International Journal of Advanced Research and Review

www.ijarr.in

EXPLORATION OF SMART BUILDINGS SHELL SYSTEMS CENTERED ON SUSTAINABILITY

Mehmet Sinan YUM (Ph.D)

sinanyum@gmail.com, Hacıahmetbey Sok. Ay Apt. 4/1 Kadikoy, Istanbul, Turkey

ABSTRACT

The planet is overpopulated due to extreme and paced population growth. Resources are almost depleted and the only solution to a global problem presents itself as sustainability. In order to resolve population growth and ecology centered problems, humanity explores contemporary fields such as bioarchitecture as mentioned long time ago by (Yeang, 2000). This search has brought forth new approaches such as green buildings, smart buildings and high rises that are automated and eco structures able to host a large quantity of people. As a result of the projection to maintain a valid quality of life away from pollution, noise, outside interference and secure with the scope of creating a protected indoor habitat, shell implementations are widely used in the last 20 years.

The study explores innovative materials and contemporary implementations on mile stone structures by presenting and evaluating the examples provided as well as exploring the qualities on automated smart buildings with facade shell systems focusing on sustainability. The article particularly centers on significant features of shell systems covering the structures. Examples selected for the study are prominent projects by renowned designers. The study provides informative highlights on these projects in order to focus and bring insight on a design related social and ecological argument.As the study explores smart building systems on sustainability features and requirements, it focuses specifically on shell systems that have effects on ecology and design.

Keywords: Architecture, Sustainability, Shell Systems, Design, Smart Buildings, Ecology.

INTRODUCTION

Smart buildings today are mostly intergated with sustainability regulations evaluated by certificates such as Leed and Breeam. Sustainable shell systems are implemented in order to preserve energy and prevent energy loss as well as offering a protected habitat within the structure. There are several factors that motivate the development of smart buildings with shell systems such as population growth, green space requirement, technological development, prestige and solution to social needs. After the validation of 'sustainability' as a term linked to ecology by UN general assembly in 1987, the notion of 'green' surfaces in the 90's as a promising idea regarding ecology. The concept has been implemented ever since to different areas in various ways.

The solution to a global problem regarding population growth and global warming presented itself centered around sustainability on architecture, technology and construction. Smart buildings with shell systems are the symbiotic products of the balance between design engineering and architectural technologies focusing on sociology. The quantity of people living in a high rise can only compare to that of a small town that implies to the regulation of social relationships. The study explores the requirements necessary for building a smart

building as well as evaluating the examples presented in order to provide a deeper perception of the subject. Examples provided include buildings of a certain height in order to maintain a standard of the presented material.

1. SMART SHELLED BUILDINGS

Smart buildings are structures that use energy and resources efficiently with the integration of an automated system and design centered engineering strategies. This approach provides a comfortable monitoring ability as well as ease of functionality. The reason under this approach is mainly related to sustainability enabling a life in a high tech, productive and a green environment.

Vertical green wall applications have great potential for energy saving purposes in residential buildings (Wong & Baldwin, 2016). General tendencies in designing smart green buildings are based on futuristic approaches mostly creating various difficulties on urbanization. Programs such as the Leadership in Energy & Environmental Design (LEED) influence and inspire the implementation of smart systems on buildings providing different categories of evaluation. Initially presented by the U.S. Green Building Council, the program encourages the recognition of green practices and implementations. The real value LEED provides is furnishing visibility to such structures as well as increasing the prestige of the brand.

Smart building depend on certain principles in order to provide service regarding goals on sustainability. These principles are general guide lines such as the location of the building, the position of the building in relation to other buildings, the direction of the building, form of the building, heat properties of the shell elements surrounding the building, smart shell, daily control and natural ventilation systems.

1.1 Heat Isolation Methods

In smart green buildings, solar, wind and earth consume 4% of the total energy. Draining energy has to be restored by auxilary systems in order to preserve the atmospheric effect of a shell system intact. Elements such as water walls, sliding surfaces, panels and walls provide some of the isolation required in high rises. Typical isolation strategies used in buildings can be listed as:

1) Insulation on the roof.
2) Sheathing systems.
3) Taking into account the sun and wind directions.
4) Window sizes.
5) Correct positioning of buildings.

The abovementioned factors are basic principles implemented through the design and construction stage of the buildings. Heat preservation is an important matter for a high building due to decreasing air temperature.

1.2 Double Shell Facade Systems

Building adaptive facade, shell or envelope is a physical division entity between the conditioned and unconditioned environment allowing resistance to natural elements and sound. Besides facilitating the maintenance of an interior environment and providing climate control, shells offer support in order to resist structural and dynamic weight, energy control and aesthetic values.

Building height double shell facade systems that have an identical height to the building provide a continuous cocoon along the structural facade. Sapphire with an ASHRAE 55-66 thermal comfort certificate is an example of a double shell facade system that uses facade

cisterns to collect water. The components of a double shell facade system are transparent components, opaque components, carrier elements, detection components, ventilation space, control equipment (solar control, vents, etc.) and walkways. In order to design a double shell facade system, certain guidelines ensure the quality of the project. There are 8 factors in the design of an energy efficient smart double shell facade systems. These 8 factors are ventilation, temperature control, natural lighting, noise control, fire protection, aesthetics, user control and costs.

1.3 Classification of double shell facade systems depending on ventilation shafts The 3 types of ventilation in double shell facade systems are natural, mechanical or hybrid ventilation. Depending on the specifications of the structure, ventilation is implemented on the building. Double shell facade systems have various types of facade systems enabling the implementation for ventilation as presented below.

1) Building Height Double Shell Facades: The ventilation gap between the inner and outer shell is not interrupted horizontally or vertically.
2) Floor Height Corridor Type Shell Facade: The ventilation gap is divided horizontally on each floor.
3) Box Type Double Shell Facade: The ventilation space between the inner and outer shell is divided horizontally at each floor level and vertically at the window level of each space.
4) Shaft Type Double Shell Facade: The principle of operation is based on the use of a double shell facade at the building height and a corridor type double shell facade system at the floor height.

The specifications of the shell are considered when selecting the right kind of double shell facade system. The study presents examples of different buildings with double shell facade.

1.4 Indoor Thermal Comfort Properties of Double Shell Systems

Harrison & Meyer-Boake (2003), define the double shell facade system as a pair of glass shells separated from each other by an air corridor. The air layer between the glass walls provides insulation as a precaution against overheating, wind and sound. Solar control components are usually positioned in the space between the two layers. By creating a buffer zone such as large volume air ducts, intermediate space surrounds the areas of use and forms a habitat more beneficial to the environment than real outdoor conditions. Double shell facade systems provide various services related to natural ventilation, solar radiation control, daylight control, natural lighting, noise control, fire prevention, security ease of cleaning and maintenance. Smart shells provide comfort minimize the load of ventilation, air conditioning and lighting energy of the building with the automatic movement of natural ventilation and solar control elements and provide user comfort naturally. The gap between the two facades of glass creates a buffer zone between the interior and the exterior, making it easier to control energy expenditures.

1.5 Smart Building Automation Systems

Smart buildings are systems where the energy expenditures of the building are automatically controlled by the building's own staff and additional equipment in order to increase the energy efficiency. The energy performance of the buildings as passive system is related to their location, direction, form and building shell. The most important goal of smart buildings is to ensure that the buildings are energy efficient regardless of their location.

Smart buildings are structures managed by an automation system. Automation systems passive system that regulates energy performance and monitors service quality. Services provided by an automation system can be listed as shown below.

1) Setting the elevator frequencies.
2) Providing energy saving for an effective use.
3) Providing security measures.
4) RFID guest card application.

Guest cards offer a control over the credentials of guests insuring safety and avoiding any difficulties in the building (Aytıs, 1996). Automation systems provide security and furnish optimization for sustainability. Beck off Automation Technology implemented inside new and restored buildings provides maximum energy saving services. Centralized major functions and services are processed by automated central library. Central automation systems connect and control heating, cooling, lighting, climatization, facade control and room automation features of the building.

2. SMART BUILDING EXAMPLES

Smart buildings of a certain height implement shell systems in order to maintain sustainability standards and for protection of the structure. Even though these structures are generally highly inspirational from a design and ecology point of view it is not always financially convenient to invest under the strict rules on urbanization. In the next section, selected milestone projects are presented in order to provide an insight on the aesthetic, functional and urbanization values of the structures. Some of the provided relate to more than one argument presented in which case they have been positioned in accordance with the narrative of the study.

2.1 Frankfurt Commerzbank

Designed by Foster & Partners in the early 90's, and construction finalized in 1997, it is the tallest building in Germany. The buildings gardens offer natural climatic, visual and social spaces to offices located on other branches of the structure.



Figure 1: Commerzbank

These 9 gardens are separated by glass flooring at certain intervals. The structure having a natural ventilation, mechanical ventilation system activates only under extreme circumstances.

2.2 Istanbul Sapphire

Designed by Tabanlıoğlu Architects, the construction ended in 2011.Turkey's first environmentally adapt featured skyscraper Sapphire has 64 floors. Natural ventilation system is the key equipment in realizing this feature. The air circulation of the building, which is protected by a glass cover, is provided with the help of movable and controllable vents located on every 3 floors. This feature supports the building in creating its own habitat

secured from external elements. Coccooned building provides 25% energy saving with the shell system.



Figure 2: Sapphire

The perimeter of the building consists of two independent shells. Interior space is protected from adverse meteorological conditions and sound by the isolation of the outer shell. The transparent shell also creates a buffer zone between indoor and outdoor atmosphere and the reflection of daylight inside which is controlled by a screening system that adjusts with the help of automated control blinds.

2.3 The Crystal Building, London

Solar powered The Crystal Building is a highly sustainable structure dedicated to the research and design of sustainable cities. An initiative by a technology company and designed by Wilkinson Eyre Architects, the structure is a giant on sustainability.



Figure 3: Crystal Building

Feats accomplished by the structure can be highlighted as having no heating costs, emitting 70% less carbon dioxide, recycling all its water, spending 46% less energy compared to similar structures, solar generating own electricity, collecting rainwater in order to maintain toilets and irrigation system.

2.4 Hindmarsh Shire Council Corporate Centre, Melbourne

Designed by k20 Architects, the structure is a prominent example on sustainability. The building is an energy efficient structure with goals on user experience. With goals on enhancing the working space an adaptability to the climate, the buildings consists of

underground thermal chambers and a ventilation system positioned under the floor drawing fresh air from the exterior.



Figure 4: Hindmarsh

The cooled and heated air is pumped back to the interior ready to be redistributed. The structure is equipped with led lighting to save energy, rooftop panels to collect solar energy and vertical green walls in order to purify the quality of the indoor air.

3. SHELL EXAMPLES

Certain materials are used in order to render buildings more adapt to climate conditions. Climate adaptive building shells provide the necessary protection and isolation for protection against the elements (Loonen et al. 2013). Most of the shell structures support the buildings specifically for light regulation purposes that are generally referred as filtering. Some interesting material implementations are presented below in order to provide an insight on structural shells (envelope).

3.1 Aegis Hyposurface

Designed by dECOi Architects, Aegis Hyposurface system consists of pneumatic piston activated transformable triangular metal plates.



Figure 5: Hyposurface

Interactively the plates change form in real-time based on stimulation from the environment such as sound, weather and digital information.

3.2 Aldar Central Market, Abu Dhabi

Designed by Foster & Partners, Aldar Central Market, Abu Dhabi the structure consists of a panel system controlled permeability that transform for shading purposes.



Figure 6: Aldar Market

As an example of an adaptive facade system, the coffered roof with the integration of a grid system alters the aspect of the structure.

3.3 City of Justice, Madrid

City of Justice, Madrid designed by Foster & Partners, Madrid Spain has a shell facade consisting of hexagon shaped shading elements covering the structure.



Figure 7: City of Justice

Hexagon elements when retracted become invisible integrating into the structural profile of the roof. The hexagon shaped elements forming the shell are based on an algorithm composed of real-time data automatically manipulating the transformation of the shell.

3.4 ETFE

ETFE roof implementations are often used as shells on buildings due to their lightweight, daylight transmittance and energy saving properties. High thermal insulation properties and extreme lightweight allow implementation costs to be reduced with the positioning of less structural supports.



Figure 8: Etfe facade implementation

The inflatable cushion system offering color control enables the transformation of the visual perception of the roof as implemented on Beijing National Aquatics Center.

3.5 The Esplanade

The Esplanada, Singapore designed by DP Architects and Michael Wilford& Partners has an outer shell consisting of mobile triangular sunshades regulating the admittance of daylight into the structure.

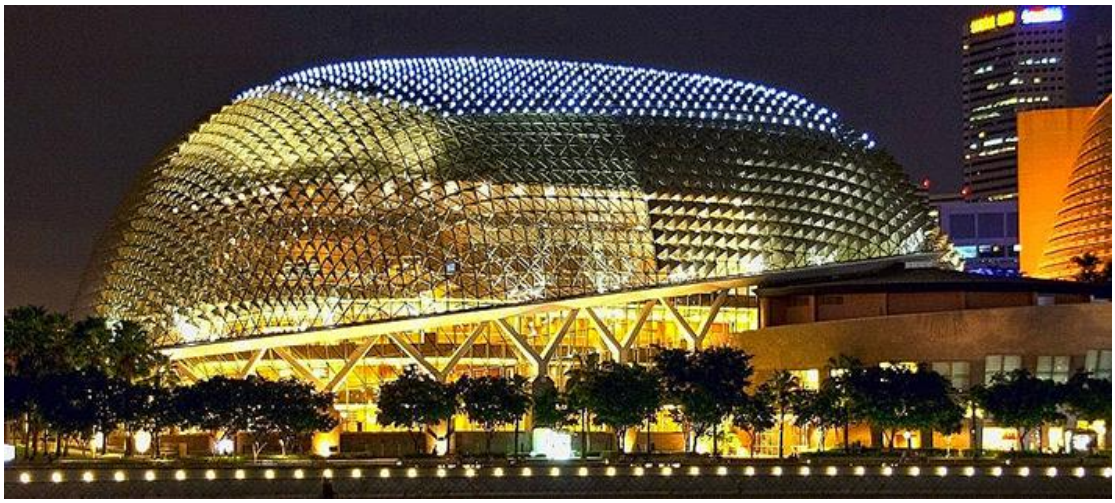

Figure 9: The Esplanade

These elements auto position in order to exclude direct sunlight as well as providing a climate control mechanism on the building. The influential structure is one of the milestone projects globally renowned.

4. DISCUSSION & CONCLUSION

Shell systems provide a protected environment with an ecosystem composed of inner dynamics belonging to the structure. Protection from the outside elements and energy saving features of a shell system enhances the quality of life for a large sum of people. The physical aspects of a shell system are generally parametric fluid-like forms as a second skin to a building. Shell systems add uniqueness and fluidity to a structure enhancing the perception.

The study explores innovative materials and contemporary implementations on mile stone structures by presenting and evaluating the examples provided.The study presents and evaluates shell systems centered on the literature presented based on the qualities pinpointed. On the other hand, there exist some risks of a double shell need mentioning. Even though it

has high performance against heat, natural lighting, user control and natural ventilation, double shell façade systems that are energy efficient carry some risks in fire protection. Since there are two layers within the facade, firefighters have to overcome the two layers in order to respond to the fire. In addition, the risk of the outer shell collapsing puts the team at risk in fighting fire. Different shell materials have different effects on the structure. Therefore, it is important not only to use renewable building materials but also to evaluate the energy and performance required to produce these materials (Rixrath & Wartha, 2015).

Aesthetically shell systems contribute a great deal to the skyline adding value to the structure as well as on urbanization assets centered on sustainability. A structure with contemporary design, engineering and social approaches acts as a landmark object for the city allowing the building to be used as a point of reference for way finding purposes. For future studies habitation and service based properties of shell systems could be a subject worth investigating.

REFERENCES

Aytıs, S. 1996. 'Yüksek Binaların Yapım Kriterleri ve Bu Kriterlerin stanbul Koullarına Göre Uygulamalı Analizi'. Doctorate Thesis. Mimar Sinan School of Fine Arts.

Harrison, K., & Meyer-Boake, T. 2003. 'The Tectonics of the Environmental Skin'. University of Waterloo, School of Architecture.
http://www.fes.uwaterloo.ca/architecture/faculty_projects/terri/ds/double.pdf

Loonen, R., M. Trčka, M., Cóstola, D. & Hensen, J. 2013. 'Climate Adaptive Building Shells: State-Of-The-Art and Future Challenges'. Building Physics and Services, Eindhoven University of Technology, Eindhoven.

Rixrath, D. & Wartha, C. 2015. 'Comparison of Different Building Shells, Life Cycle Assessment'. Integrated Environmental Assessment and Management — Volume 12, Number 3, 2016 SETAC.

Wong, I., Baldwin, A.N. 2016. 'Investigating The Potential Of Applying Vertical Green Walls To High-Rise Residential Buildings For Energy-Saving In Sub-Tropical Region', Building and Environment 97(2016).

Yeang, K. 2000. 'The Green Skyscraper: The Basis for Designing Sustainable Intensive Buildings'. Prestel Publication, ISBN-10: 3791319930, ISBN-13: 978- 3791319933 McGraw-Hill.

LINKS

http://www.mediaarchitecture.org/aegis-hyposurface-kinetic-mediafassade/
http://www.adaptivebuildings.com/aldar-central-market.html