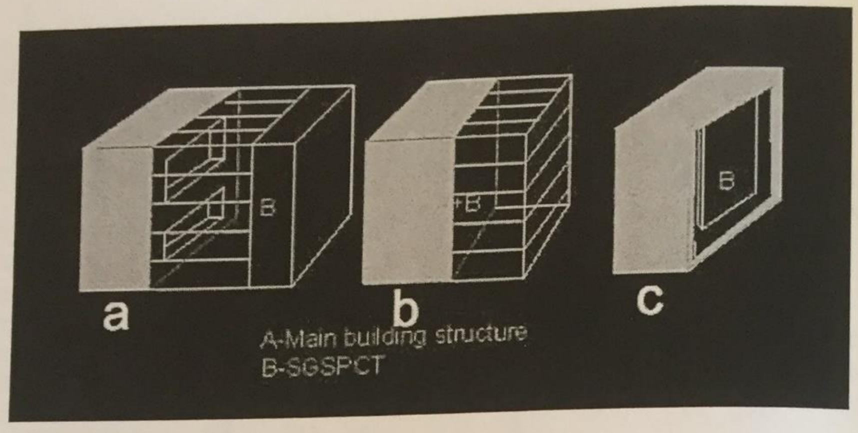

Fig. 3 Types of suspended glass system with pre-stress cable truss.(Atakara, 2002)

a. 3D secondary structure with some distance from the main building structure,

b. Two structures integrated,

c.2D secondary structure between the two slabs of the main building structure.

These cable truss systems serve to indicate the new symbolism of contemporary buildings. It is very difficult to differentiate what is structural and what is ornamental in these buildings.The geometry of SGSPCT is determined according to the perpendicular wind loads on the glazed plane. The form of the main building structure is also determined according to wind load, which are transferred from the SGSPCT. The appropriate geometrical solutions contribute towards the design of the building. (Atakara, 2002; Rice, Dutton, 1995).

The cable trusses and the secondary structure are permitted some perceivable deflection, whilst this is not valid for the main building structure. (Atakara, 2002).

The spaces (if they can be thus described), the proportions and the harmony between the parts, seem to be designed for a race of giants, extraterrestrials, perhaps, from a future age. Man, on his human scale, is completely squashed and insignificant. Architecture encloses and protects him to the point that it often can be seen as a massive, unstable rock, poised, ready to fall on our heads.

The contribution of some other new materials to SGSPCT may be initiated with the help of the new developments in nanotechnology.

3. STRUCTURAL CHARACTERİSTİCS IN RELATİON TO NANOTECHNOLOGY

It is so simple to define the item nano as 10^{-9}. That means that the nano is a symbol of a very small element that cannot be recognized by humans.

This term has been used in all fields of the sciences, technology, medicine and economy.A single nanometer, 1 billionth of a meter, is about four times wider than the size of an atom and more than 1,000 times narrower than the width of a human hair.

C60 is special, because all of its structures are made up of pentagons and hexagons that are curled around and closed. This is done so smoothly that every atom has the same curvature as every other one. (Varco, 2001)

"Nanotechnology refers to the ability to manipulate individual atoms and molecules, making it possible to build machines using molecular building blocks or create materials and structures from the bottom up by designing properties to control structure." (Coontz, 2000).

Science and technology, on the scale of a nanometer is revolutionary. It could change the way almost everything, – from medicines to computers, automobiles, and objects not yet imagined, works. Evidence, which shows that nanotechnology can safely enhance our lives is already around us. It is currently being used in waterproof clothing and self-cleaning glass. (Milles, 2003)

It is an expression for all the micro things, and processors that enter the production field, and technology. It is worth pointing out that the word "nanotechnology" has become very popular and is used to describe many types of research, in which the characteristic dimensions are less than about 1,000 nanometers. (Coontz, 2000) Nanotechnology is the logical process of microprocessors. As these processors are now a nano, we are unable to see them, or even imagine them.

The future of nanotechnology is unlimited in all fields, because the new technologies are mostly concentrated on, and involved with, the development of nanotechnology. Whatever we can receive and obtain from this technology, its application, and use, will not only help us in the practical sense, but these fast applications, and high quality products, will also increase the inspiration and creativity in the field of architecture. In order to continue and keep up with the advanced progress in other fields and in their own field, architects will, in the not too distant future, have to confront the challenge between the functioning and the abilities of the human mind, and the intelligence of machines and techniques. Architects will be required to increase their creativity and conceptual ideas in order to satisfy, and keep abreast of, the great progress in the field of architectural technology, in terms of materials, tools etc. However, all of this should not affect the main architectural principles, which fulfill our basic demands, or damage our basic architectural meanings, as well as keeping the artistic, beauty and meaning of true architecture.

Architecture, as with all other professions, requires a life-long education. Nanotechnology has its own importance in architecture and architectural education, as does other types of new technologies. Architects are looking forward to a new future, in which houses and spaces will be combined in a much more harmonious, pleasing and creative manner, with the new technologies. Or, in other words, the new architecture is expected to be an intrinsic part of the new technology.

3.1. Smart Materials

The term "smart materials" is again a part of the new revelation of nanotechnology. Initially, it began as small efforts to enlarge the efficiency of buildings by inventing new materials, or using new techniques, which all emanated from the developing technology of processors and technology. The advanced steps taken by the scientists made it possible to see the application of such fast-moving technology, especially in the area of materials, e.g. as it was applied in Saudi Arabia airport. In this building, new kinds of materials that can change hot air into cool air, depending on the microprocessors, (fig 4) which are used in the materials required for isolation purposes. There are many other examples of such applications.

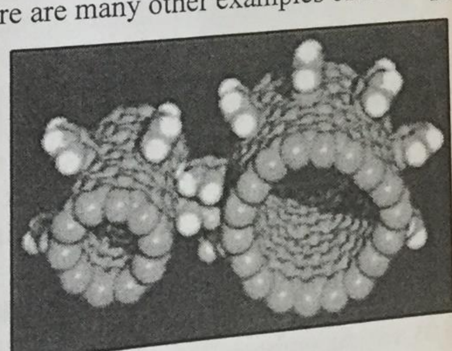

Fig. 4 Nanotechnology and material (Smart materials, 2003).

Smart materials that can be attached to, or embedded in, structural systems, can also be used to enable the structure to sense disturbances. This information can be processed and the information can be transferred to actuators through commands. This can achieve some important beneficial reactions, such as vibration or deformation control. Accordingly, these smart materials must exhibit the material properties that enable them to sense disturbances, such as new forces. They can also act as actuators and apply beneficial forces.

Smart material systems and structures range from basic research in polyelectrolyte gels (a polymer matrix, swollen with a solvent that can expand or contract up to 500%, when exposed to an electrical field or other stimulation) to applied research in the use of thin film sensors, actuators and memory-shaping metals. (Smart materials, 2003). It is necessary to form a smart materials and structures team, and establish experimental facilities and test beds. New projects involve the use of an active material to implement precision shape control of solar reflectors, and the integration of active devices with structures for vibration suppression in high precision manufacturing and machining. (Smart materials, 2003).

3.2. Biomimetics

Researchers are tapping into millions of years of biological, evolutionary experience to develop the next generation of materials. This research, which is known as biomimetics, aims to incorporate properties unique to nature into manufactured devices and materials.

While one key discipline of biomimetic research focuses on developing replacement parts for the human body, researchers in other areas are pursuing advances in sensors, structural materials and functional devices. This may lead to more efficient sensory systems, stronger and lighter manufactured items, and the development and manufacture of new machines, which may open up, and lead to, a host of undiscovered applications. (NASA, 2002).

A substance, which offers high aspect ratios in small dimensions could enable the production of a material that is as moldable and flexible as plastic but ten times as stiff and five times as strong. The recent developments in carbon nanotubes seem promising, but their surface chemistry may preclude them from being able to be transformed into suitable resins. However, their technology is currently very expensive.

3.3. Biological Architecture And Ceramic Materials

Biological architectures, on the other hand, feature deliberately layered structures that localize the effects of any small impact, crack or other damage. Being able to reproduce this capability in ceramic materials would permit their use in applications, such as internal combustion engine blocks, for example. (NASA, 2002).

3.4 Silk

In the non-human realm, silk is generating substantial interest amongst researchers. The radial strands of a spider web are particularly strong and tough. The U.S. Army Research, Development and Engineering Center in Massachusetts, are pursuing research into this area. (NASA, 2002). One possibility is to use bacteria to clone spider silk in quantity. A key to such a development could lie in the understanding of how proteins work as structural materials.

'DARPA's Rudolph notes that his agency is working to capture the multifunctional properties of organic skin. Other programmes are examining dynamic elastics, such as the cross-linking of fibrous materials in sea cucumbers. These marine invertebrates can rapidly extend their lengths by 400%, and scientists seek to understand and apply the process to materials.' (NASA, 2002).

3.5 T 1000

T1000 is a nano material, which forms a liquid metal, which might shape our future. (NASA, 2002). It is a smart material, which has its own memory. Today research shows that one day we will put our buildings in our pockets and the building will be able to move. This shows us that scientific developments in materials can cause radical changes in the value system of architecture.

4. SGSPCT WITH NANOTECHNOLOGY

The material changes that can occur with the use of nanotechnology become very clear when they are applied to suspended glass systems (SGSPCT). Consequently, it can be stated that nanotechnology is the future of architecture, because it solves the actual problems of the recent systems and spaces, besides creating totally new opportunities.

The changes that can be achieved in SGSPCT with the use of nanotechnology can be seen in Table 1.

Table 1. Contribution of the future materials to SGSPCT.

SGSPCT	Material
Possibility of Moving and Changing Place	Biomimetics
Increase In Strength	Ceramic
Decrease In Dead Weight	Silk
Liquidification of the Structure	T1000

Biomimetic researches will provide the opportunity for SGSPCT to have more deflection and to move from one place to another place. SGSPCT can be intelligent and change itself in dimensions, colours, and in other details. It can have some characteristics that robots have. These researches might also lead to the elimination of perceivable deflection, which is a current problem of SGSPCT.

The change in the material properties will also cause fundamental changes in the structural behavior of the SGSPCT. This might, in turn, cause a radical increase in the strength of the materials. Polymers, ceramics, silk and T1000 are the future materials, which will change the face of the world.

SGSPCT might become invisible and there might be no outside or inside differentiation, although there will be no security problems. The surfaces might be able to change their colours, in order to separate and differentiate the external from the internal. Thus, it will be possible to design more flexible spaces. With the use of such new materials, SGSPCT can form more dematerialized surfaces. This type of development could create a kind of utopia. Dematerialized surfaces can also be formed with the use of laser cables.

5.CONCLUSION

Suspended glass systems with pre-stressed cable truss (SGSPCT) are the products of recent technology. SGSPCT is the most dematerialized and transparent structure in comparison to all other previous structures. However, this system is still open for further development. In the near future, with the help of material science, SGSPCT may be able to progress towards further transformation.

If nanotechnology is used together with SGSPCT, three different types of improvements may occur.

1. The existing problems of SGSPCT, such as perceivable deflection, might be solved.
2. The existing advantages of SGSPCT, such as dematerialization and transparency, might be developed further.
3. Some totally new characteristics, such as the ability of movement, might be achieved.

Thus, it can be stated that SGSPCT will radically change its face in the near future. This situation supports Le Corbusier`s following statement.

"If we eliminate from our hearts and minds all dead concepts in regard to the house, and look at the questions from a critical and objective point of view, we shall arrive at the house-machine." (Hartoonian, 1994)

Although Le Corbusier`s statement lead to the discrimination of nature and ornamentation, SGSPCT has not yet caused such a rejection. The cables, spiders, and articulated bolts are, themselves, ornamentation, as well as their representing the ultimate level of contemporary technology.

It can be stated that *".....if you are really an up-to-date architect you might be 10 years behind the times in terms of the other sciences. Although it is a joke, it stands up quite well...."* (Spiller, 2003)

6.REFERENCES

Atakara C., (2000), *Spatial Characteristics of suspended Glass system with Prestress Cable Truss.* Unpublished Masters Thesis, EMU.

Coontz, (2000), *Science and technology*, webpage.

Dalton. J., (2003), *Blueprint for the Future*, Tech Tv. Inc.

De Varco B.G., (1997), *Invisible Architecture*, nanoscale architecture web page.

Drexler K.E., (1993), Engines of Creation,IMM,http://www.n-a-n-o.com .

Hartoonian G., (1994), *Ontology of Construction*, Cambridge University Press, USA.

Milles L., (2003), *Brave New Science That Will Change the World*, Telegraph group limited, net.

Nasa, (2002), http://www.nas.nasa.gov/Group/Nanotechnology/gallery/

Rice P., Dutton H., (1995), *Structural Glass*, E &FN Spon, an Imprinting of Chapman & Hall, London.

Smart materials, (2003), http://www.foresight.org, www.telegraph.co.uk

Spiller, (2003), *How Science and Technology will Change Architecture*, www.ABCNEWS.com