Journal Homepage: - www.journalijar.com
INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)
Article DOI: 10.21474/IJAR01/8628
DOI URL: http://dx.doi.org/10.21474/IJAR01/8628
ISSN NO. 2320-5407

RESEARCH ARTICLE

INVESTIGATION OF SUSTAINABLE BUILDING SYSTEMS IN HIGH-RISE BUILDING EXAMPLES FROM ISTANBUL.

Naz Katırcıoglu.
katırcıoglu archıtecture, yenibosna-istanbul / turkey.

Manuscript Info

Manuscript History

Received: 06 January 2018
Final Accepted: 08 February 2019
Published: March 2019

Key words:
Istanbul, Sustainable Architecture, High-Rise Buiding

Abstract

The humanity, which must have a balanced relationship with the physical and biological environment, is more likely to be loaded than it can, thus the relationship has deteriorated and serious environmental problems have prevailed as a result.

In the second half of the 19th century, as a result of the technology that developed along with the Industrial Revolution and rapid population growth, the widespread use of resources has led to environmental problems such as global warming, ozone depletion, environmental pollution, energy crises and biodiversity loss. Increasing environmental problems and reaching larger dimensions have inevitably led to the search and implementation of sustainable methods.

In the process of rapid economic development following World War II, cities have received great immigration to meet their great business potential. As a result of the urbanization, the inadequacy of the construction sites and the excessive increase of the land prices led to vertical building. Sustainability of high structures has gained importance, as the energy and resources consumed during the construction, use and destruction of high structures are very high compared to other building types.

In this study, it is aimed to show the importance of sustainable qualities of the high buildings in Istanbul in terms of environmental, economic and social development of the city. It will be investigated by what kind of applications these structures can exhibit in terms of sustainable characteristics.

Introduction

The environmental problems that arise in many parts of the world are rooted in the imbalance between resource consumption and the natural environment. Our existence can only continue if, our world continue providing resources to us, and with our ability to destroy our own wastes and the pollution we have created. Sustainable development foresees to act sensitive to natural systems at this point.

The building sector is responsible for a large part of the total energy consumption in the world. Production, transportation, construction, operation, maintenance-repair and demolition activities directly or indirectly damage the natural environment. Sustainable architectural design is also of great importance in this context.

Corresponding Author:- Naz Katırcıoglu.
Address: katircioglu architecture- nish istanbul ressidence d-floor:6/71 cobancesme sanayi st. Yenibosna-istanbul / turkey

The Istanbul metropolis, which has experienced extraordinary growth in the past 50 years with the impact of globalization, has begun to force its existing structural and vital capacities as a result of bad governance. High buildings, which are the indispensable elements of today's fast-growing cities, have a number of unique design conditions and are accompanied by a number of opportunities and threats due to their high altitude. For example, the high buildings in the Levent Zone, one of the regions where Istanbul is seen as the most concentrated area for high construction, it causes some population threats for the region as a result of heavy population growth in the city center, traffic congestion, air pollution, insufficiency of infrastructure, speculative increase in arid areas and deterioration of historical cityscape. In addition to this, the presence of Turkey's most important companies' high-rise buildings and significant projects in this area; because the region has a vigorous potential for 24 hours, and the quality of service provision is increased (Çakır Kıasıf, 2016-a). The amount of energy, water and materials consumed during the construction, use and demolition processes of the high structures is much higher than the other constructions. Therefore, the sustainable qualities of high construction projects, which have been alleged to be a solution to the problem of high population density and limited space, are of great importance for the development of Istanbul (Saydam, 2007).

Sustainability of High-Rise Building

Human beings have always been in a desire to rise until the present day. It is seen that one of the most important factors is the religious beliefs goes to previous years in the process of formation of high structures. Despite the limitations of building techniques and possibilities, the desire to dominate nature, approaching to God, and demonstrate the power it possesses reveals the concept of high structure. Towards the Middle Ages, the tower-shaped structures are striking built elements for protection, surveillance and power. After the Industrial Revolution, the global migration from rural to urban caused urbanization to be inadequate and due to urbanization and excessive increase in land prices, resulting in vertical building with the help of developing technology. Later on, the high structures have become the symbols of power, competition, prestige and aesthetics with the importance given to them. There is no general consensus on the height limit and floor adduction for a building to be defined as a "high building" or "very high building". There are different approaches even to the measurement of height. according to Council on Tall Buildings and Urban Habitat (CTBUH), buildings with a height of 14 floors or more than 50 meters is called "tall buildlings", buildings with a height of 300-600 meters "very tall buildings", buildings with a length of more than 600 meters "mega buildings". Here, the building height is measured as the vertical distance from the pedestrian entry point to the top floor of the building. No antenna risers or similar elevations on the building are considered. According to Emporis Standards, buildings with 12 floors or higher than 35 meters are classified as "high buildings" and those higher than 100 meters are classified as "skyscrapers".

Analysis of Sustainable High Building Designs from Examples in Istanbul

This era, which we call the era of globalization, is experiencing a paradoxical process with the advantages and disadvantages it creates within itself. After the 1980s, globalization and its ideology increasing the power of neoliberalism, as in all mega-cities, has shown its effect in Istanbul as well (Çakır Kıasıf, 2016-a).

Uncontrolled population growth and the uneven and unplanned growth afterwards and excessive consumption of natural resources have begun to enforce Istanbul's environmental, social and economic capacity. The construction sector as the chief executive of this trend is observed that we had no other choice but sustainable technologies. In this context, the sustainable qualities of the high structures that are confronted as a solution to the limited area and high population density are of great importance for the future of Istanbul (Çelebi, 2003).

Sustainable Land Use and Site Selection

Investors who want to maximize their use at the maximum level are allowed to build the building area within certain boundaries with the public interest regulations. It is not possible to handle an area only in economic terms. In addition to the economic dimension, the social and environmental dimension is also found for the efficient use of the area. In this context, the principles to be considered in the conceptual stage in terms of land choice and use (Sev, 2009):

• Factors such as ground level character and underground water level influence the foundation system and the structural system. As a result of the expected poor quality of the ground, some additional measures need to be taken so that the cost of the foundation system can be much higher than expected. For this reason, the plot should be studied in a good way and it should be ensured that sufficient budget is allocated.
• As the structural system and material of the structure will greatly affect the usage decisions, various structural system options should be considered, analyzed and the right decision should be made. It should not be forgotten that decisions will play a huge role in shaping the structure of the decisions and the cost.
• The location and characteristics of the building should be taken into consideration when making decisions such as the purpose of use, floor plans, depth of the rooms, position of the service core, façade covering, flooring type, floor height, building openings and fire escapes.

Access point of the area should be considered. Users and the necessary parking space should be calculated and it should be decided where to build this spot. According to land size, budget, building height, available ground floor area, parking lot should be designed in basement levels or on the ground level. In the event of a request such an indoor parking lot, the additional load that the vehicles will bring to the structural system should not be forgotten.

It should be investigated whether or not the project site has adequate infrastructure and it should be targeted not to put too much burden on the surrounding infrastructure. The necessary measures should be taken and sufficient budget should be allocated.

42 Maslak Project

Built by Bay İnşaat, 42 Maslak is a mixed project that combines various functions such as shopping center, office, residence, life and art center. Architectural design was done by Chris Lanksbury, Jan Dijkema and Javier Vieiro, architects of Chapman Taylor Spain (Figure 1). Licensing and implementation projects were carried out by Piramit Mimarlık under the leadership of Turgut Toydemir (URL-1). 42 Maslak Project Office 2 block at the end of the year 2013 are eligible to receive LEED Platinum certification Turkey's first commercial LEED Platinum certified building has been. Immediately after that, the Office 3 block was awarded with the LEED Platinum certificate in 2014. Later, in 2015, Tower A sustainable project by received LEED Gold Certification (URL-2).

Figure 1:- Project that respects future "42 Maslak Building" (URL-1)

The project located in Maslak District, also known as "Central Business Area of Istanbul, has a safe and solid ground level as the location and ground quality. the foundation of Maslak 42 is a massive rock mass belonging to the Paleozoic Trakya formation that has high security in terms of earthquake (URL-1).

An old sock factory was on the 42 Maslak territory earlier. After moving to Çerkezköy in 2006, Bay İnşaat started to work on a sustainable project with 220 thousand square meters of covered construction area (URL-3). The existence of a factory structure earlier on the grounds provided great advantages to the project for sustainable land use pursposes. The construction of a modern life and arts center instead of the industrial structure at the center of Istanbul has improved the region in an environmental, social and economic sense (Figure 2). Within the scope of this project, the infrastructure of the region was arranged from scratch. New channels are opened and connected to the main system. In order to solve the water flood problem, high-quality rain water tanks have been put under the building for efficient use of water (URL-4).

Figure 2:- For the sake of Sustainable Land Use 42 Maslak Construction in an old factory site (URL-1)

Passive ventilation, wind effect and wind energy

Without the use of any mechanical equipment, as a result of the pressure change caused by the wind, the air entering through openings such as doors and windows of the building are subjected to passive ventilation by providing fresh air to the enclosed spaces. Passive ventilation has a very positive effect on people's health and comfort. This method is applied in countries with more mild climate conditions. In countries with hot, cold and desert climates, natural ventilation is effective when applied together with mechanical systems (Çakır Kıasıf and Selçuk, 2016).

How high-level natural ventilation is achieved should be addressed in the design phase and aimed at ventilating the structure as a whole. In general, designs allow for natural ventilation of the structures using atrium, sky-courtyards, openable and closable control windows, ventilation chimneys, air inlet-outlet channels and fans. The most important consideration when constructing an air-permeable construction shell is the ability to control fresh air intake.

When the wind current is perpendicular, façade panellas are puhed inwards, when the wind current is parallel, façade panellas are pushed outwards. Therefore, when facade systems are designed, this internal and external pressure must be able to be balanced. Variable wind loads, such as cut winds and storms, also have compelling effects on structures and façade systems. The buzzing and noise sounds caused by the wind have negative effects on the health and comfort of the users.

As a result of the integration of the wind turbine's kinetic energy, this enery firstly converted to mechanical energy and then to electricity, with this big amount of energy producton can be achieved.

Spine Tower

Designed by İki Design, Spine Tower has been awarded with LEED Gold Certificate in September 2014 with a project area of 138,000 square meters at Maslak, which is an office, residence and social facility center (URL-5).

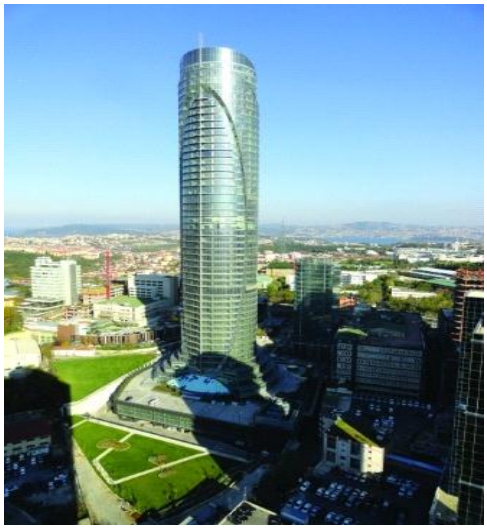

Figure 3. Spine Tower (URL-6)

At 217 meters height and 47 stories, all areas including the top floors have openable and closable wings, allowing fresh air to be taken in and the user comfort is kept at the highest level. Thanks to the openable glass system inside the curtain wall, users can provide natural ventilation. Especially at office floors that are not used during night-time, night-cooling can provide significant energy savings. In addition, wing control can be done in the automation system(URL-7).

Inspired by the spine form, the building has been successfully passed through wind tunnel tests. Prof. Ruscheweyh, one of the world's most important experts in his field, has done a successful job using special wind optimization (Figure 4) (URL-8).

Figure 4:- Prof. Rusheweyh designed a special wind optimization for Spine Tower (URL-8)

Facade Systems

Curtain wall systems, one of the most preferred facade systems in high structures, have become more than passive elements with the help of advancing technology. Bioclimatic facade designs provide natural ventilation and natural lighting. In this way, many energy savings are achieved while meeting the building's ventilation and lighting needs. With the energy efficient facade design, control of heat, light and sound passing between the inside and outside environment can be controlled and the negative features of the outside environment can

be removed. Energy efficient facades can be designed with qualified glass selections, double shell facade systems, structural silicon facades, solar panels, photovoltaic panels (Bekar, 2007).

Maslak No: 1 Building

Designed by Emre Arolat, with LEED Gold certification, Maslak No: 1 Office Building is completed in the first quarter of 2014. This project with a total construction area of 29000 square meters in Maslak is owned by Saral Group of Companies, Koçkaya and Altınbaş Holding (URL-9).

Figure 5:- Maslak No: 1 Building External View (URL-9)

The most prominent feature of the project with its sustainable design is its double shell façade system (Figure 6). To define a double shell façade system which is an energy efficient façade in the simplest terms; an outer layer, an inner layer, and the air gap between these two layers. Outer layer protects the building from adverse environmental conditions and plays a major role in providing spatial comfort. Through the windows on the inner shell, natural and clean air can be introduced into the interior space by providing air inflow from the outer layer to the interspace. The double shell can be ventilated naturally, mechanically or integrally (Çakır Kıasıf, 2016-b). With this façade system, user satisfaction is achieved at the highest level by providing thermal, visual and acoustic comfort.

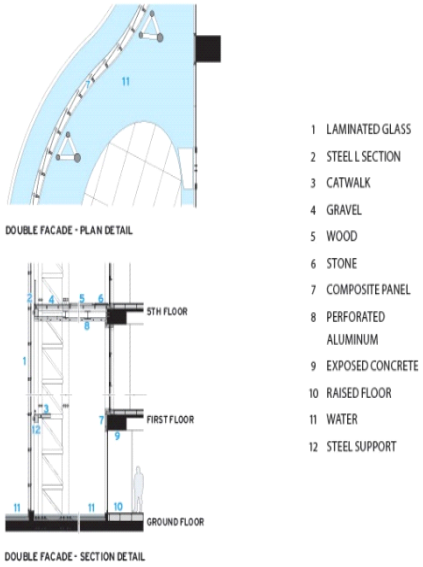

Figure 6:- Maslak No: 1 Building's Double Shell Detail (URL-10)

Maslak No: 1 Building 8.25 * 8.25 m grid system has an independent and rational transparent exterior layer of rectangular modules consisting of 1.50 * 2.00 m on the system plan. The glass panels on the outer layer are

covered with a translucent film layer and placed in a fish flake arrangement. Special performance glass panels are preferred to allow air flow and natural ventilation is provided to save energy and provide acoustic comfort (Figure 7). Visual comfort is also enjoyed by users with its circularly designed outer shell design, which allows maximum utilization of its apperance (URL-11).

Figure 7:- Internal view of Maslak No: 1 Building from Double Shell Facade System (URL-11)

Green Roof and Vertical Garden Applications

The green roofs and vertical gardening practices are emerging as a sustainable solution proposal to increase the decreasing green texture in urban areas. Users who live and / or work in green roofs and vertical garden structures are able to get close to nature in cities which have limited green space. In other words, these facade systems increase user comfort and create healthier and more comfortable spaces (Çakır Kıasıf and Selçuk, 2018). They can easily be applied to all types of structures, including high-rise buildings.

While green roofs are sustainable, they have many advantages compared to other roof systems. It appears that maintenance and operating costs are lesser compared to the benefits provided by the overall structure which creates many advantages. Only necessary measures should be taken during the design phase to test the additional load to the building, necessary water insulation layers, drainage systems, soil layer thickness.

Green roofs and vertical garden applications; reducing the effects of urban heat island, preventing air pollution, raising the quality of indoor and outdoor air, destroying greenhouse gases, creating a living natural environment, reducing the heating and cooling costs of the structure, providing sound insulation, providing visual comfort, absorbing electromagnetic radiation (Çakır Kıasıf, 2018).

It is preferred that the plants to be used in green gardens and vertical gardens are selected from the endemic plant cover of the region. Watering and maintenance must be done at certain intervals so that the plants can survive. This water should be evacuated by making the necessary detail to avoid damaging the building structure, floor coverings and equipment components.

Tekfen OZ Levent Office Building

Construction completed in 2010, Tekfen OZ Levent Istanbul Levent Office Building is the first commercial building to be certified as LEED Gold building (Figure 8). Tekfen Real Estate, the owner of the project, has built the concept design of the project with Prof. Juan Pablo Molestina and the architectural projects with the Swanke Hayden Connell Architecture Company (URL-12).

Figure 8:- Outside View of Tekfen OZ Levent Building (URL-13)

Tekfen Levent Office Building provides a different working environment to the users and provides them with green texture in Levent, where the high construction is seen intensely, with the vertical garden façade design (Kara, 2017). With this façade system, it is possible to make maximum use of the daylight for the users and to be able to see the outside easily. The planted vertical façade brings visibly created beauties besides the shading effect, bringing a buffer zone and reducing the building's solar-induced cooling loads (Figure 9). The choice of local plants that do not consume excessive water and the efficient use of water has been achieved by recycling water (URL-14).

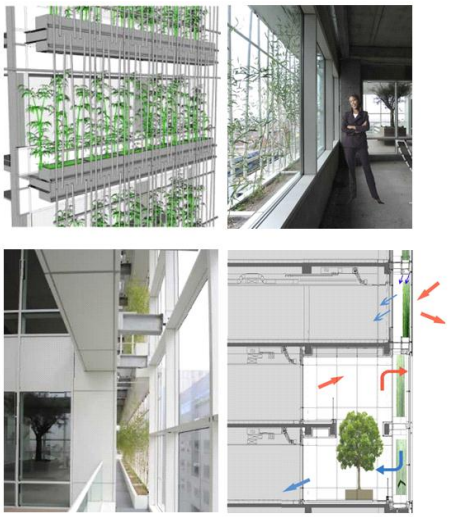

Figure 9:- Tekfen OZ Levent Building's Vertical Garden Facade (URL-13)

Sky-courtyards and Atriums

The high-rise buildings are pulled back on the facades to avoid undesirable effects of the sun, with balconies or several floors retracting together. In addition to its bioclimatic functions, the sky-courtyards create social spaces for its users. In this way, natural environment is created in the building and comfort conditions are provided for the users. In the sky-courtyard design, the speed of dominant wind must be kept at a level that does not disturb the user comfort (Çakır Kıasıf and Selçuk, 2016).

The atrium is called to the void spaces in a building. If the gaps are along the height of the building, the upper part of the gaps may not be completely covered. Arranging the passageways in the building perpendicular to the designed atrium areas will enable these gaps to work as an air channels (Sev, 2009).

Istanbul Sapphire Building

Istanbul Sapphire Building is a shopping center and residence structure with a total construction area of 165,139m2 on a base area of 11.339m2 on Levent Buyukdere Caddesi where high construction is being observed. The design of the project carried out by Biskon Inc. under Kiler Group which belongs to Tabanlıoğlu Architecture. It is a total of 64 floors with 10 floors in the basement and 54 floors above the ground. 235m. height of the building and with a 26m. height of antenna, the total height of Sapphire is 261m. It holds the Turkey's tallest building title. The building consists a shopping center, housing, parking, sports and recreation functions in its own right (Akın, 2010). The building completed in 2011 attracts attention with energy efficient building design (Figure 10).

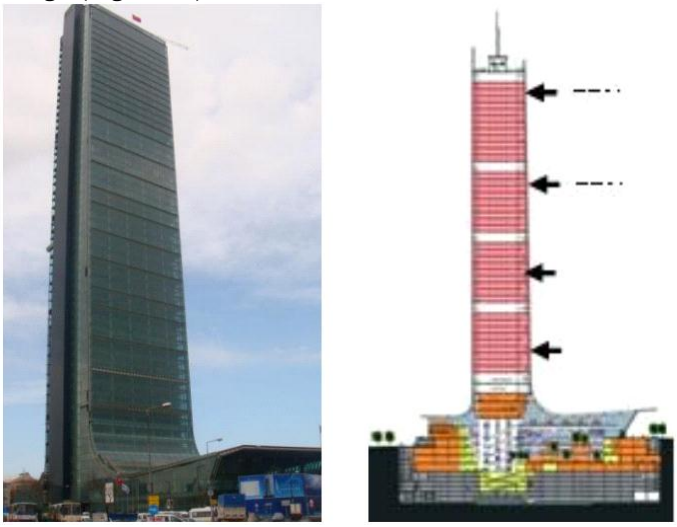

Figure 10:- Outside view of the Istanbul Sapphire Building and its cross-section (Eren and Erturan, 2013)

The residential floors of the Sapphire Building are designed in such a way that each of them will form a 3-storey sky-courtyard. The building has 9 storey tall 4 different zones (lifebands) consisting of a combination of 3 sky courtyards. Floors between the zones are used as swimming pool, spa, lounge, golf course, residential lobby and mechanical service floor (Figure 10). The greatest privilege of the Istanbul Sapphire building is that it has vertical gardens with a three-storey skywalk design (Eren and Erturan, 2013). With this celestial design, which keeps neighborhood relations warm, even at very high elevations, users can get fresh air from the balcony without any security problems and enjoy the unique view of Istanbul (Figure 11).

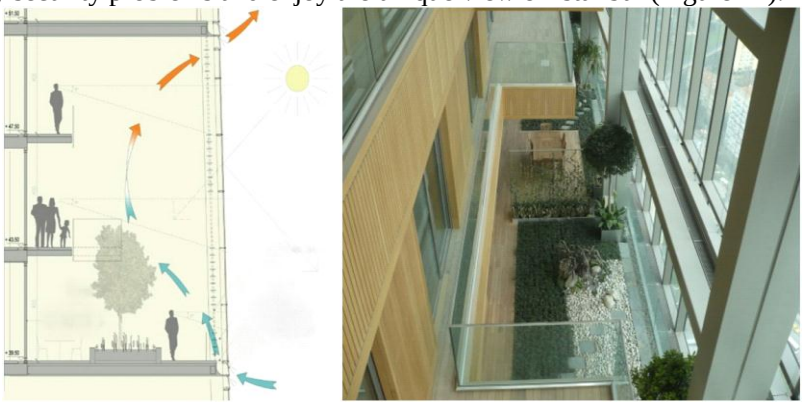

Figure 11:- The sky gaps between the inner shell and the outer shell that forms sky-courtyards of the Sapphire Building (URL-15)

Cogeneration and Triggering Systems

Cogeneration and Triggeration Systems are systems that allow both electricity and heat energy to be produced together in the same system (Figure 12). Energy saving is a preferred system as a result of harmful gas release and external reliance on energy demand.

Figure 12:- Cogeneration and Triggering System - Combined Heat Power Generation Facility (URL-16)

CVK Park Bosphorus Hotel

CVK Park Bosphorus Hotel, which attracts attention with its traditional architecture in Beyoğlu, Istanbul, opened in 2013 (Figure 13). With its technological infrastructure, this hotel offers privileged accommodation for its guests, and a clean and environmentally friendly cogeneration system is used. In this system, which can be used in all areas requiring energy, the losses that occur in the transmission and distribution lines can be prevented because the electricity can be produced where the energy is consumed. Co-generation applications that allow the required energy to be produced at the desired time and amount and bring energy independence together reveal the sensitivity of Park Bosphorus Hotel to sustainable energy and environmental sensitivity (URL-17).

Şekil 13:- CVK Park Bosphorus Hotel (URL-18)

Conclusıon And Evaluatıon:-

Designing a high structure in a metropolis like Istanbul emerges with its great responsibilities. A high-rise building should never be designed by only keeping commercial targets on the frontline. Because it is a high structure, it has the power to affect the silhouette of the whole city either positively or negatively. In this case, the task of the architect is to improve the planning and marketing strategies that will increase the commercial value of the construction and to put forward successful aesthetically sustainable structures by studying the land and environmental conditions as well. Many high buildings have negative effects on people living or working inside them. If you do not use as much as you can without natural ventilation and lighting, depending on the completely mechanical systems, there are serious problems in terms of user comfort. As a result, there are serious reductions in work efficiency and quality of life. Where infrastructure is inadequate, high buildup places more burdens on the urban network and causes poor impact on sustainability. In this context, application of environmentally friendly technologies on high buildings is of great importance in terms of sustainability. It is possible to carry sustainable qualities of high structures with bioclimatic design, sustainable land use, green roof and vertical garden applications, sky-atrium designs, energy efficient facade design and cogeneration-trigeneration systems. In this way, many benefits can be gained from social, environmental and economic aspects and success can be achieved in the name of sustainable development.

References:-

1. Akın, U., 2010. "2005 Sonrası Konut Mimarisinin Değişimi- İstanbul Levent Örneği",Yüksek Lisans Tezi. T.C. Beykent Üniversitesi Fen Bilimleri Enstitüsü, İstanbul.
2. Bekar, D., 2007. "Ekolojik Mimarlıkta Aktif Enerji Sistemlerinin İncelenmesi", *Yüksek Lisans Tezi*, Y.T.Ü. Fen Bilimleri Enstitüsü, İstanbul.
3. Çakır Kıasıf, G., 2016-a. "Küreselleşmeyle Birlikte Levent Bölgesindeki Değişimin Yarattığı Fırsat ve Tehditlerin Sürdürülebilir Kalkınmaya Etkisi", 2.Uluslararası Kent Araştırmaları Kongresi, 11-13 Mayıs 2016, İ.T.Ü., İstanbul.
4. Çakır Kıasıf, G., 2016-b. "Enerji Etkin Çift Kabuk Cephe Sistemlerinde Yangın Performansını İyileştirecek Yöntemler", 8.Ulusal Çatı ve Cephe Sempozyumu, 02-03 Haziran 2016, MSGSÜ, İstanbul.
5. Çakır Kıasıf, G., 2018. "In the Context of User Comfort Examining of Green Wall Technologies", XIII. International HvacRSanitary Technology Symposium, 12-14 April 2018, İstanbul.
6. Çakır Kıasıf, G. and Selçuk, E., 2016. "Yüksek Yapı Tasarımında Sürdürülebilir Yapım Sistemlerinin İncelenmesi", 4.Proje ve Yapım Yönetimi Kongresi, 03-05 Kasım 2016, Anadolu Üniv., Eskişehir.
7. Çakır Kıasıf, G. and Selçuk, E., 2018. "Yeşillendirilmiş Konut Cephelerinin Kentlerin Çevresel Kalkınmasına Etkisi", İstanbul I. Konut Kurultayı, 10-11 Mayıs 2018, Y.T.Ü., İstanbul.
8. Çelebi, G., 2003. "Environmental Discourse and Conceptual Framework For Sustainable Arch.", G.Ü. Journal of Science Dergisi, 16, 205-216.
9. Eren, Ö. And Erturan, B., 2013. "Intelligent Facades As An Energy-Efficient Building Design Approach", E-Journal of New World Sciences Academy, NWSA, Turkey.
10. Kara, B., 2017. "Akıllı Cephelerin Sürdürülebilir Kalkınma Bağlamında İrdelenmesi", *Yüksek Lisans Tezi*, Haliç Üniversitesi Fen Bilimleri Enstitüsü, İstanbul.
11. Saydam, Ç., 2007. " Yüksek Yapıların Kentsel Gelişme Bağlamında İrdelenmesi ve Yüksek Yapı Politikaları, Yüksek Lisans Tezi, MSGSÜ Fen Bilimleri Enstitüsü, İstanbul.
12. Sev, A., 2009. "Sürdürülebilir Mimarlık", YEM Yayın, İstanbul.
13. URL-1: https://view.publitas.com/42maslak/42-maslak-yasam-burada-sanat/page/64-65 (02.06.2018)
14. URL-2: http://www.mimtarch.com/docs/201602_42MaslakKuleA.pdf (05.05.2018)
15. URL-3: http://www.yesilbinadergisi.com/yayin/717/ticari-gayrimenkul-segmentinde-leed-platin-sertifikali-42-maslak-projesi_21713.html#.WxLccUiFOM8 (24.04.2018)
16. URL-4: http://www.yesilbinadergisi.com/edergi/21/35/files/assets/basic-html/index.html#30, (02.05.2018)
17. URL-5: http://www.erketasarim.com/referans/spine-tower/ (13.04.2018)
18. URL-6: http://www.ekoyapidergisi.org/1035-surdurulebilirlik-guvenlik-ve-konfor-bir-arada-spine-tower.html (14.04.2018)
19. URL-7: http://www.ekoyapidergisi.org/1036-omurga-formundan-esinlenen-feminen-bir-durus.html (08.04.2018)
20. URL-8: http://www.spine-tower.com/services.html (16.04.2018)
21. URL-9: http://www.maslakno1.com/tr/ (18.04.2018)
22. URL-10:https://www.architecturalrecord.com/articles/12678-maslak-tower-no-1-by-emre-arolat-architecture?#305;r&industry=INDUSTRY%20ACCESS:%20%20Architecture,%20Engineering%20&%20Construction%20&sites=SITES:%20%20Architectural%20Record%20&epubid=&appid= (22.04.2018)
23. URL-11: http://www.arkiv.com.tr/proje/maslak-no1-ofis-yapisi/5840 (Erişim Tarihi: 02.04.2018)
24. URL-12: http://www.arkiv.com.tr/proje/levent-ofis/1546 (24.03.2018)
25. URL-13: http://www.altensis.com/wpcontent/uploads/2011/08/Tekfen_Levent_Pictures_Booklet.pdf (24.03.2018)
26. URL-14:http://www.altensis.com/proje/tekfen-oz-levent-ofis-binasi-ilk-leed-sertifikali-ticari-ofis-binasi/ (24.03.2018)
27. URL-15: http://v3.arkitera.com/news.php?action=displayNewsItem&ID=50234 (27.03.2018)
28. URL-16: http://www.eskoenerji.com.tr/kojenerasyon-trijenerasyon/ (01.06.2018)
29. URL-17: https://www.turizminsesi.com/haber/cvk-park-bosphorus-hotelde-kojenerasyon-teknolojisi-18721.htm (01.06.2018)
30. URL-18: https://www.turizminsesi.com/haber/cvk-park-bosphorus-hotelde-kojenerasyon-teknolojisi-18721.htm (01.06.2018)