A FACADE MAPPING METHOD TO UNDERSTAND HUMAN COMFORT IN BUILDINGS WITH HIGHLY GLAZED FACADES

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ABSTRACT

A FACADE MAPPING METHOD TO UNDERSTAND HUMAN COMFORT IN BUILDINGS WITH HIGHLY GLAZED FACADES

Tüzer, Ceren
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The energy demand of societies increases continuously with related to technological improvements, population increases and daily needs. Building sector is one of the highest energy consumer sector. Office buildings are also critical type of buildings, because these types of buildings generally accommodate lots of occupant and there is high demand of energy for lighting, heating, ventilation, and air conditioning to provide indoor air quality, thermal and visual comfort. The buildings with glass curtain wall that is used for high rise office buildings mostly, are also critical type of buildings in terms of thermal performance and user comfort which effect the energy consumption.

This study aimed to show the probable impact of glass curtain wall on thermal performance and user comfort with facade mapping method. For this aim, eight buildings that are cladded with glass curtain wall and located in Ankara, were examined as the case buildings. Photos were taken from their facades for fall, winter, spring and summer seasons. To determine the percentage of facade closed by the users that are forced to take precaution for their thermal and visual comfort, the facade mappings of the buildings were created by the help of these photos. The results were discussed according to direction of the facade and the season. The results of four case buildings were compared with properties of glass which were belong to these case buildings. According to the results, the highly use of internal shading elements is due to the occupants trying to provide thermal and visual comfort. The rate of internal blind' use is partially related with thermal properties of glazing.

Keywords: Glass Curtain Wall, Facade Mapping, Thermal Performance, User Comfort, Shading Strategies

ÖZ

GENİŞ CAM CEPHELİ YAPILARDA İNSAN KONFORUNU ANLAMAK İÇİN CEPHE HARİTALAMA METHODU

Tüzer, Ceren
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Teknolojik gelişmelere, nüfus artışına ve günlük ihtiyaçlara bağlı olarak toplumların enerji talebi artmaktadır. Yapı sektörü yüksek oranda enerji tüketen sektörlerden biridir. Özellikle gün içerisinde yoğun olarak kullanılan, aydınlatma, ısıtma-soğutma ve havalandırma için fazla enerji gereken ofis binaları enerji tüketimi açısından önemli bina tiplerindendir. Aynı zamanda yüksek katlı ofis binalarında çokça kullanılan cam giydirme cepheler de ısıl performans ve kullanıcı konforu açısından kritik bir öneme sahiptir.

Bu çalışma cam giydirme cephelerin binaların ısıl performansı ve kullanıcı konforu üzerine olası etkilerini cephe haritası çıkarma yöntemiyle göstermeyi amaçlamıştır. Bu amaç doğrultusunda, Ankara'da bulunan sekiz tane cam giydirme cepheli bina örnek olarak seçilmiştir. Bu binaların cephelerinden alınan fotoğraflar yardımıyla cephe haritaları oluşturulmuş ve ısıl ve görsel konforunu sağlamaya zorlanan kullanıcı tarafından kapatılan cephenin kapalılık yüzdesi elde edilmiştir. Kapalılık yüzdeleri, binaların cephelerinin yönlerine ve mevsime göre irdelenmiştir. Daha sonra, cam özelliklerine ulaşılan dört örnek binanın cephelerinin kapalılık oranları, cam özellikleriyle karşılaştırılmıştır. Sonuçlara göre, iç gölgeleme elemanlarının yüksek oranda kullanılmasının sebebi, kullanıcıların ısıl ve görsel konforu sağlamaya

çalışmasıdır. Cam özelliklerinin, iç gölgelendirme elemanı kullanımıyla kısmen ilişkili olduğu saptanmıştır.

Anahtar Kelimeler: Cam Giydirme Cephe, Cephe Haritası, Isıl Performans, Kullanıcı Konforu

To my family

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CHAPTER 1

INTRODUCTION

In this chapter the argument, aim-objectives, procedure and disposition for the thesis are presented. The study discusses the thermal performance of buildings that have a glass curtain wall, in Ankara, and user satisfaction.

1.1. Argument

Due to the technological improvements, rise in population and lifestyle, the energy demand of societies is increasing continuously. Hence, the building sector is one of the highest energy consumer sectors. According to the latest data (2018) of International Energy Agency, buildings and buildings construction sector consume 36% of the total energy used worldwide. In meantime, because many people spend most of time in closed spaces that are isolated from the exterior environment and mostly from nature, user comfort becomes an important issue to protect the health of the users and improve productivity.

On the other hand, to protect the environment and provide higher living quality for users, energy consumption should be decreased by considering the energy efficiency strategies and applying them according to location and the function of the building, starting from the design phase.

Besides, the buildings that have glass curtain walls, especially in hot climate, are critical type of buildings in terms of thermal performance and user satisfaction which effect the energy consumption. In the light of literature review, use of glass curtain wall is seen to be disadvantageous, if its material or shading devices on it, are not considered properly. Especially, since the vast glass surfaces of the building envelope tend to collect solar heat due to the greenhouse effect, thus leading to uncomfortably high temperatures within the buildings. For this reason, glass curtain wall system, the daylighting, shading strategies and user satisfaction were researched to support the problem statement and suggested solutions to such problems.

The glass curtain wall system has been preferred to a great extent in modern architecture, because it can provide uniformity for facade design, gives a lightweight and attractive view in aesthetic aspects. In meantime, the uninterrupted glazing provides wide angle of view to outside and natural lighting for occupants. However, facade that will have the glass curtain wall should be designed by considering climate to reduce energy consumption while maintaining indoor environment.

In Ankara, many buildings with glass curtain wall have been constructed recently. Almost all of these buildings are designed by ignoring climatic condition of the city and no shading strategy were designed for these buildings. With respect to this idea, when these buildings were observed, it was realized that many users are forced to take precaution for their thermal and visual comfort with fabric roller blinds which is a basic internal shading strategy and not very effective. Therefore, the basic purposes of the glass curtain wall can not be provided. Because of the complicated view of fabric blinds, the uniformity of facade breaks down partially and the view to outside is restricted.

1.2. Aim and Objectives

User satisfaction and thermal performance are the crucial issues that affect the energy efficiency and health of the users. The aim of this study is to determine the impact of curtain walls on user satisfaction with their comfort condition due to the solar gains (heat and light). Three objectives of this study are listed below:

- To examine basic principles of heat and light transfer through glazed facade and their impact on user satisfaction, through a literature review.
- To evaluate the selected highly glazed case study buildings in Ankara in order to understand strategies adopted by occupants to deal with the problem of excessive solar heat and light gain.

- To study shading and daylighting strategies and transfer these strategies to case buildings for the future development of glass curtain wall application

4. To study shading and daylighting strategies and transfer these strategies to case buildings for the future development of glass curtain wall application

1.3. Procedure

The study contains a literature review to understand the concept of glass curtain wall, thermal performance, natural light and lighting condition, shading strategies and user comfort. After the literature review was done, the eight case study buildings that have glass curtain wall and located in Ankara were chosen. The selection criteria were shading type of the building and visibility of the internal shading devices from outside. The photos of all facades of these eight buildings were taken in fall, winter, spring and summer seasons and the rate of curtained area were compared. Furtherly, the facade mapping of eight buildings was made for summer and winter season to get numeric data about rate of curtained area. Further, four cases of which glass properties could be obtained were compared with curtained area rates for summer season.

1.4. Disposition

This report consists of five chapters. In the first chapter, introduction, motivation for the research subject, problem definition, aim and objectives of the study is explained relatively.

In the second chapter, literature review is presented. Literature involves information about glass curtain walls, heat and light transfer principles through glass, daylighting and shading strategies. At the last part user satisfaction is studied as visual and thermal comfort.

The third chapter, materials and method, explains the eight cases, the software like AutoCAD, Photoshop, Microsoft Excel and other materials like camera and polarized filter that are used in this research. Additionally, process of the research and photograph taking, facade mapping, analysis steps are explained in method section, in detail.

Analysis and results are given in the fourth section. The facade mappings and the curtained area rates of each case building were given separately for summer and winter seasons. The comparison of the results according to facade orientations and seasons, relation between glass properties and total curtained area of four case buildings for summer season were discussed.

In the fifth section conclusion takes place. The results are highlighted, and recommendations are indicated for further studies.

CHAPTER 2

LITERATURE REVIEW

This chapter presents a literature review regarding glass curtain wall, thermal performance in a building, natural light and lighting condition, shading strategies and user comfort. This study based on 40 published sources.

2.1. Glass Curtain Wall Systems

According to Chew, Tan and Kang (2004) facade of a building is the part of the building envelope that protects the inside of the building from outside weather conditions, in order to maintain a comfortable interior environment. The factors that affect the facade design are “the structural loading, aesthetic appeal, enhanced view to the exterior and energy efficiency” (Chew, Tan, & Kang, 2004).

Morris (2013) stated that, the most significant features that makes the glass attractive in architectural aspects are light reflectance and transmittance. It can reflect the blue sky on a clear day or clouds on an overcast day, while it allows view to outside for the occupants of a building, provides connection between outside and inside and provides natural lighting to interior. The glass skin that can be seen in high rise buildings, is called as curtain wall. Its primary function is separating environment from interior space. Hence, it should be able to;

- resist water
- support wind loads, especially in high rise buildings
- minimize heat loss in cold weather
- minimize heat gain in warm weather
- comply with the movements caused by wind, live and seismic loads.

Curtain walls are lighter than other facades like masonry and precast concrete. Its name is derived from its installation method which is hanging like a curtain. The Crystal Palace is generally accepted as precursor of the glass curtain wall system, but the similarity ends with the use of glass wall, because the curtain wall system is supported by the structure of the building, according to Yeomans (1998). According to Murray (2009), the interest of modern architects in curtain wall began in the late nineteenth century with the development in framing system which allow much more transparent surfaces. According to Murray's book, in 1922, Mies van der Rohe expressed the relation between structure and glass as:

"…we can see the new structural principles most clearly when we use glass in place of the outer walls, which is feasible today since in a skeleton building these outer walls do not actually carry weight. The use of glass imposes new solutions."

In 1930's, with the development of the double pane insulating glass unit and float glass manufacturing led to expectations from increased transparency. In 1950's and 60's the success in some buildings with glass curtain wall like SOM's Lever House and Mies's Seagram Building (Figure 2.1), led to spread the popularity of the "glass box" phenomenon. This phenomenon also led a revision of the mid-century curtain wall.

Figure 2.1. Photographs of Lever House (right) and Seagram Building (left) (Source: https://www.som.com/projects/lever_house, https://www.archdaily.com/59412/ad-classics-seagram-building-mies-van-der-rohe/53834618c07a802121000421-seagram-building-mies-van-der-rohe-photo)

In recent decades, concept of glass box phenomenon has changed. It changed from thin and transparent wall to more complex component of a building with more functions. According to Ábalos and Herreros (2003), the transformation was to active system from passive system and the glass curtain wall was defined as "the site at which glass, climate control, and the external environment assume congruent and interactive roles."

Glass curtain walls consist of mainly framing elements and glazing. Framing elements can be composed of aluminum or steel profiles. The material can be chosen according to aesthetical expectations like module spacing and grid while it can be according to loading constrains (McFarquhar, 2013).

Glazing is an important part of curtain wall in terms of daylight transmissivity and energy performance of the building. The glass can be grouped by its type, color, size and strength. The glass type can be divided into three basic groups: monolithic, insulating units and laminated panes (McFarquhar, 2013). Monolithic glass expresses a singular thickness. The insulating units contain two layers of glazing with air gap between them. Two layers of glazing have four surfaces that can be covered with low-e coating or tint. These layers control the energy and light transfer depending on reflectivity, level and color of the tint. As higher technology, photovoltaic cells can be applied to glazing system in order to generate energy. The multiple layers of monolithic glass with air gap and a laminate interlayer membrane between them, constitutes laminated glass. As to glass color, the inherent color of a glass is greenish because of iron content. Clearer glass which is low-iron glass, is obtained by decreasing the amount of iron content. The inside surfaces of the two panes can be tinted. To minimize the heat transfer through glass, low-e tint can be combined with reflective tint. The size of the glass can vary according to application, loading constrains and manufacturing constrains like limitations of float plant or autoclave. The glass strength is also important because it is strong in compression and weaker in tension. There are three groups in terms of manufacturing that effects the strength: annealed, heat strengthened and fully tempered.

Besides the advantages of glass curtain wall like natural light transmittance, providing view to outside, giving light weight view to a structure aesthetically, it has disadvantages. Yi (2011) stated that the glass curtain wall has lower level of energy performance than other building envelopes. The author researched the thermal performance of glass curtain wall with respect to different window to wall ratios and different glass properties, in four different climatic zones which are extremely cold region, cold region, hot-summer and cold-winter region and hot-summer and warm-winter region, in China. In all climatic conditions, heating load and cooling load generally increased with increasing window to wall ratio while shading coefficiency and U-value was found to have significant impact on energy consumption. Morris (2013) stated that excessive heat gain or loss across the glass curtain wall cause user discomfort while it leads to increasing energy consumption.

2.2. Thermal Performance in a Building

The increasing population and human needs cause increase in energy demand. The building sector consume the 40% of the global energy according to research of Zenginis and Kontoleon (2017). Consequently, people are seeking and using energy efficiency strategies for the built environment. Energy efficiency strategies consider the environment, inhabitants and their needs and comfort besides the financial and energy efficiency purposes. Also, in the research of Yao (2018), impact of energy efficiency strategies on preventing climate change and wasting money is stated. According to this research the energy for heating and cooling creates approximately 50-60% of the total energy consumption in a residential building. Therefore, thermal performance of the building envelope should be improved.

The orientation of the facade should be considered when the precautions are taken to improve thermal performance. Dutta, Samanta and Neogi (2017) claim that the maximum heat gain occurs through South oriented windows and it is followed by the East, West and North oriented facades in tropical climate of northern hemisphere. With the help of movable exterior shading elements, the annual average of energy saving can be 9.8% and the maximum energy efficiency can be obtained in June with 14.9% percentage. Besides the energy efficiency, financial profit is important. According to this economic analysis, the payback period is only six months.

Thermal performance depends on plan configuration, percentage of air-conditioned space, building envelope materials, window to wall ratio and shading devices that effects the energy consumption of HVAC and artificial lighting. Bano and Seghal (2018) examined the impact of these parameters on energy consumption of six mid and high-rise energy efficient office building in composite climate zones. According to their research, some considerations can enhance thermal performance. For instance, service cores can be placed along West facade to create buffer zone. In that way, natural lighting and ventilation can be provided to the service core. Using mixed-mode ventilation system increase energy efficiency. Also improving natural ventilation with atriums or landscaped courtyards can support energy efficiency, while lower window to wall ratio provides lower cooling load.

In another research impact of similar parameters on thermal performance were studied by Manu et al. (2018). Six case studies that are located in different climate zones in India, were examined in terms of their design strategies and divided into two groups. The first strategy is giving importance to spatial organization e.g., designing spaces that have different heights and volumes to provide stack ventilation, preferring operable windows for cross-ventilation, designing courtyard with shading. The second strategy is preferring appropriate materials and construction technology e.g., creating high thermal mass by using fired clay brick, reducing heat ingress by creating air cavity between the layers of the wall. According to their analysis, applying appropriate material and technology is the most effective way to minimize heat gain. These strategies are useful for all climate zones to provide lower internal surface temperatures. Manu et al. (2018) claimed that, in all strategies, the coordination of outdoor condition and operational conditions is determinant for the success of strategies.

2.2.1. Heat and Light Transfer Through Glass

The major ways of heat transfer are conduction, convection and radiation. Conduction is a process by which heat is transferred from the hot area of a solid object to the cooler area by the collisions of particles. In convection, heat is transferred from one part of a fluid (liquid or gas) to another by the bulk movement of the fluid itself. Radiation is transfer of heat with electromagnetic waves through space. (Brown and DeKay, 2001)

According to Kong, Liu, Yang, Zhong and Qi (2016), glass curtain wall is the most crucial part of the building in terms of heat conduction, because of its lower thermal resistance. It can cause larger heat loss than a “traditional building wall” (Kong et al., 2016). According to Çengel (2002), windows are the part of building envelope that have least resistance in terms of heat flow. So, it causes higher heating and cooling load as compared to other parts of the building component. On the other hand, the windows are the major parts of the building envelope in terms of daylighting and heat gain for the cold winter season. The need for artificial lighting can be reduced by efficient use of natural lighting and the optimum design for a window as having “a good light transmittance while providing effective resistance to heat flow.” (Çengel, 2002)

Çengel (2002), explained that sun rays can reach to a surface by direct radiation, diffuse radiation or reflected radiation as it is shown in Figure 2.2.

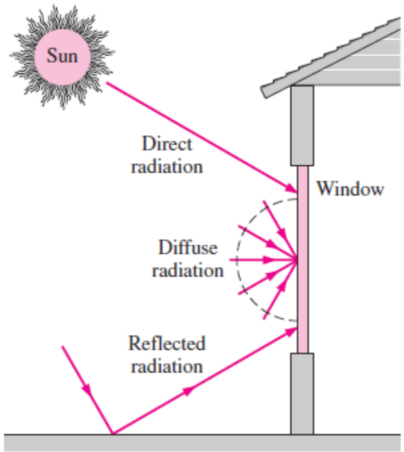


Figure 2.2. Direct, diffuse, and reflected components of solar radiation incident on a window (Source: Çengel , 2002)

After the solar radiation reaches a glass surface, some part of it transmitted, some part reflected and rest of it absorbed by the glass; therefore, the sum of the transmissivity, reflectivity and absorptivity of the glass is equal to one. The ratios can change according to thickness and the composition of the window, while absorbed solar radiation can transfer inward or outward as it is shown in Figure 2.3. (Çengel, 2002)

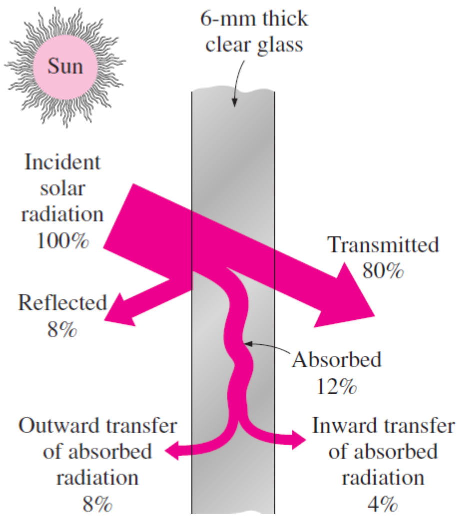


Figure 2.3. Distribution of solar radiation incident on a clear glass (Source: Çengel, 2002)

Transmitted solar radiation is absorbed by an object or reflected from a surface and eventually it is absorbed as sensible heat; therefore, transmitted solar energy means heat gain for a building. The solar heat gain is equal to the total transmitted solar radiation and the part of absorbed radiation that is transferred inward. Another term about heat transfer is solar heat gain coefficient which is the ratio of solar heat gain through the window per solar radiation incident on the window. (Çengel, 2002)

The solar transmission properties of different sort of glazing materials and shading devices can be defined by comparing them with a base glazing material or shading device of which solar transmissivity is known. This is called as shading coefficient and calculated by divided solar heat gain of the product to solar heat gain of reference glazing. (Çengel, 2002)

In heat transfer calculations the resistance of the material is expressed as R-value which means the thermal resistance per unit area. The inverse of the resistance of the material is the transmittance of the material which is expressed by U-value.

As for light transfer, Galbraith (2015) explain that after the light beam reach to the surface of glass, some part of the beam is reflected, and some part is transmitted. The refractive index is related with type of material. It determines the amount of reflected, transmitted light and the angle between them and the surface. (Figure 2.4)

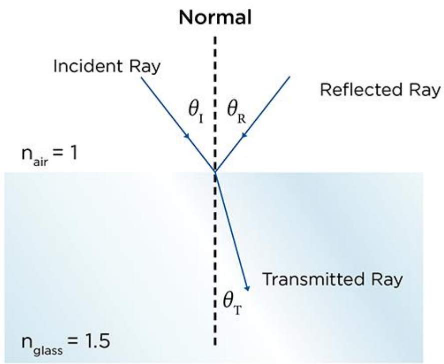


Figure 2.4. Light that is incident on a glass surface will be reflected at an angle equal to the angle of incidence and transmitted according to Snell’s law. (Source: Galbraith, 2015)

2.2.2. Factors Effecting Thermal Performance

Zenginis and Kontoleon (2017) investigate the impact of orientation of the facade, glazing area ratio, aspect ratio of the building and U-value on heat fluxes. The research was made according to climate of northern Greece region, during the three months of winter. The studied building zone that is thermally insulated, is shown in Figure 2.5. The zone has three interior walls and an exterior wall. This exterior surface was investigated with different parameters such as different facade orientation, with glazing that have different U-values, with different fenestration type, with different aspect ratio and different settings of indoor air temperature.

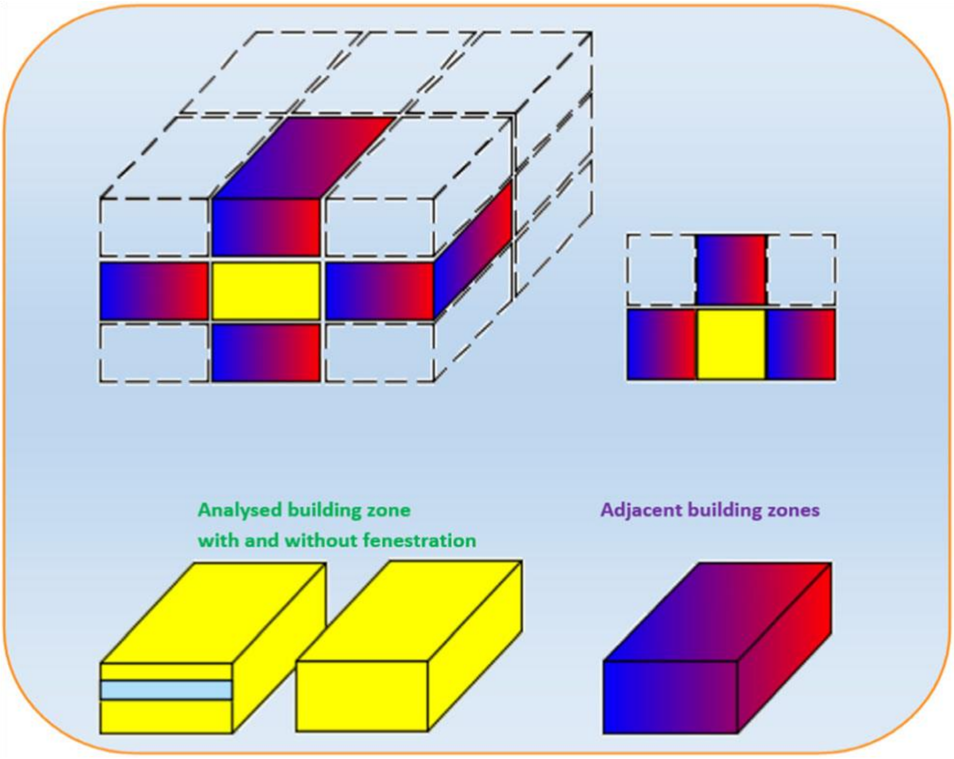


Figure 2.5. Depiction of the analyzed building zone with and without openings (perspective and plan view) (Source: Zenginis and Kontoleon, 2017)

Data about different U values, indoor air temperature, glazing proportions and facade orientations are compared to determine how heat gain and loss changes according to these parameters, as shown in Figure 2.6. For this comparison, building aspect ratio was taken as 1:1.

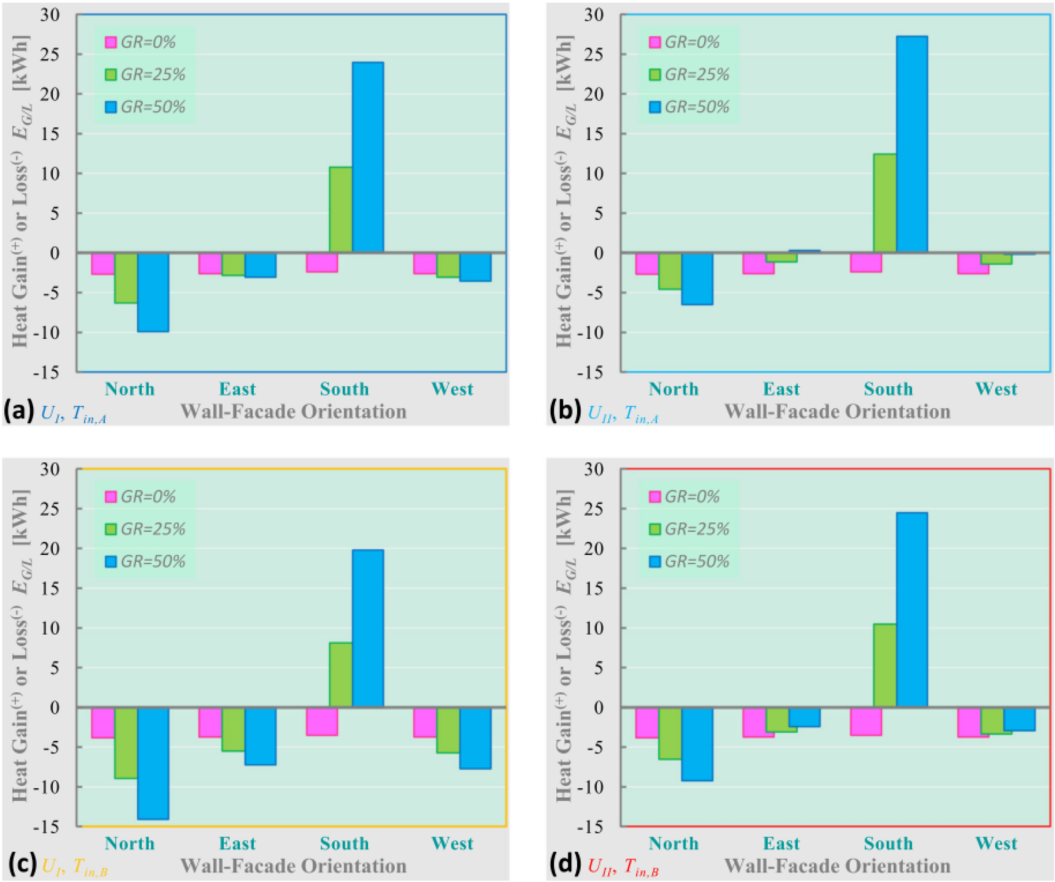


Figure 2.6. Diurnal heat gains or losses EG/L averaged over the considered 3-month winter period with reference to different U- values and Tin selections. (a) U1 = 2.50 Wm−2 K−1, Tin,A= 18°C. (b) U1I = 1.50 W m−2 K−1, Tin,A = 18°C (c) U1 = 2.50Wm−2 K−1, Tin,B = 22°C. (d) U1I = 1.50 W m−2 K−1, Tin,B = 22°C (Source: Zenginis and Kontoleon, 2017)

As it is shown in Figure 2.6, effect of the glazing proportion is greater in South facades. When considering the overall performance of the different orientations, the South facing facade accounts for a larger amount of heat gain as compared to other facades, where the total heat losses are greater than heat gain. Hence, according to orientation of the facade, glazing and facade ratio should be taken into consideration. Glazing ratio is important factor especially for the South facade. On other facades, heat losses are observed. On the North facade glazing proportion and heat gain are inversely proportional. On the East and West facade, the heat gain/loss value changes according to U-value and interior air temperature. For the East and West facade, glazing with smaller U-value should be preferred if the glazing proportion will be higher.

Building aspect ratio also has an impact on thermal performance. Zenginis and Kontoleon (2017) compare the buildings with different aspect ratio, glazing proportion and orientation, as shown in figure. Aspect ratio changes from 1:2 to 2:1. On the North, East and West facade, increasing building aspect ratio cause decrease in thermal performance. The South facade has a reverse situation again and heat gain increases with increasing aspect ratio with 25 and 50% glazing ratio.

Bae, Oh and Kim (2015) claim that frame-glass ratio and frame material can affect the thermal performance in buildings that have curtain wall. Curtain wall frames have greater impact on thermal performance rather than glazing. The authors examined and compared 24 combinations with three different glazing and eight different frame ratios. They stated that steel frames are stronger than aluminum profiles. So, larger panels can be constructed by using steel to decrease the thermal transmittance. As the result of the research, they found that, increasing frame-glass ratio causes decreasing thermal performance.

Çengel (2002) stated that heat transfer through the windows can not be decreased by making the glass thicker. However, adding an air layer between two glass panes reduces the thermal conductivity. Consequently, 1 cm air layer between two glass panes, has the same effect that would be obtained from a 30 cm thick pane.

Kong, Liu, Yang, Zhong and Qi (2016) state that double skin facade, with internal and external glass, can create “green house effect”. Moreover, with openable parts on the internal and external facade “chimney effect” occurs, as shown in Figure 2.7. Hence, such facades can enhance the thermal performance.

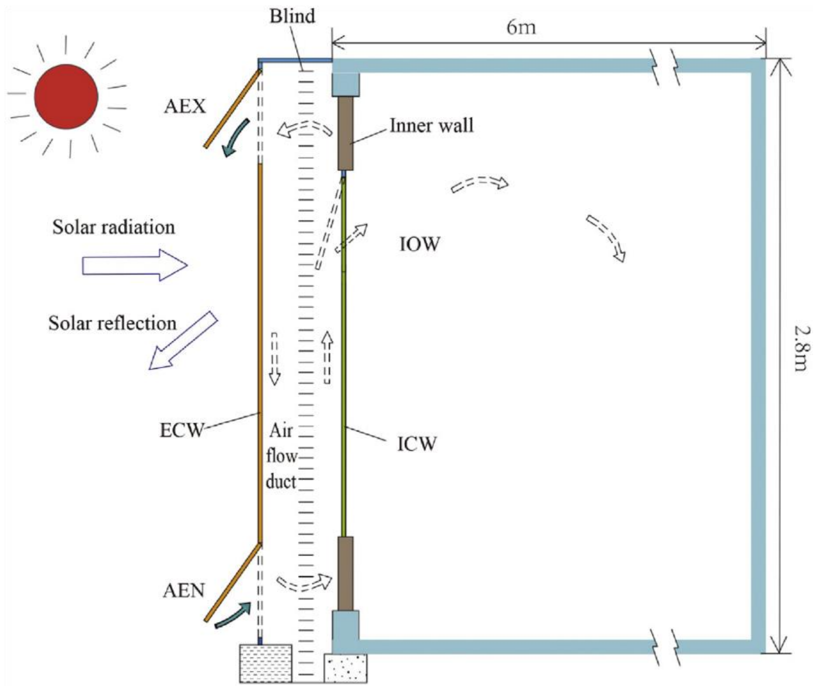


Figure 2.7. Structure of respiration-type double-layer glass curtain wall system. (Source: Kong *et al*., 2016)

Al-Tamimi and Qahtan (2016) claimed that U-value, the gas that is filled between glass panes like argon, krypton, air etc., and coating for glass panes like low-e effects the thermal performance of the curtain wall. The authors compared the thermal performance of six different glazing types which are single clear, single reflective, double clear, double reflective, double low-e and double coated reflective, for a period of one year. The ranking was made in terms of thermal performance of glazing type as double coated reflective, double reflective, single reflective, double low-e, double clear and single clear, from better to worst respectively. In this ranking single reflective glazing had better thermal performance than double low-e and double clear glass, since the single glass allows heat to escape during night time easily and balance the indoor air temperature which is maximized during day because of solar heat gain.

2.3. Natural Light and Lighting Condition

Daylighting is controlled natural lighting that comes to the interior space and it is used to decrease energy loads, caused by artificial lighting (Yousuf, Alamgir, Afzal, Maqsood and Arif, 2017). The daylighting availability is changed according to coordinates of the building, weather condition and surrounding obstructions like high rise buildings that can be closer than it should be. In the buildings where the daylighting is considered in design phase, energy cost can be decreased, while visual comfort can be enhanced. In meantime, daylighting has impact on human health positively. Inadequate natural light can cause the feeling of exhausting, nephrology diseases, cardiac muscle weakness etc. Moreover, daylighting is one of the key factors for the green building design. In green building design the quality of the daylighting is determined by daylight factor. The higher daylight factor means the more natural light is available inside. It can be calculated by using formula

DF=(Ei/Eo)x100

Ei : illuminance due to daylighting at a point on the indoors working plane

Eo : outside horizontal illuminance under an overcast (CIE sky) or uniform sky

(Source: Yousuf, Alamgir, Afzal, Maqsood and Arif, 2017)

Brown and DeKay (2001) explained that daylight factor is available percentage of exterior illumination for indoor space; it is dependent on window size and placement, sky obstructions, glazing transmission and interior reflectance. Daylight availability is dependent on weather conditions and latitude. Sizes and location of windows should be considered according to the period of year that has the lowest exterior illuminance. In this case, in brighter days, more than enough daylight will be available indoors and shading devices should be used for such days to reduce amount of light admitted during the middle of the day.

Ramirez, Pujols, Casares, Ramirez-Faz and Luque (2013) claim that daylight availability is an important factor for user satisfaction. In some countries the minimum required solar access which is related to natural light, is considered as “solar rights”. Solar rights are about “the rights of building occupants to enjoy minimum daily sun exposure in their homes.” (Ramírez, Pujols, Casares, Ramírez-Faz, & López-Luque, 2013).

Ochoa and Capeluto (2016) point that countries with high solar radiation, can benefit from natural lighting conditions in order to provide visual comfort and avoid energy waste due to the artificial lighting. In the light of their research, the data from National Electric Company in Israel shows that, on a summer day, the energy consumption for artificial lighting in the office buildings is about 30% of the total energy consumption. This contradictory situation is caused by the contrast between the zone near the window and the zone at the other end of an office room, in terms of availability of the natural lighting. Additionally, in warmer seasons uncontrolled daylight can cause increase in thermal loads. Nevertheless, their need for artificial lighting should be decreased. By integrating daylight control systems to glazing, like shading devices, energy performance can be improved and required daylight level can be provided.

Osterhaus (2005) states that for efficient daylighting in rooms with windows in a single exterior wall, room depth should be maximum 2,5 times (2,5H) the height of window (H), since only 2 to 2,5H depth can benefit from daylight. The room depth should not be longer than 5 meter. Otherwise, it can cause discomfort glare because of luminance contrast between windows and other surfaces. Even if sufficient daylighting is provided to the interior, view to outside should be provided for occupants. So, daylighting cannot be provided only by skylights or windows that are located above or below eye-level or translucent glazing systems.

Ruck et al., (2000) state that different aspects of daylighting should be considered in four major phases of a building, as conceptual design, design phase, construction planning and commissioning and post-occupancy. In the conceptual design phase, daylighting can be formed by considering the proportions, shape and orientation of the building. In the design phase, building daylighting plan should be formed, facades and interior finishing should be designed according to daylighting. In final planning/construction step, materials and components should be selected according to daylighting strategy. Final details about daylighting strategies should be completed with construction plans. In the last step, commissioning and post occupancy, lighting control should be arranged.

To prevent glare in interior spaces, indirect lighting strategies can be implemented; these strategies include light shelves, internal and external shading. Placement of these elements should also be considered carefully to maintain visual contact of occupants.

2.4. Shading Strategies and Shading Efficiency

According to Ochoa and Capeluto (2005), in summer, uncontrolled solar radiation may increase heating load unwantedly and it can cause extra energy consumption because of air conditioning systems. Glazing and shading systems should be considered in order to "achieve improved overall energy performance as well as enhanced lighting levels with visually comfortable uniformity." (Ochoa & Capeluto, 2005).

Maestre, Blazquez, Gallero, Cubillas (2015) stated that energy consumption in buildings is highly related with incident solar radiation which affects frequency of air conditioning and artificial lighting use. Use of shading devices control the natural lighting and solar energy. Line Karlsen, Heiselberg, Bryna and Johra (2016) investigated solar shading control strategies. The research emphasized that the shading control strategy should be improved by considering energy use, thermal and visual comfort. The researchers proposed an optimal shading strategy by considering internal heat gains (occupants, equipment and lighting), HVAC system, occupied time interval, total radiation on the glazed facade, vertical irradiation to control glare. The operation cost, maintenance and payback periods, especially for retrofit projects, should be considered for the efficiency.

2.4.1. Internal Shading

Brown and DeKay (2001) explained that internal shading can be placed interior space, inside the glass or between layers of double or triple glazed window. This can reduce direct daylight, glare and solar heat gain in summer. If blinds are placed between the layers of glass, the shading coefficient (SC) will be low, since the solar gain is reduced at the window before entering the space. So, low SC means lower heat gain. Internal shading that is placed inside of window is more efficient than that placed in the room, in terms of maintenance; it can collect dirt easily and be corrupted by external factors.

Marsh (2006) claims that internal shading devices can prevent glare and daylight to a high extent, but, if there are no obstructions for direct sunlight at the exterior surface of the window, there will be solar gain that increases heat inside, between internal shading and glazing. To determine the problem, the author compared four cases with different internal shading types by using computational fluid dynamics (Figure 2.8.). In the first case open-top curtain system is used as shown in Figure 2.8. Because of the solar absorptance of the curtain fabric, U-value of both window and glazing, and absence of natural ventilation, temperature stratification occur inside of the room. In 30 minutes, warmed air is circulated in the room and loses its heat lower levels enough to enter the new loop and heat the space faster.

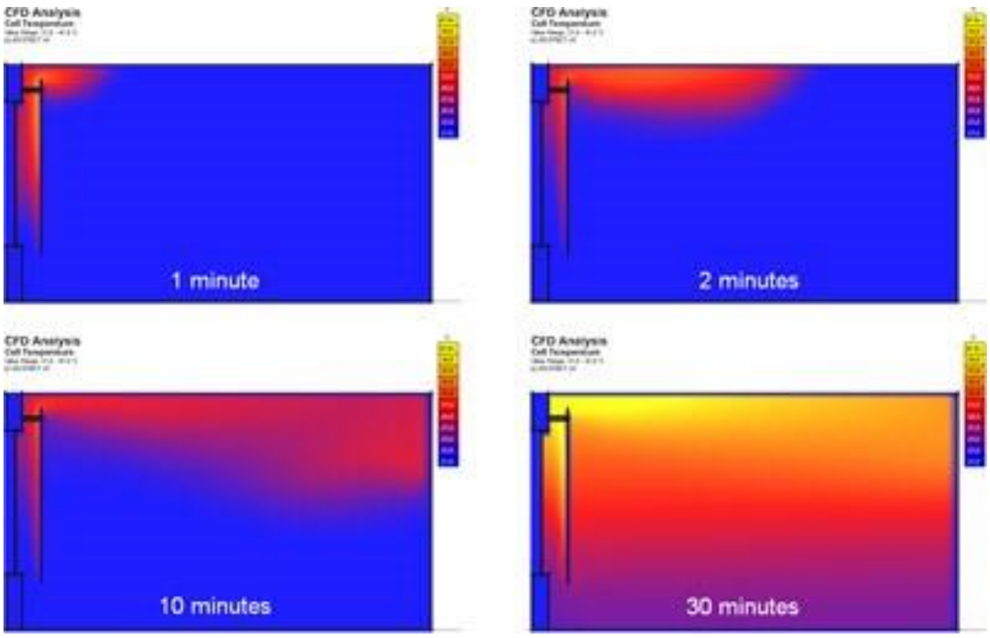


Figure 2.8. A time-sequence using computational fluid dynamics (CFD) to show the effect of thermo-syphoning on room air temperatures when an open-top blind system is subject to 660W/m² of incident solar gain. (Source: Marsh, 2006)

In the second case horizontal louvres are used. Blinds are set at an angle of 45 degrees to let some daylight to come in. Results are similar with the first case. However, the new loop begins earlier than the first case because of the separated parts of the shading system. Since the warmed air come into the room more easily, material of the shading is less important than the first case. In the third case, sealed pelmet is used, and heated air is squeezed in the gap. In this case material of the internal shading is more important in terms of its transmissivity. According to Marsh (2006), after 30 minutes, the warmed air in the gap will begin to spill out into the room from bottom of the internal shading. In the last case, sealed pelmet system with external exhaust vent is investigated, as shown in Figure 2.9. As different from third case, external exhaust vent provides warmed air exit. So, temperature stratification is not observed in this case.

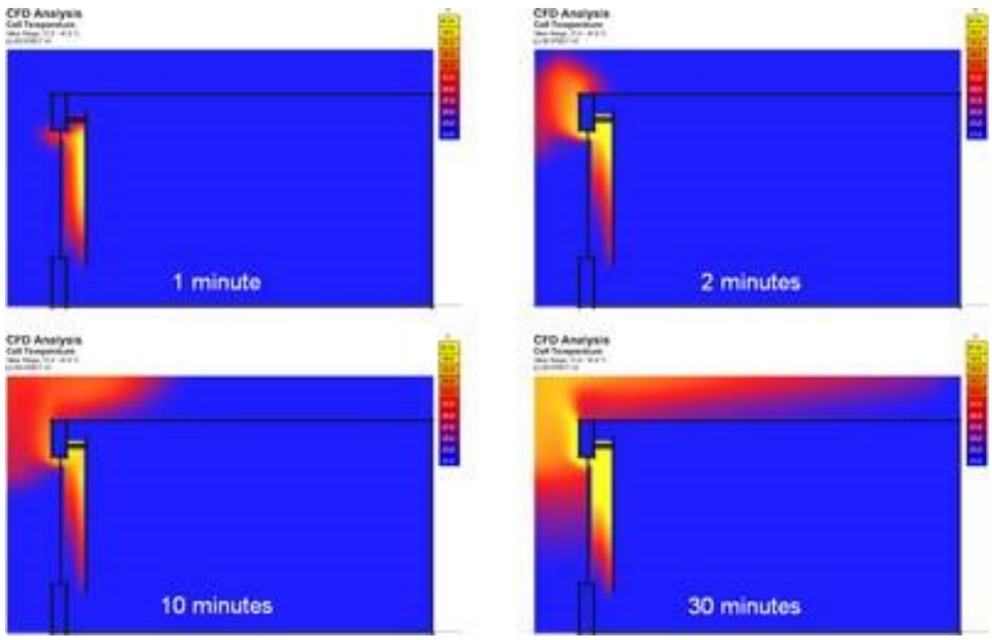


Figure 2.9. The same time sequence showing the pelmeted system with a vent at the top of the window allowing the warm air to escape to the outside. (Source: Marsh, 2006)

On the other hand, internal shading devices can be more flexible to use, cheaper and easier to repair than external shading devices. Ye, Xu, Mao, and Ji (2015) stated that internal shading devices are as effective as external shading devices if the appropriate materials would be chosen. Thickness, infrared hemispherical emissivity, visible reflectivity, and solar reflectivity of the internal shading device are decisive factors for performance of the system.

Internal shading elements also can be used for horizontal glazed surfaces effectively. Wang, et. al. (2013) proposed an internal shading device to top of the atrium of a commercial building in tropical climate. They achieved to prevent high level of solar gain while keeping the natural lighting level in optimum levels by proposing internal shading element for atrium. The suggested internal shading reduces the two third of the solar heat gain in summer season. With internal shading, the mean illuminance changes between 195-300 lux which is not as bright as the condition without using internal shading, but enough according to CIBSE’s recommendations for foyers and entrance halls. For the winter season or overcast days of the summer, retractable shading would be appropriate to supply natural lighting.

2.4.2. External Shading

External shading can be provided by both horizontal and vertical elements. Brown and DeKay (2001) pointed that horizontal elements can be preferable when the sun altitude is high in summer and low in winter. In this case, solar gain is maintained in winter and direct sun light can be reduced in summer. Vertical shading elements are effective when the sun is low. Angle of the vertical elements can be changed according to facade and angle of sun. For instance, vertical elements that are perpendicular to window is more efficient in North, West and East facades than South facade.

In contrast to some general belief, windows on the North facade can need shading elements to provide energy efficiency. Alhuwayil, Mujeebu and Algarny (2018) stated that this necessity depends on the location of the building. In tropical and hot-dry climates all facades of the building including the North facade should be cladded with shading elements to reduce solar heat gain throughout the year. Because in the morning and the afternoon when the sun rises and sets, the sun rays reach the North facade obliquely from the Northeast and the Northwest directions. Alhuwayil, Mujeebu and Algarny (2018) studied the effects of vertical fins on the North facade, on total energy saving. They compare the energy saving rates of a building with 4.2 meter height of floors and 4 meter height of windows, by using the vertical fins with different width as it shown in Figure 2.10. The smaller value of saving is related with the smaller solar heat gain from the North facade of the building. Although the energy saving rate increases by increasing of fin width, 1.7m was chosen as optimum width when they consider the balance between energy saving and building geometry which increases from 0.61% to 1% of total energy savings when depth of fins increases from 1 meter to 2.5 meter.

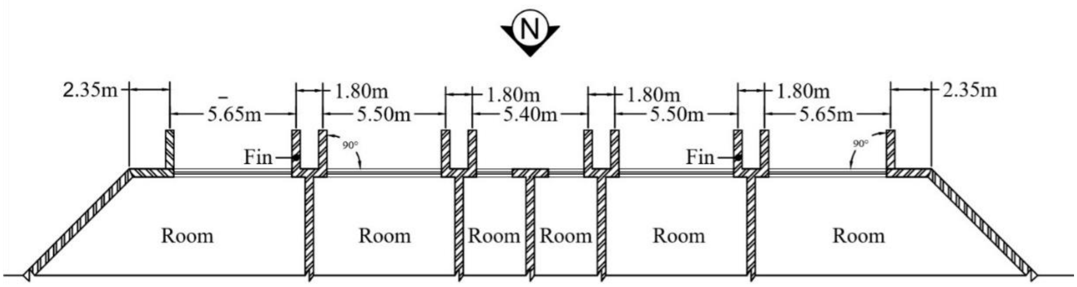


Figure 2.10. Arrangement of fins on North facade. (Source: Alhuwayil, Mujeebu and Algarny, 2018)

Alhuwayil, Mujeebu and Algarny (2018) stated that fixed shading increase heating load in winter season. Nevertheless, it provides energy saving annually, because shading elements decrease cooling load in hot summer months. They compared three conditions in terms of energy saving: without shading (base), with shading elements on all facades (case 4) and with improved insulation and triple low-e glazing instead of double-glazed window without shading (case 5), as shown in Figure 2.11.

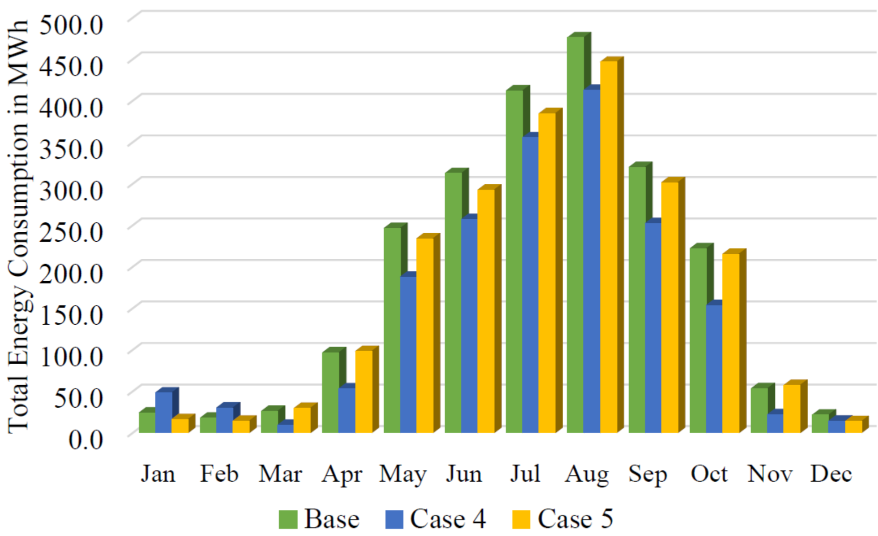


Figure 2.11. Comparison of monthly variation in total energy consumption. (Source: Alhuwayil, Mujeebu and Algarny, 2018)

Impact of fixed external shading devices on cooling load is greater than heating load in cooling dominated climates. Therefore, energy saving that depends on cooling load is more important in this kind of climates. Material decision for windows, without external shading can be preferable in cold climate to increase the solar heat gain in winter season. In this research, approximately %20 energy saving was achieved in case 4 and 5% were achieved in case 5. Additionally, the cost of the shading devices can be paid back in 2 years.

Uribe, Bustamante and Vera (2017) point that control of direct solar radiation and solar heat transmission can be provided by louvers, venetian blinds and perforated panels. These can be compared of fixed or movable elements. The authors investigated the optimization of a complex fenestration system with curved and horizontal perforated louvers. This shading system is utilized for climatic condition of Santiago (Chile) and Oslo (Norway). The research is repeated with different angles of louvers between 15° to 75°; with different louver angle change strategies as bi-monthly, quarterly and bi-annual. In meantime, results are compared with fixed shading system and the case that shading devices are not used. Annual energy consumption data for each case is shown in Figure 2.12.

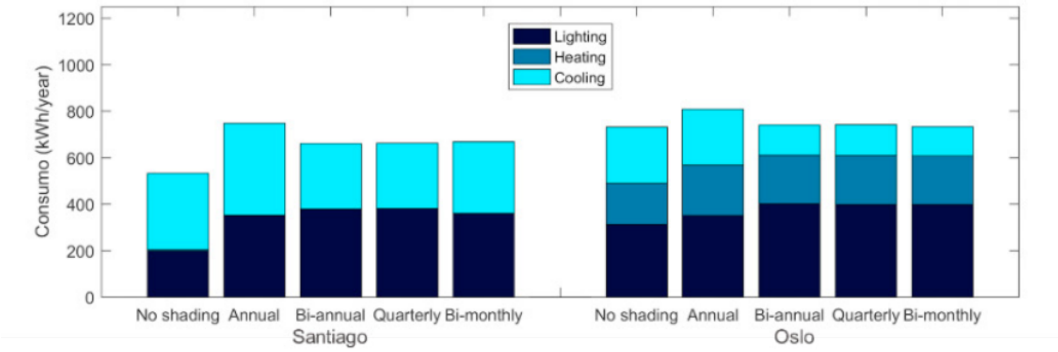


Figure 2.12. Energy Consumption (kWh/year) for each case (Source: Uribe, Bustamante and Vera, 2017)

For the non-shading case, energy consumption in Santiago is 533kWh/year while, in Oslo 732 kWh/year. Fixed angle of shading(annual) is provider year-round this consumption increases to 749 kWh and 810 kWh respectively Santiago and Oslo. But the highest reduction in energy consumption is obtained in bi-annual and quarterly variation cases in Santiago. The year-round energy consumption decreases from 749 kWh/year to 661 kWh/year if shading is varied biannually or quarterly variation, the increase in energy consumption is less than that for fixed annual shading case. As it is shown in Figure 2.12., when the number of changes in louvers position increase, lighting energy consumption increases because of control of indoor daylighting. The reduction for cooling energy consumption can reach 29.5% in Santiago and 45.3% in Oslo. Energy consumption for heating is stable in all cases.

Line Karlsen, Heiselberg, Bryna and Johra (2016) examined the thermal performance of an office model in four conditions: with external shading, internal shading, with both together and without any shading device. According to their research in moderate cold climates application of only external shading devices can be preferable. Because the cost of internal and external shading installation and automatic control system is higher than expected value when the lifetime of these devices is considered. In more extreme cold climates combination of the internal and external shading devices may be preferable according results of cost analysis.

2.4.3. Light Shelves

A light shelf is a system that reflects natural light from outside deep into an indoor space (Kim, Lee, Jang, Park, Choi, 2018). Brown and DeKay (2001) explained that light shelves divide windows into two parts horizontally. It prevents direct sun that can cause glare.

Brown and DeKay (2001) explained that according to material of shelves, they can reflect the light and provide indirect lighting to the space. To decide the optimum size light shelves, location of building, direction of facade, angle of sun rays should be taken into consideration. Kim et al. (2018) stated that width, angle, height and material properties of the light shelves affect the lighting performance while materials with high intensity, can cause glare problem.

The light shelves can be divided into three groups according to installation: interior, exterior and mixed. Interior light shelves can provide much more natural lighting to the interior than exterior type, while the exterior light shelves prevent the direct solar radiation.

Lee, Kim and Seo (2017) researched the impact of light shelves on the energy consumption of artificial lighting and air conditioning. According to research, light shelves can reduce up to 10.5% of the lighting load and 6.9 to 9.3% of the cooling load in summer season. In winter season, light shelves can not help for energy consumption. They increase the lighting load up to 25.3% and the heating load from 0.2 to 3.2%. The longer dimensions for light shelves can increase cooling load in summer, because the larger reflective area increases the amount of natural light getting in. Increased light shelve angle also increase the amount of the light.

Ochoa and Capeluto (2006) show the influence of using lightshelf and depth of lightshelf on thermal and electrical lighting loads. They investigated south-facing office with 6.7-meter depth, in Tel Aviv for their research. The optimum application of lightshelves provide reduction in glare and energy loads per square meter as shown in Figure 2.13.

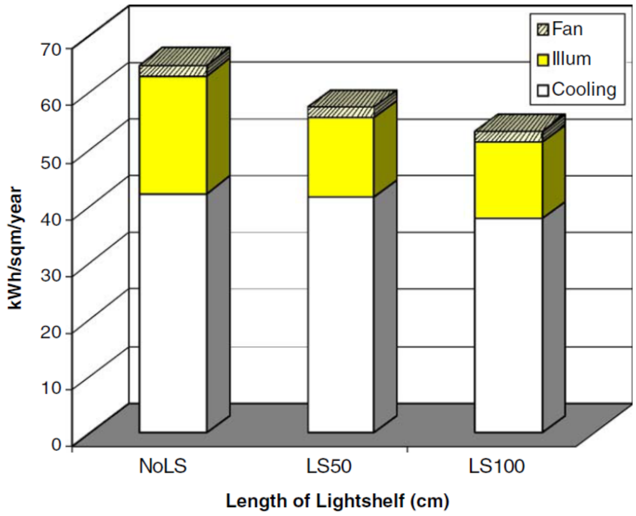


Figure 2.13. Year-round influence of lightshelves with different depth over thermal and electrical lightning loads for a south-facing office, Tel Aviv, Israel (Source: Ochoa and Capeluto, 2006)

2.4.4. Overhangs

The optimum length for the overhang can be found by the help of energy simulations. Alhuwayil, Mujeebu and Algarny (2018) investigated the impact of overhang depth to energy saving by using DesignBuilder. The overhangs were installed on the South facade with the depth between 1 to 2.5 meter. The floor height is 4.2 meter and the window height is 4 meter. The depth between 1 and 1.2 meter provides 4.3% energy saving while 1.5, 2 and 2.5 meter provides 4.4% energy saving as shown in Figure 2.14. So, 1.5 meters was selected as the optimum length for this research.

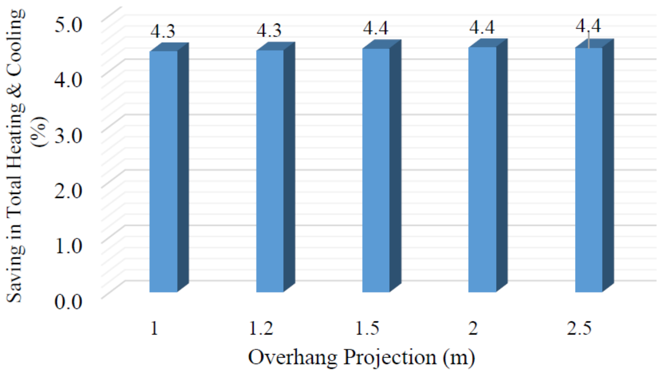


Figure 2.14. Variation of saving in total energy consumption with overhang length on south-facing (Source: Alhuwayil, Mujeebu and Algarny, 2018)

2.5. User Satisfaction

Modern office buildings often consist of a high proportion of glazing in the facade, which requires considerable attention during the building design with respect to its impact on occupant comfort as well as on energy demand for cooling, heating and lighting. (Line Karlsen, Heiselberg, Bryna and Johra, 2016). For this kind of office buildings with high window to wall ratio, shading strategies should be developed to provide visual and thermal comfort besides decreasing energy demand for cooling.

Ramirez et al. (2013) state that user comfort interior spaces is related with daylight availability. Minimum required solar access for the buildings according to their function should be considered to provide healthy space for users and visual comfort, which is related with natural lighting and clear view.

Providing more flexibility for user control of thermal and visual comfort can enhance the user satisfaction. Kwona, Remøyb, Dobbelsteena and Knaacka (2019) investigated the relation between user satisfaction and user control with a questionnaire survey. The user control was grouped into four parts: complete control (full control of user), partial control (user control in limited range), no control (user is not allowed to control) and do not have (no installation of user control system). According to results, the highest user satisfaction belongs to user group with complete control, while the highest dissatisfaction belongs to user of 'no control' and 'do not have' groups.

2.5.1. Thermal Comfort

Volkov, Sedov, and Chelyshkov (2014) stated that indoor environments are important in workplaces for people because of duration of use in a day. So, the thermal conditions and thermal comfort become a crucial factor that affects comfort, health, and productivity of user. The researchers have defined human thermal comfort as "the combination between the subjective sensation of a group of people and the objective interaction with the surrounding environment." (Volkov, Sedov, & Chelyshkov, 2014, p. 362). So, the thermal comfort is related to personal and environmental factors; metabolic rate, clothing insulation, air temperature, radiant temperature, air speed, and humidity. Alamin, Castilla, Alvarez and Ruano (2017) stated that international standards like ASHRAE 55, define the thermal comfort as "That condition of mind which expresses satisfaction with the thermal environment" (Alamin, Castilla, Alvarez, & Ruano, 2017).

Çengel (2002) highlighted that thermal comfort depends on metabolism rate and clothing insulation besides the environmental factors like the temperature, air motion and relative humidity. 23 to 27 °C is accepted as operative temperatures for normally clothed people who are resting or doing light work. The relative humidity affects the heat fluctuation; with high relative humidity decrease in heat by evaporation slows down. The normal range of relative humidity is accepted as 30-70%, so the optimum level is 50%. The excessive air motion can cause thermal discomfort by creating partial cooling on human body. Also, asymmetric thermal radiation can cause thermal discomfort. The large glazed surfaces, uninsulated walls/floor radiant heating panels can cause the asymmetric thermal radiation.

Air conditioning of typical office buildings is generally provided with central air conditioning systems. The conventional manual thermostats are generally arranged to fix indoor temperature. However, the sensation of thermal comfort is more complicated, because it can change from one person to another. Yau and Chang (2015) investigated thermal comfort level of occupants through a case study in an office in Malaysia. They made active measurement with data loggers about the air temperature, global temperature, air velocity and relative humidity, in the occupied zone, during five working days. Besides the active measurement, they made subjective measurement through a comfort survey which is based on 7-point ASHRAE thermal comfort rating of occupants: cold (-3), cool (-2), slightly cool (-1), neutral (0), slightly warm (+1), warm (+2), hot (+3). A fuzzy logic controller (FLC) that control the thermostat settings based on operative temperature and relative humidity, was installed and another survey was conducted. The comparison of first survey (pre-survey) and second survey (post-survey) showed that the FLC based air conditioning system improved thermal comfort of occupants rather than conventional centralized air conditioning systems where occupants try to control indoor air temperature by switching ON/OFF the system. Figure 2.15. shows the thermal comfort level of occupants in the case study.

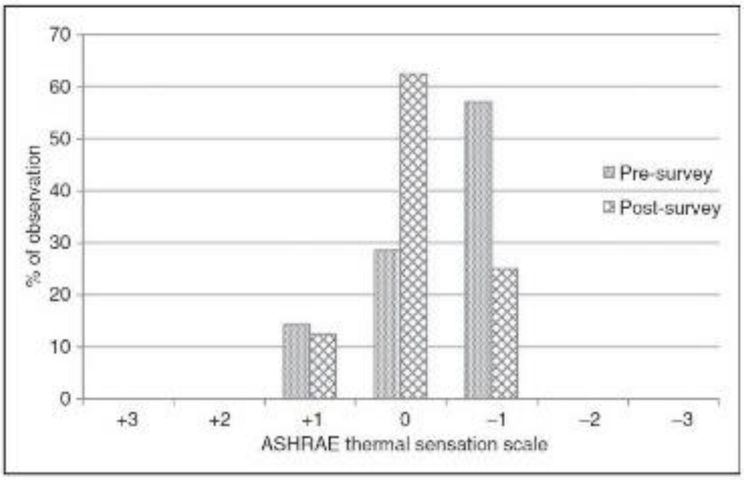


Figure 2.15. Thermal comfort level of occupants in the MKRM building (Source: Yau and Chang, 2015)

Shahzad, Brennan, Theodossopoulos, Hughes and Calautit (2015) state that thermal control by occupants has a significant effect on thermal comfort. They compared a British and a Norwegian office building. In the Norwegian cellular plan office building, occupants could control the windows, blinds, door and heating/cooling devices to find their own control. In British open plan office building, only the occupants who were seated around the perimeter of the building, could control windows and blinds. In this office, heating and cooling was provided by centrally operated displacement ventilation. As the result Norwegian office had 35% higher user satisfaction and 20% higher user comfort compared to the British open plan office, as it is shown in Figure 2.16.

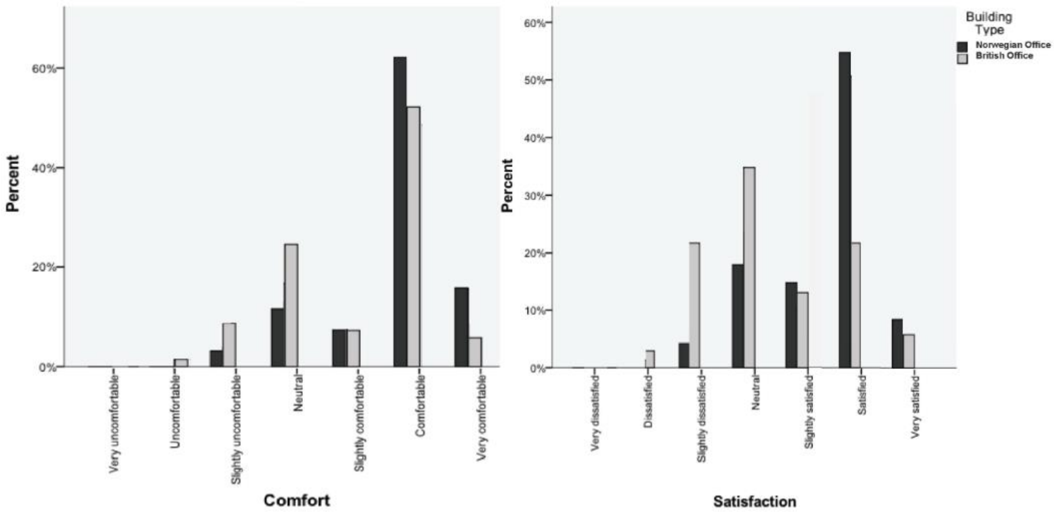


Figure 2.16. Comparing comfort and satisfaction of users in the two buildings (Source: Shahzad, Brennan, Theodossopoulos, Hughes and Calautit, 2015)

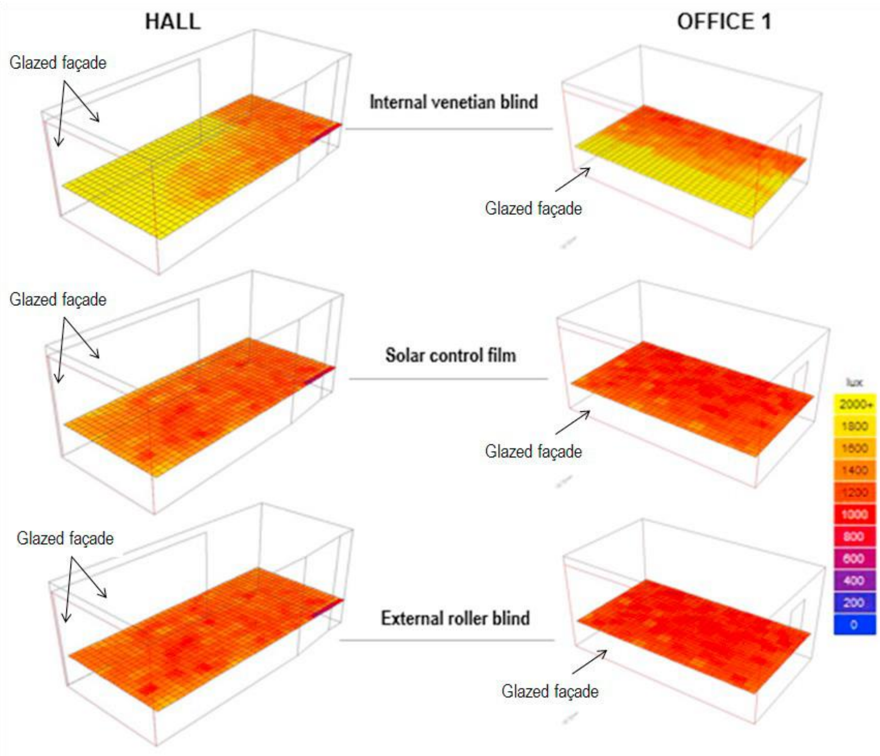
2.5.2. Visual Comfort

Daylight level is an important impression in terms of glare effect that can disturb user comfort and health. According to Osterhaus (2005), in many office buildings, glare discomfort is a general problem that is caused by sunlighting. The glare problem is of two types: disability and discomfort glare. Disability glare is the effect of stray light that reduces visual performance of the eyes. The occupants may protect themselves by changing their position or utilizing any shading devices. Discomfort glare cannot be determined as easily as disability glare, by the occupants. However, they may experience certain physiological symptoms like headache.

Lechner (2015) explains the glare as “visual noise that interferes with visual performance” and stated that there are three type of glare: direct glare, indirect glare and veiling reflections. Direct glare can occur if there is a light source that is bright enough to cause reduction in visual performance, in the field of view. If the direct light is reflected because of glossy surfaces, it can cause indirect glare. Veiling reflections are caused by reflection of light source on tasks like glossy printed pages.

Visual comfort can be determined with glare index and daylight factor (DF) according to research of Fasi and Budaiwi (2015). They compared the impact of three different glazing types on visual comfort in office buildings: conventional double-pane clear-glass, double-pane tinted and low-E glazed windows. The highest DF value was observed when the conventional clear glass was preferred. DF was slightly higher when double-pane tinted glass was applied rather than double-pane low-e glass. The glare index had the highest value with clear-glass and higher than comfort level for all facades and for all dates in a year. The values for double-pane tinted and low-e glasses were similar, and they helped to reduce glare index under comfort level only on the North facade. In this research, it was proved that type of glazing does not have a significant effect on visual comfort. The visual comfort can be improved by automated blinds by reducing glare index value.

Uniformity ratio of illuminance is another factor that determines the visual comfort. According to research of Evola, Gullo and Marletta (2017), internal blinds provide lesser visual comfort than external blinds and solar control film. In their research, internal blinds provide the adequate illuminance, but the uniformity ratio is less than that provided by other strategies as shown in Figure 2.17. This situation causes the visual discomfort and makes other strategies preferable.



	Illuminance [lux]				Uniformity Ratio [-]	
	Hall		Office		Hall	Office
	Min	Mean	Min	Mean		
Internal venetian blind	1388	1889	653	1671	0.64	0.39
External roller blind	1023	1320	510	1160	0.76	0.44
Solar control film	1018	1261	483	1105	0.79	0.44

Figure 2.17. Daylight illuminance distribution and corresponding Uniformity Ratio under CIE overcast sky (Source: Evola, Gullo and Marletta, 2017)

The results for external roller blinds and solar control film are very close to each other. The minimum illuminance is about 500 lux which is a threshold for offices. Also, the uniformity ratio is 0.44. This value is higher than minimum value which is 0.4 that is determined by EN 12464.

CHAPTER 3

MATERIALS AND METHOD

This chapter includes the detailed explanation of the research in two parts as material and method. In material part, case studies, their location and weather data, the software that are used for this research are presented. The process of research is explained in the method part.

3.1. Materials

In light of observations, determined problems and the research questions, the aim of the research was to determine the impact of buildings having glass curtain walls on the thermal performance of the buildings and user satisfaction. The following sections present the selected case study buildings in Ankara as well as software and web sites that were used to create facade mapping, collect data, organize the results and apply hypothesis testing methods. These materials are listed below:

- Autodesk AutoCAD 2018
- Microsoft Excel 2016
- Google Earth Pro
- Adobe Photoshop CS6
- www.fremeteo.com
- www.sunearthtools.com
- Several websites for floor plans, interior photographs

To investigate the impact of glass curtain walls on user satisfaction and thermal performance, eight case buildings were selected from Dumlupınar Boulevard where the use of glass curtain wall density is higher in Ankara. Some information about cases are given below:

Case 1: Besa Kule

Besa kule (Figure 3.1) is designed by A Tasarım architectural office and constructed by Besa Construction company. The construction finished in 2015. The building is located at following coordinates; 39°54'34.19"N, 32°48'15.72"E.

Figure 3.1. Photographs of Besa Kule

In Besa Point journal, Ali Osman Öztürk says that special glazing was used to keep the light in and radiation, sun and heat out. In the light of information obtained from the technical person responsible for architectural glass projects at Trakya Cam, Ahmet Mumcuoğlu, 'Guardian 51/28' glass is used in Besa Kule. The physical properties of the glass are given in the Table 3.1.

Table 3.1. *Glass properties of Besa Kule*

Visible Light				Solar Energy			Solar Factor (g) En 410 (%)	U-value (EN 673) W/m²K
Trans-mission (%)	Reflection Outside (%)	Reflection Inside (%)	Colour Rendering Index	Direct Trans-mission (%)	Reflection Outside (%)	Absorp. (%)		
51	12	23	93	26	37	37	28	1.3

(Source:http://www.sunguardglass.ru/cs/groups/sunguardeurope/documents/web_content/gi_003658.pdf)

The building has doors that are opened to balconies on the Northeast and Southwest facades, as it can be seen on typical floor plan (Figure 3.2). In meantime, there are openable windows, behind the shading components according to indoor photograph (Figure 3.3). So natural ventilation is available for this building.

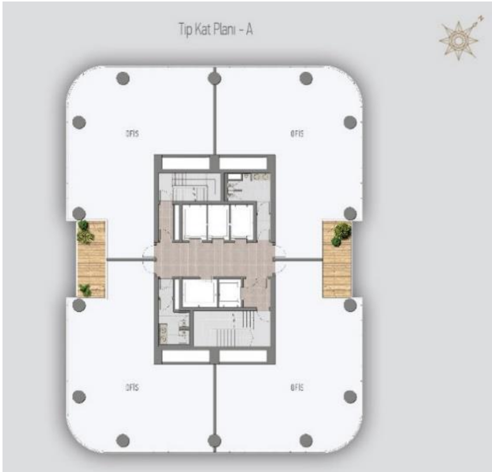


Figure 3.2. Plan of Besa Kule (Source: http://www.yeniprojeler.com/3/0/vaziyet-ve-kat-plani/resimleri/besa-kule)

Figure 3.3. Interior view of Besa Kule (Source: http://www.haberyapi.com/gundem-haberleri/besa-kuleden-ofislerde-minimal-akim.html)

Case 2: Via Twins

The building is located at the following coordinates; 39°91'23.39"N, 32°79'57.77"E. Via Twins (Figure 3.4) was designed by Mono architectural firm and constructed by

Bayraktar construction company. According to information in Via Twins catalog, 4-pipe fan-coil system is used for heating, cooling and ventilation. This system can warm or cool the area rapidly. This system, which reacts more quickly than all other systems, saves fuel when used continuously and opposite; reducing operating costs. The ventilation system is projected for minimum fresh air per person. The building has not open area like balcony or terrace that can be seen in plan (Figure 3.5). Additionally, there are openable windows that can provide natural ventilation as it can be seen in the indoor photograph (Figure 3.6).

Figure 3.4. Photographs of Via Twins

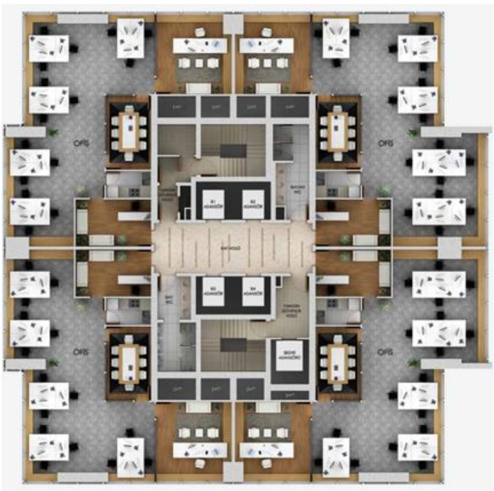


Figure 3.5. Plan of Via Twins (Source: http://www.viatwins.com.tr/KatPlanlari)

Figure 3.6. Interior view of Via Twins (Source: Via Twins Catalog, http://www.viatwins.com.tr/viatwinskatalog.pdf)

According to the Via Twins Catalog, Guardian Sunguard Bright Green High Performance 40/29 glass used in Turkey for the first time, in this project. The physical properties of the glass are given in the Table 3.2.

Table 3.2. *Glass properties of Via Twins*

Visible Light				Solar Energy			Solar Factor (g) En 410 (%)	U-value (EN 673) W/m^2K
Trans-mission (%)	Reflection Outside (%)	Reflection Inside (%)	Colour Rendering Index	Direct Trans-mission (%)	Reflection Outside (%)	Absorp. (%)		
4	37	24	96	26	24	50	29	1.4

(Source:http://www.sunguardglass.ru/cs/groups/sunguardeurope/documents/web_content/gi_015994.pdf)

Case 3: Platin Tower

Platin Tower (Figure 3.7) is located at the 39°54'35.21"N, 32°47'51.89"E coordinate. The tower was designed by Atabaş Architecture and constructed by Platin Construction. According to information in web site of Platin Tower, the construction finished in 2013. The building has openable windows on each facade. There are shading elements on east and west facades.

Figure 3.7. Photographs of Platin Tower

6 + 16 + 6 combination outer glass was used on the facades of Platin Tower. The layers are 6mm helio green glass + 16mm air space + 6mm low-e (heat control glass) and edge filling material is silicone filler. According to information obtained from Ankara Aluminium Firm average U-value of curtain wall is 2.3 W/m2K. The physical properties of the glass are given in the Table 3.3.

Table 3.3. *Glass properties of Platin Tower*

Visible Light		Solar Energy		U-value W/m^2K
Transmission (%)	Reflection outside (%)	Total transmission (%)	Shading Coefficient (%)	
64	9	39	45	1.3

(Source: Ankara Aluminum)

Case 4: Next Level

The complex was designed by Brigitte-Weber Architecture firm and constructed by Pasifik Construction company. The construction finished in 2014. In this research office tower (Figure 3.8) is studied.

Figure 3.8. Photographs of Next Level

The building is located at the 39°54'40.77"N, 32°48'45.00"E coordinate. There is a balcony on each floor, on the West facade of the office tower. It can be seen in the floor plan, as shown in Figure 3.9.

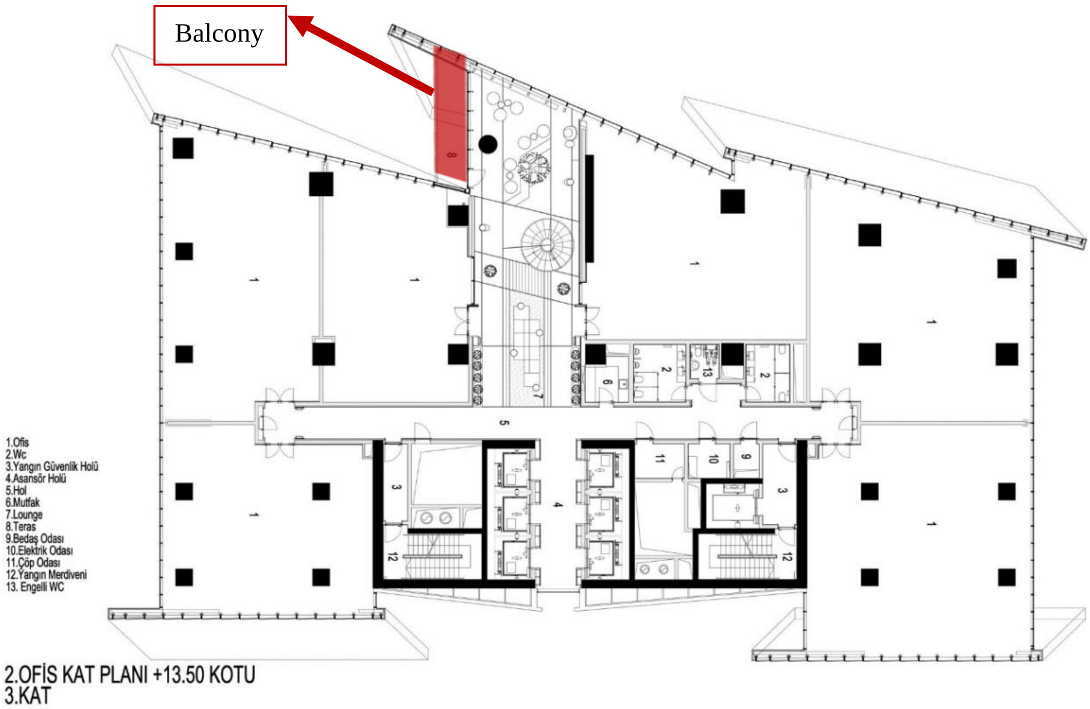


Figure 3.9. Plan of Next Level (Source: http://galeri3.arkitera.com/var/albums/Arkiv.com.tr/Proje/brigitte-weber/next-level-ankara/38.jpg.jpeg)

Ahmet Mumcuoğlu who is Trakya Cam architectural glass projects technical product manager, said that Guardian 35/26 glass is used in Next Level. The physical properties of the glass are given in the Table 3.4.

Table 3.4. *Glass properties of Next Level*

Visible Light				Solar Energy			Solar Factor (g) En 410 (%)	U-value (EN 673) W/m^{2}K
Trans-mission (%)	Reflection Outside (%)	Reflection Inside (%)	Colour Rendering Index	Direct Trans-mission (%)	Reflection Outside (%)	Absorp. (%)		
35	44	23	98	24	43	33	26	1.4

(Source:http://www.eu.en.sunguardglass.com/cs/groups/sunguardeurope/documents/web_assets/pro_046015.pdf)

Case 5: İlaç Ve Tibbi Cihaz Kurumu (ITCK)

There is not certain information about the architect, construction firm and project date of the building. The building was constructed by Akgül Construction company according to information obtained from Google Earth. The construction of the building finished in 2009. According to information received from ITCK (Figure 3.10) web site, the foundation moved in this building in June 2011. So, the building has been used since 2011. There is not any information about façade/glass properties of the building. As it is observed, there are openable windows on each facade at lower levels. At the upper levels, there are openable windows only on the East and West facades. The building is located at the following coordinates; 39°54’35.13” N, 32°47’55.30”E.

Figure 3.10. Photographs of ITCK

Case 6: KGK

The building started to be used in 2012 by The Public Accounting and Auditing Standards Authority (Kamu Gözetimi, Muhasebe ve Denetim Standartları Kurumu), according to information in the annual activity report kgk.gov.tr web site. The construction/architecture firm information is not accessible on the internet. As it was observed by site visit, there are openable windows on each facade. In the meantime, there are balconies in each floor, on the west and east facade. KGK (Figure 3.11) is located at the following coordinates; 39°54'37.51"N, 32°47'45.28"E.

Figure 3.11. Photographs of KGK

Case 7: İlbank

The building of İlbank (Figure 3.12) was constructed by MFZ Group. The construction was completed in 2013. The building was constructed for AFAD and is now being used by İller Bankası. The Northeast facade of the building is used as its service core. The building is located at the 39°54'31.36"N, 32°48'34.32"E coordinates.

Figure 3.12. Photographs of İlbank

Case 8: Farilya Business Center

Farilya Business Center (Figure 3.13) is located at the 39°54'33.40"N, 32°48'37.18"E coordinates. The building is designed by A Tasarım architectural firm and constructed by Ufuk Mesken construction company in 2010. According to information in Ufuk Mesken construction company’s web site, conditioned fresh air is used as ventilation system in offices. Heating and cooling system works independently of outdoor air temperature, so every user can set the indoor air as they want.

Figure 3.13. Photographs of Farilya

3.2. Method

Firstly, the buildings with glass curtain wall, that are located on Dumlupınar Boulevard, were observed. As it is mentioned in materials section, eight of them were selected as case studies. Buildings were selected regarding two criteria. One of them was shading type of the building. Buildings with internal shading were selected. The other one was the visibility of the facade. To get more accurate results, buildings of which interior was visible enough to see internal shading device, were selected. According to observations, occupants of these buildings use fabric roller blinds as internal shading device rather than louvre blinds. So, the internal shading elements were either partially or completely cover the glazed surface.

The site is visited for fall, winter, spring and summer seasons. Photos were taken from facades of the eight selected buildings. After the taking photo, since the weather condition is important for thermal and visual comfort, hourly weather condition data were collected from https://tr.freemeteo.com website. By using Google Earth, coordinates and orientation of the buildings were determined. In meantime, the incidence angle of sunlight according to date, hour and coordinates of the building were determined with the help of the website https://www.sunearthtools.com. Since the daylight saving time is applied whole year in Turkey, GMT +3 time zone was selected for winter season while, GMT +2 time zone was selected for spring, summer and fall seasons to obtain the angle of the sun rays.

The site trip dates and weather condition information are given below;

Fall Season

The site trip was made four times for fall season. The first trip was made on the 19th of September between 3:00 p.m. and 4:00 p.m. The photos of Platin Tower, the building of ITCK and the building of KGK were taken in the first trip. For the weather data between 3.00 p.m. and 4:00 p.m., data for 3:20 p.m., was used. According to data that were obtained from freemeteo website, the air temperature was 36°C; relative humidity was 18%; wind speed was about 11 km/h. The sun angle was calculated by using average of the 3:00 p.m. and 4:00 p.m. time interval. Angle of the sun rays at 3:30 p.m. is almost 36°.

The second trip was made on 21st September, between 10:30 a.m. and 12:00 noon the photos of Next Level, Besa Kule and Farilya were taken. Weather data that belongs to 11:20 a.m. was used for 10:30 a.m. and 12:00 a.m. time interval. The air temperature was 29°C; relative humidity was 23%; wind speed was ranging between 4-7 km/h with regard to data that were obtained from freemeteo website. The angle of sun was determined according to average of 10:30 a.m. and 12:00 a.m. At 11:15 a.m. angle of the sun rays was almost 46°.

The third trip was on 23rd September. The photos of Via Twins were taken between 3:00 p.m. and 3:30 p.m. According to freemeteo website, the air temperature was 23°C; relative humidity was 64%; wind speed was 34 km/h. The sun rays angle was 36.69° at 3:15 p.m. which is the average of time interval of site trip.

The fourth trip was made on 7th October between 2:30 p.m. and 4:00 p.m. The photos of İlbank were taken. According to data that were obtained from freemeteo website, the air temperature was 25°C; relative humidity was 19%; wind speed was 6 km/h.

The angle of the sun rays was 31.63°. The photographs for fall season are given in Appendix C.

Winter season

Only one trip was made for winter season on 20th January, between 2:00 p.m. and 3:30 p.m. The photos of eight case study buildings were taken. According to freemeteo website, the air temperature was 6°C; relative humidity was 53%; wind speed was ranging between 4-7 km/h. The angle of the sun rays was approximately 29°. The photographs for winter season are given in Appendix C.

Spring season

The photos of facades were taken on 13th May, between 1:30 p.m. and 2:30 p.m. The photos of eight case study buildings were taken. The air temperature was 16°C; relative humidity was 42%; wind speed 7 km/h with regard to data that was gotten from freemeteo website. At 2:00 p.m. the angle of the sun rays was about 63°. The photographs for spring season are given in Appendix C.

Summer season

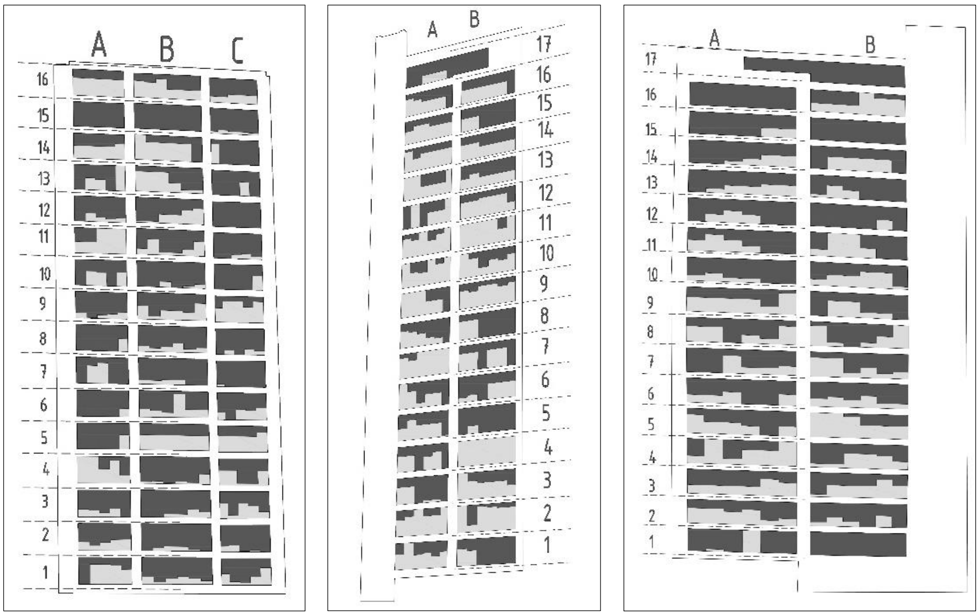
The photos of the facades were taken on 12nd August, between 12:45 a.m. and 2:00 p.m. The photos of Via Twins, KGK, Platin Tower, the building of Pharmaceutical and Medical Device Establishment (İlaç ve Tıbbi Cihaz Kurumu binası), Besa Kule, İlbank, Farilya and Next Level. The air temperature was 27°C; relative humidity was 24%; wind speed was ranging between 7 km/h with regard to data that was gotten from freemeteo website. The angle of the sun rays was 64.36° at 13:30 p.m. The photographs for summer season are given in Appendix C.

After the site trips, facade mapping was made for each facade in order to determine the rate of curtained area of glazed facades. In this section, to explain the process of creating facade mapping and calculations, drawing and results of İlbank are used as an example. The example indicates the study for fall season. Photographs of the four facades i.e. Southwest, Northwest, Southeast and Northeast facades can be seen in Figure 3.14.

Southwest facade Northwest facade Southeast facade Northeast facade

Figure 3.14. Photographs of Ilbank's facades

AutoCAD 2018 was used in order to create facade mapping. The photos of the facades were inserted as raster images and the outlines were drawn. Since the important thing for facade mapping results is the ratio of the curtained facade to the total glazed area rather than the exact areas of these two variables, therefore actual dimensions were not required. Each facade was divided into small sections vertically and horizontally, since, the perspective view of the buildings was distorted and could lead to a miscalculation in the total facade area. Since the perspective angle of the Southeast facade photo of İlbank, can cause misleading results, perspective settings of the photo were changed on Photoshop to create an orthogonal facade drawing. The border of each section was drawn over the photos. Each rectangle area symbolizes a glazed section as it is shown in Figure 3.15. In drawing process, the rectangles were hatched with light grey color to determine the area of glass facade. After that, border of internal shading elements was also drawn and hatched with dark grey color. Their area was determined by using 'properties' command. Additionally, the Northeast facade was not drawn in this example, because service core is located near this facade and the glazed area was not significant.



Southwest facade Northwest facade Southeast facade

Figure 3.15. Facade mapping of Ilbank

After the facades were drawn, the area values were inserted in MS Excel which was used to calculate the ratio of curtained area to total glass area in the following manner, as shown in Table 3.5. Area values of all vertical and horizontal sections were listed in the table. For each section, curtained area was divided to the total area to determine the rate of use of internal shading elements. Mean value of rates are given for each column in the table while the mean value of all the column gives us the total rate for the facade. The process was repeated for each facade. As it can be seen in the Tables 3.5, 3.6 and 3.7; the rate for the Southwest facade is 70.24%; the rate for the Northwest facade is 44.11%; the rate for the Southeast facade is 68.30%. In other words, overall 60% of the glazed facade of the building is closed with internal shading.

Table 3.5. *Southwest facade rate*

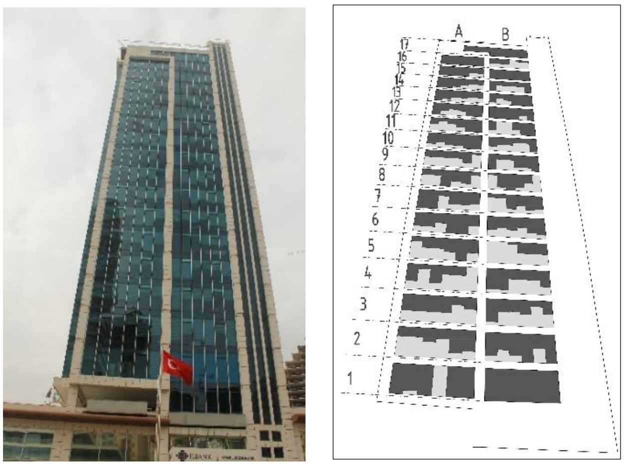
FLOOR	SOUTHWEST FACADE								
	A			B			C		
	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate
1	26215	11902	45.40%	34941	30749	88.00%	24449	16811	68.76%
2	26582	18122	68.17%	35324	30937	87.58%	24593	22109	89.90%
3	26151	20909	79.95%	35001	14573	41.64%	24551	15319	62.40%
4	25917	6589	25.42%	34988	21306	60.90%	24050	15821	65.78%
5	24953	22357	89.60%	33835	29857	88.24%	23907	8602	35.98%
6	25248	23783	94.20%	33689	26476	78.59%	24351	17087	70.17%
7	25077	17631	70.31%	33437	21176	63.33%	23569	23215	98.50%
8	24996	22718	90.89%	32937	30001	91.09%	23300	20733	88.98%
9	25355	21358	84.24%	33627	20994	62.43%	23301	6448	27.67%
10	24605	16933	68.82%	32350	16108	49.79%	22432	19709	87.86%
11	23927	5582	23.33%	32243	11053	34.28%	22653	20515	90.56%
12	23957	20232	84.45%	31307	35324	112.83%	22196	22196	100.00%
13	23740	14990	63.14%	31736	13450	42.38%	21707	19235	88.61%
14	23542	11104	47.17%	30931	11053	35.73%	21546	18734	86.95%
15	23072	23072	100.00%	31167	31167	100.00%	22135	19893	89.87%
16	24799	8365	33.73%	29897	13450	44.99%	21386	14741	68.93%
17	-	-	-	-	-	-	-	-	-
	Total rate		66.80%	Total rate		67.61%	Total rate		76.31%
	T"otal rate for the facade					**70.24%**			

Table 3.6. *Southeast facade rate*

FLOOR	SOUTHEAST FACADE					
	A			B		
	Total	Curtained	Rate	Total	Curtained	Rate
1	95957	78503	81.81%	88876	88876	100.00%
2	103682	53036	51.15%	89220	70806	79.36%
3	106157	59362	55.92%	93208	48886	52.45%
4	106963	40048	37.44%	94629	57667	60.94%
5	107704	64513	59.90%	94683	23860	25.20%
6	107106	79628	74.35%	96410	65928	68.38%
7	105723	76895	72.73%	96255	54495	56.62%
8	106019	60699	57.25%	92491	52484	56.74%
9	107157	45023	42.02%	94517	67201	71.10%
10	102025	86168	84.46%	90908	50639	55.70%
11	97736	64451	65.94%	89625	48658	54.29%
12	100443	79811	79.46%	88659	82569	93.13%
13	97030	67298	69.36%	85040	69939	82.24%
14	99112	76434	77.12%	86803	54592	62.89%
15	95262	82984	87.11%	82530	82530	100.00%
16	95967	95967	100.00%	81850	31631	38.65%
17	-	-	-	113172	113172	100.00%
	Total rate		68.50%	Total rate		68.10%
	Total rate for the facade			**68.30%**		

Table 3.7. *Northwest facade rate*

FLOOR	NORTHWEST FACADE					
	A			B		
	Total	**Curtained**	**Rate**	**Total**	**Curtained**	**Rate**
1	58925	21955	37.26%	67816	54229	79.96%
2	58055	11755	20.25%	68265	14899	21.83%
3	57716	42715	74.01%	66817	23703	35.47%
4	55130	31095	56.40%	63989	0	0.00%
5	55946	27764	49.63%	64846	61441	94.75%
6	54426	27618	50.74%	62706	39273	62.63%
7	52885	4222	7.98%	62054	31945	51.48%
8	51471	30648	59.54%	60616	45298	74.73%
9	51164	15565	30.42%	59998	15108	25.18%
10	50307	9690	19.26%	57850	20739	35.85%
11	48196	9088	18.86%	56886	4402	7.74%
12	47547	23316	49.04%	56632	18502	32.67%
13	46963	12703	27.05%	55002	30381	55.24%
14	46427	13541	29.17%	54344	24849	45.73%
15	45472	16456	36.19%	51817	41482	80.05%
16	43742	20376	46.58%	52485	26124	49.77%
17	69912	61006	87.26%	-	-	-
	Total rate		41.16%	Total rate		47.07%
	Total rate for the facade			**44.11%**		



(a) (b)

Figure 3.16. Perspective (a)Southeast facade (b) Southeast facade drawing

The facade mapping of perspective Southeast facade photo was made as shown in Figure 3.16, and the calculations were repeated to see if the perspective distortion was chancing the actual rates of curtained area significantly. In the perspective facade, the rate of closure is 67.73% while in the orthogonal facade the rate is 68.30% as it can be seen in Table 3.8. The rates of the perspective facade are not significantly different from flattened facades; hence this method of calculations was adopted for all case studies.

Table 3.8. *Perspective Southeast facade rate*

FLOOR	SOUTHEAST FACADE					
	A			B		
	Total	Curtained	Rate	Total	Curtained	Rate
1	180037	145779	80.97%	168430	168430	100.00%
2	165031	81106	49.15%	142005	110191	77.60%
3	140763	75399	53.56%	123797	63384	51.20%
4	123106	48503	39.40%	108228	65345	60.38%
5	104514	59550	56.98%	92978	24270	26.10%
6	88601	66528	75.09%	82002	52996	64.63%
7	79190	57710	72.88%	69092	38350	55.51%
8	67358	37882	56.24%	60264	33480	55.56%
9	61017	26388	43.25%	53427	37452	70.10%
10	53023	44340	83.62%	46052	25465	55.30%
11	44944	28620	63.68%	40370	21935	54.33%
12	40166	31682	78.88%	35226	32925	93.47%
13	35446	25598	72.22%	31635	25613	80.96%
14	31080	24055	77.40%	28482	17669	62.04%
15	27555	24021	87.17%	25716	25716	100.00%
16	26148	26148	100.00%	22249	8211	36.91%
17	-	-	-	30665	30665	100.00%
	Total rate		68.15%	Total rate		67.30%
	Total rate for the facade			**67.73%**		

The facade mapping was made for summer and winter season. Summer and winter season facade mapping results were compared for each building. Photographs for other seasons were used in visual comparison. Since the use of internal shading elements are related with air temperature, humidity, wind speed and sun angle, these factors were graphed according to date, in order to show the change according to season. After that summer season and winter season results of facades of each building were compared as graphs in order to determine change of the internal shading use between facades according to season. Thereafter, results of all buildings were compared according to facades for summer and winter seasons. Then, the cases of which glass properties were found, were examined. The relation between visible light transmission and rate of internal shading use; direct transmission of solar energy and rate of internal shading use were tested with regression analysis which is a hypothesis testing method, by using Microsoft Excel. Since the sorting of four cases' curtained area rate was the same for summer and winter, the test was not repeated for winter season.

CHAPTER 4

RESULTS AND DISCUSSION

4.1. Environmental Conditions

In this section collected data of the air temperature, humidity, wind speed and incidence of the sun rays were shown in graphical form. The graphs show the change of parameters according to seasons. Additionally, time interval parameter was added to the graphs, since the time intervals of photo shooting are not exactly the same. As it was described in the section of methodology, the air temperature, humidity and wind speed data were collected hourly from 'freemeteo' website.

Table 4.1. *The accessed data about weather condition and angle of sun rays*

Season	Date	Time Interval	Air Temperature (°C)	Humidity %	Wind Speed Km/h	Angle of Sun Rays (°)
Fall	19.09.2017	3:00p.m.- 4:00p.m.	36	18	11	35.83
Fall	21.09.2017	10:30a.m.- 12:00a.m.	29	23	4-7	45.98
Fall	23.09.2017	3:00p.m.- 3:30p.m.	23	64	11	36.69
Fall	07.10.2017	2:30p.m.- 4:00p.m.	25	19	6	31.63
Winter	20.01.2018	2:00p.m.- 3:30p.m.	6	53	4-7	29.09
Spring	13.05.2018	1:30p.m.- 2:30p.m.	16	42	7	63.14
Summer	12.08.2018	12:45a.m.- 2:00 p.m.	27	24	7	64.36

Data for the exact time of site visits was not available, so the closest time period was taken. For example, on 19th September, building sites were visited between 3:00 p.m. and 4:00 p.m. Since there are data for 3:20 p.m. in freemeteo website, these values were used. As it can be seen from Table 4.1, the air temperature is 36°C at 3:20 p.m. The accessed weather data is shown in Table 4.1.

As it can be seen in the air temperature-date graph (Figure 4.1), the air temperature ranges from 6°C to36°C. The maximum heat was observed on 19th September and minimum heat was observed in winter season, on 20th January.

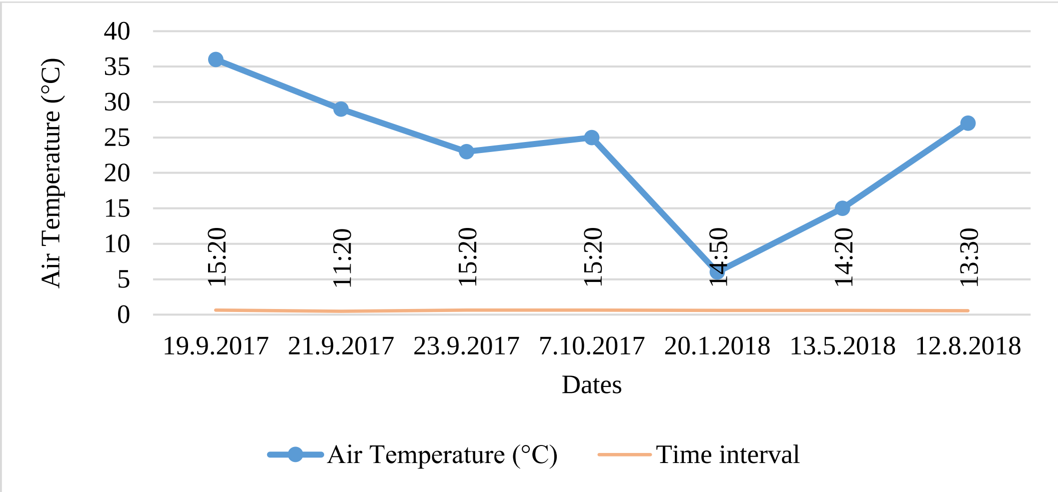


Figure 4.1. Graph showing temperature data for dates of site visits.

The change in humidity is not dependent on the season. The range changes from 18% to 64% as it can be seen in the graph (Figure 4.2). The maximum humidity belongs to the 23rd of September and minimum value is observed on 19th September.

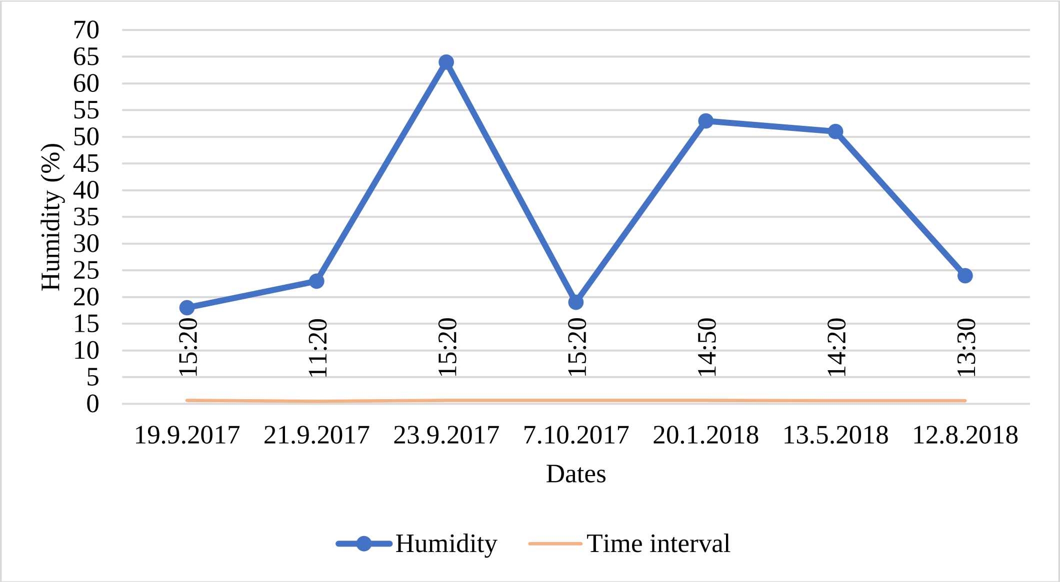


Figure 4.2. Graph showing humidity data for dates of site visits.

Also, the change in wind speed is not related to the season. The wind speed ranges between 4 km/h and 11 km/h. The maximum speed is observed on 19th and 23rd September, while the minimum value is observed on 20th January, as shown in the graph (Figure 4.3).

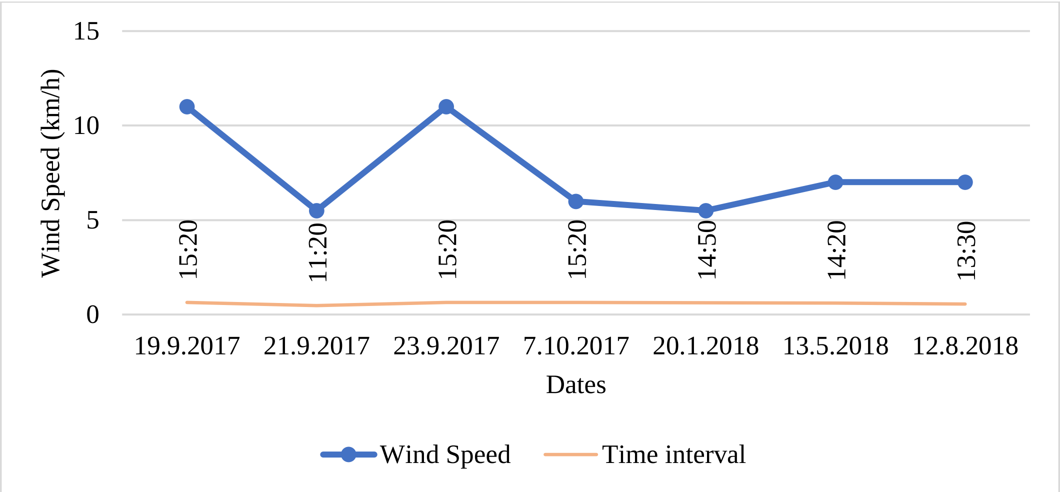


Figure 4.3. Graph showing wind speed data for dates of site visits.

The altitude angle of the sun rays ranges from 29° to 64° related to season and time interval. In 12th August, at 13:15 o'clock, the angle of sun rays is the highest position in this study. The minimum angle which is 29° is observed on 20th January. The altitude angle of the sun rays according to dates and hours are shown in the graph (Figure 4.4).

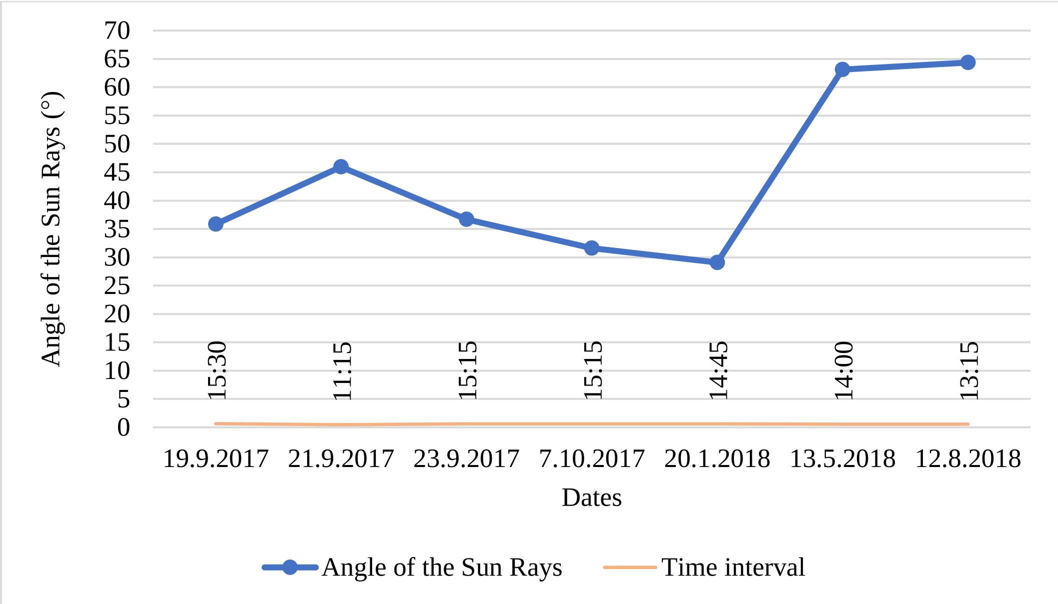


Figure 4.4. Graph showing altitude angle of the sun rays for dates of site visits.

The data about angle of sun rays was collected from sun path diagrams where the position of the sun can be seen. The sun path diagram of 19th September is shown in Figure 4.5. The sun path diagram for the other dates are given in Appendix A.

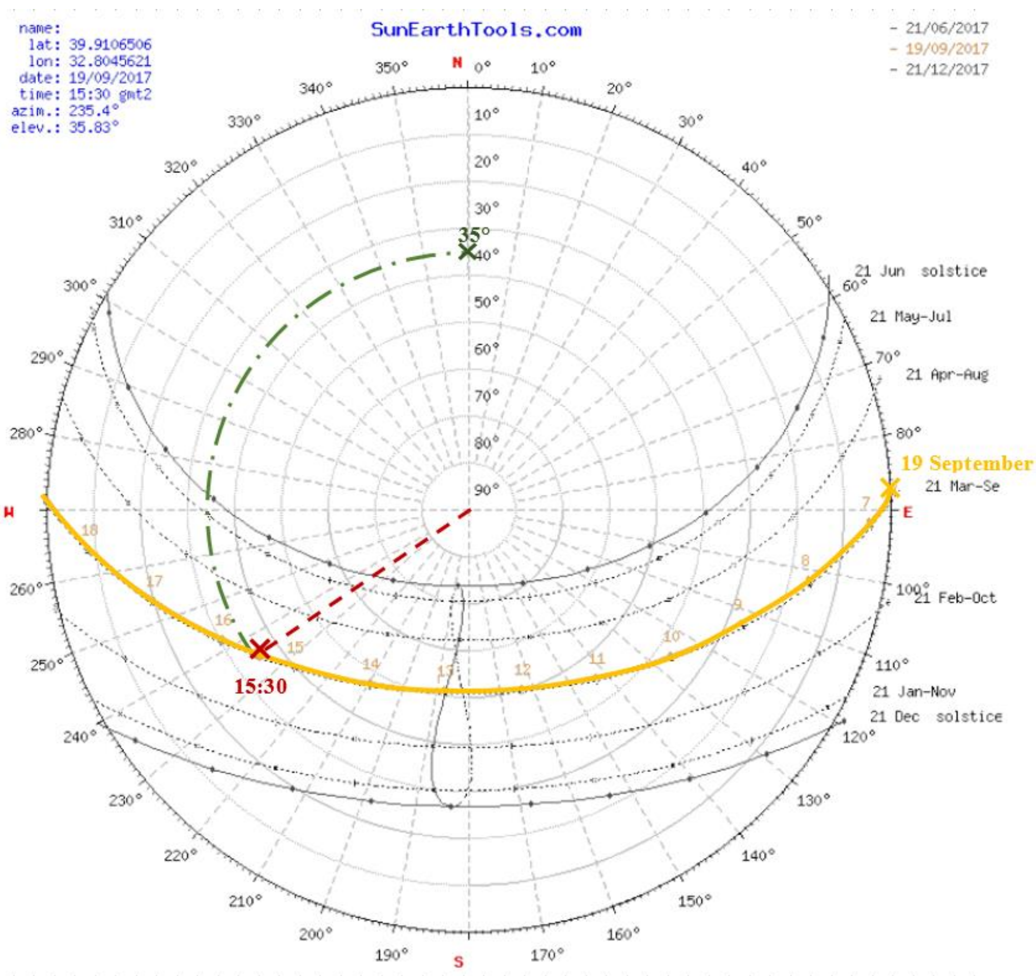


Figure 4.5. The sun path diagram for 19th of September

Elevation angle is the angle between horizontal surface and the sun rays. This angle changes according to date and hour. The elevation angle can be obtained automatically from 'sunearthtools' website or can be obtained with following steps;

- The line that is shown in yellow color in Figure 4.5, should be drawn according to date.
- The hour which is shown as red cross should be determined on the date line.
- An arc should be drawn from the center of the circle while the end point of the arc gives the elevation angle of the sun rays.

4.2. Results for Summer and Winter Seasons

Photographs of buildings were used for facade mapping in order to determine the difference between the summer and winter condition. Results of facade mapping were found by preparing tables in MS Excel®. Comparative data of examined eight cases are listed below. The orientation of the eight buildings are shown in Figures 4.6 and 4.7. The orientations were determined according to the North direction.

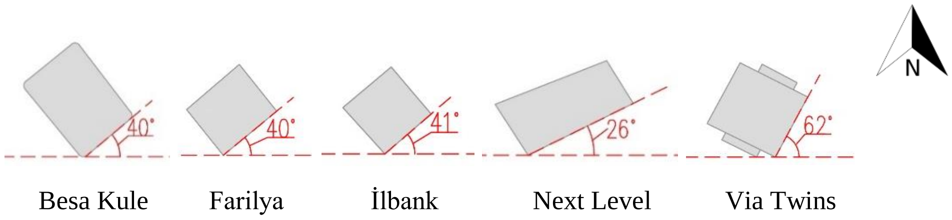


Figure 4.6. The buildings not paralleled to X-axis

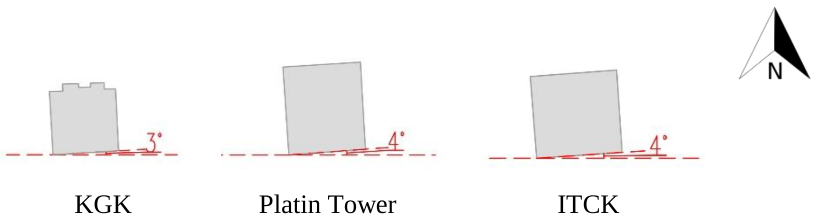
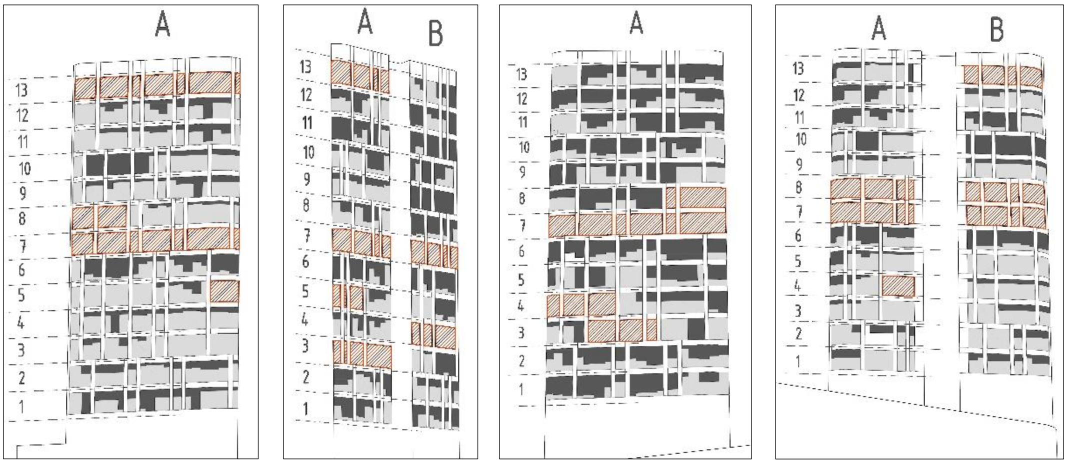


Figure 4.7. The buildings nearly paralleled to X-axis

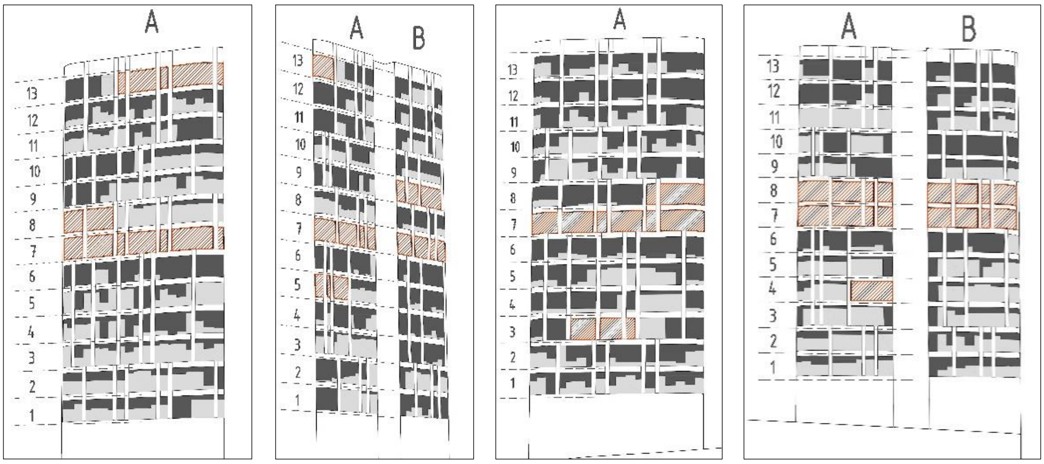
Case 1: Besa Kule

The four facades of the building were examined. The angle between building plan and X-axis is 40° as shown in Figure 4.6. So, Besa Kule has facades facing Northwest, Southwest, Southeast and Northeast directions. The Northeast and Southeast facade were examined as a whole (A), while the Southwest and Northwest facades were examined in two parts (A and B); as shown in Figure 4.8 and Figure 4.9. The thirteen floors from nineteen floors of the building were examined. The first six floors could not be observed because of visual obstacles at the environment.



Northwest Southwest Southeast Northeast

Figure 4.8. Facade mapping of Besa Kule for winter season



Northwest Southwest Southeast Northeast

Figure 4.9. Facade mapping of Besa Kule for summer season

In some spaces, no sign of occupancy was observed; facades of these spaces were marked by red bold lines and hatch. For example, in winter season, seventh floor was totally empty, while some parts of third, fourth, fifth, eight and thirteenth floor were also empty. The empty units were shown as ‘X’ on the table (Appendix B) and they were not included in the calculation.

The results of winter season were given in the Table 0.2 (Appendix B). In winter season, the rate of curtained area on Northwest facade was 28.93%; on Southwest facade 56.22%; on Southeast facade 57.96% and on Northeast facade 33.89%. The maximum rate belonged to Southeast facade while the minimum rate of closed area was on the Northwest facade on 20th of January, at 11:20 a.m.

The results of summer season were given in the Table 0.3 (Appendix B). As shown in the table, closed area rate of Northwest facade was 49.93%, Southwest facade 67.22%; Southeast facade 66.26% and Northeast facade was 51.92%. The maximum rate was 67.22% which is on Southwest facade, while the rate of Northwest facade had the minimum value, 49.93%, on 12th August, at 1:30 p.m.

The comparison between summer and winter conditions were given in the graph. Maximum change in rate of closed area belonged to Northwest facade, which ranges between 29% and 50% approximately. Because the duration of the sun rays on the Northwest facade is greater in summer than the other facades. On Southeast facade, the change between summer and winter condition was less than other facades. The total rate of closed area for this facade changed between nearly 58% and 66%. The total curtained area rate is about 44% in winter, while the rate is nearly 59% in summer season.

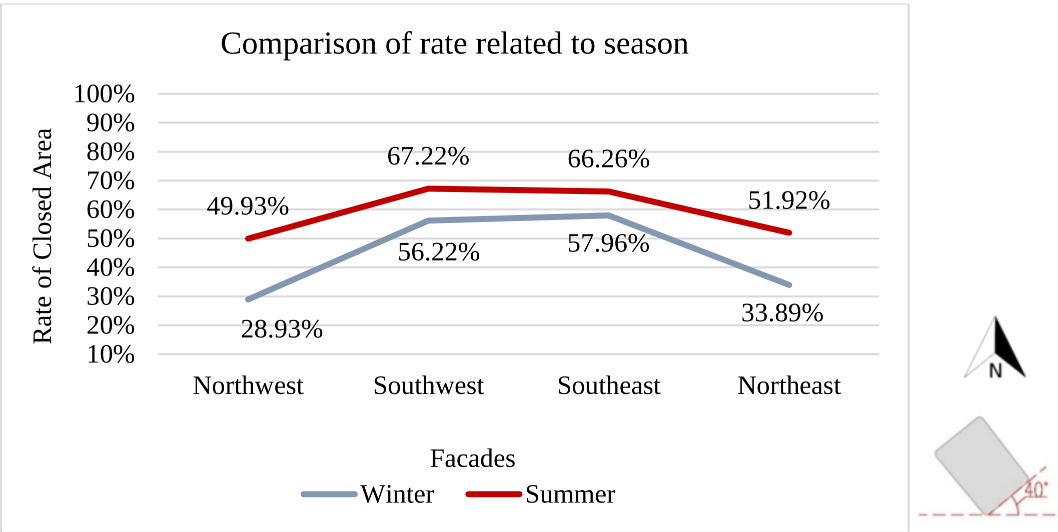
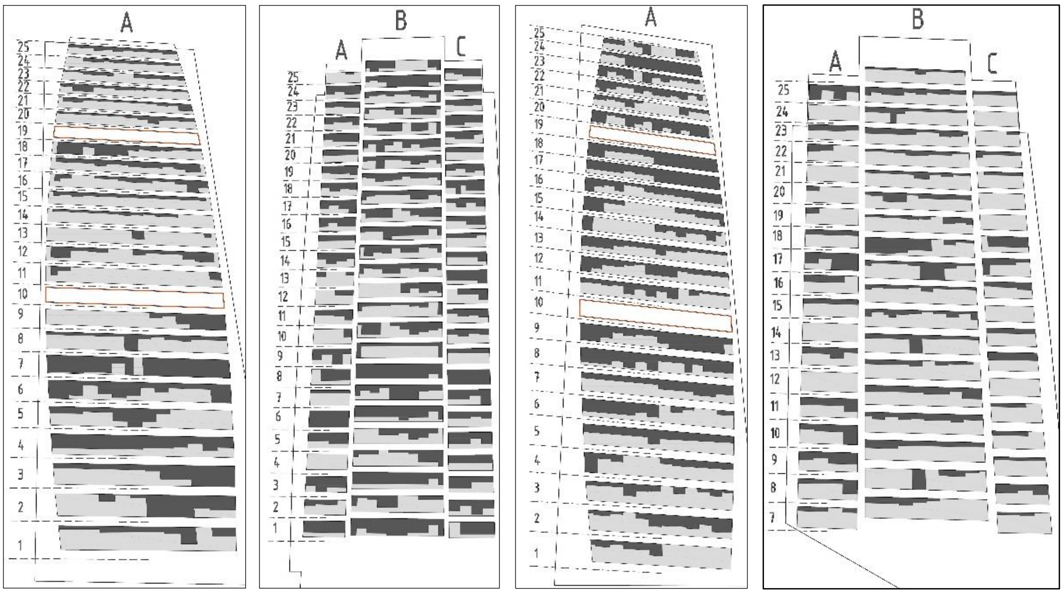


Figure 4.10. Summer and winter season curtained area rates of Besa Kule with its sketch that shows the orientation

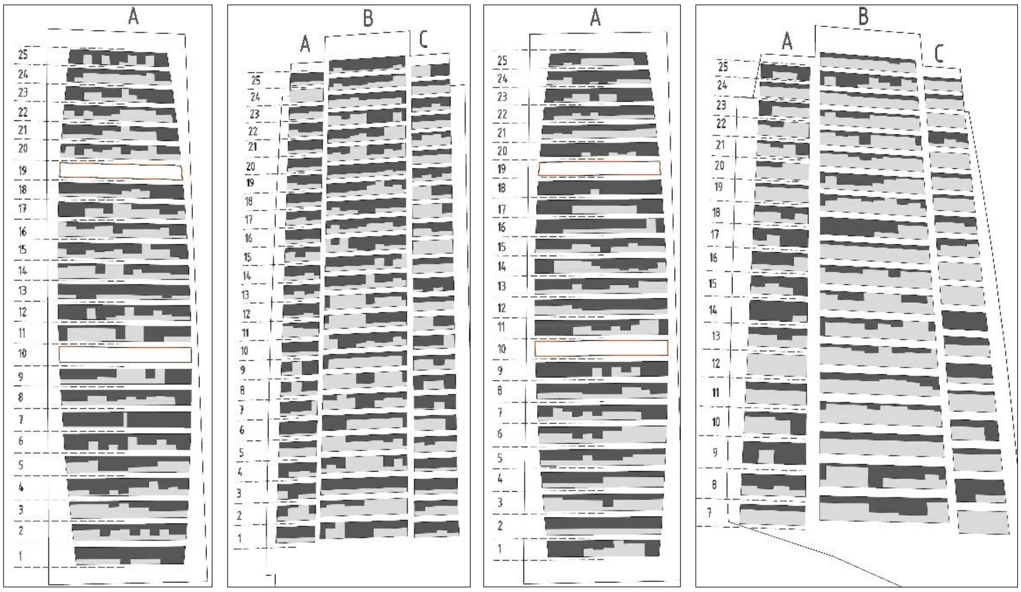
Case 2: Via Twins

The facades of Via Twins face the Northwest, Southwest, Southeast and Northeast directions, since the angle between building and X-axis is 62° as shown in Figure 4.6. All of the facades were observed for the study. The Northwest and Southeast facades were considered as a whole (A), while the Southwest and Northeast facades consist of three parts (A, B and C) as shown in Figure 4.11 and Figure 4.12. The top nineteen floors of the Northeast facade and the top twenty-five floors of other facades were examined, while the first fourteen floors on the Northeast facade and first eight floors on the other facades were obstructed by high canopy.



Northwest Southwest Southeast Northeast

Figure 4.11. Facade mapping of Via Twins for winter season



Northwest Southwest Southeast Northeast

Figure 4.12. Facade mapping of Via Twins for summer season

This building is used by governmental organization. So, no empty unit was observed. However, 10th and 19th floors on the Northwest and Southeast facade were observed as mechanical rooms. These are indicated with red bold lines, as shown in Figures 4.11 and 4.12.

Results of winter season were given in the Table 0.4 (Appendix B). The maximum rate of curtained area belonged to Southwest facade, whereas the minimum value belonged to Northeast facade. The rate of curtained area was 50.81% on the Southwest facade; 48.60% on the Southeast facade; 35.14% on the Northwest facade; 24.85% on the Northeast facade, on 20th of January, at 11:20 a.m.

The rates of curtained area for summer season were 52.43% on the Southwest facade, 63.16% on the Southeast facade, 58.10% on the Northwest facade and 36.54% on the Northeast facade. So, the maximum curtained area was observed on the Southeast facade, while the minimum rate was observed on the Northwest facade.

Comparison of curtained area rate for winter and summer is shown in graph (Figure 4.13). The maximum change in rates belongs to Northwest facade, whereas the minimum change belongs to Southwest facade. The curtained area varies between around 35% and 58% on the Northwest facade and varies between nearly 51% and 52% on the Southwest facade. The change of curtained area on Southwest facade is lesser, since the duration of sun rays on Southwest facade does not change much between summer and winter season as compared to the other facades. Furthermore, use of internal shading elements for the whole building, changed from approximately 40% to 53% in winter and summer respectively.

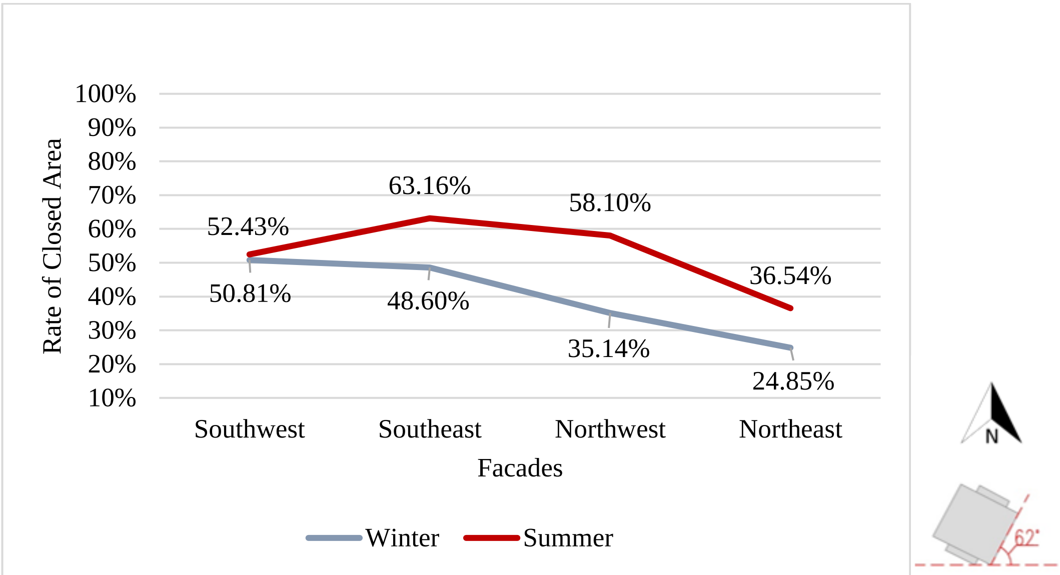
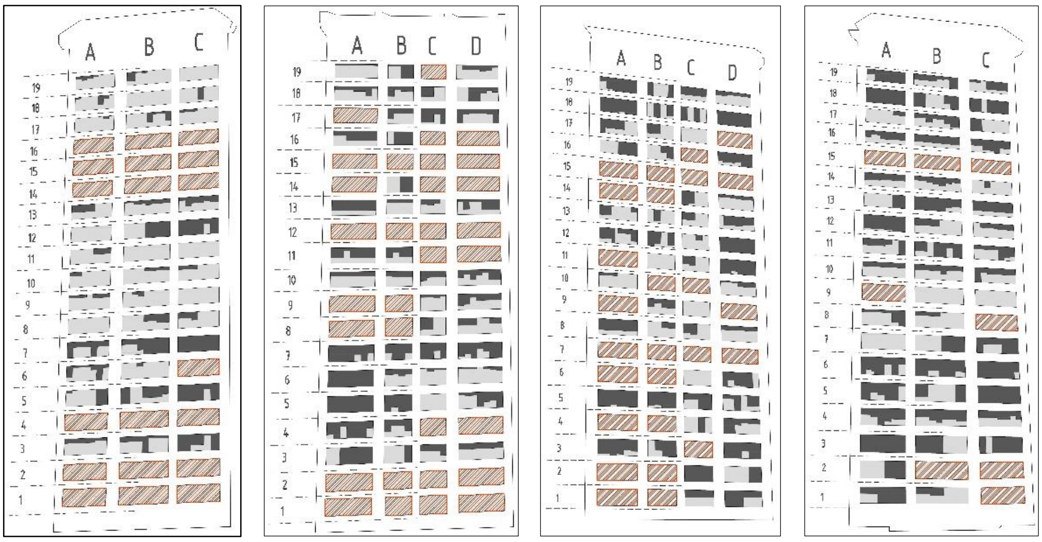


Figure 4.13. Summer and winter season curtained area rates of Via Twins with its sketch that shows the orientation

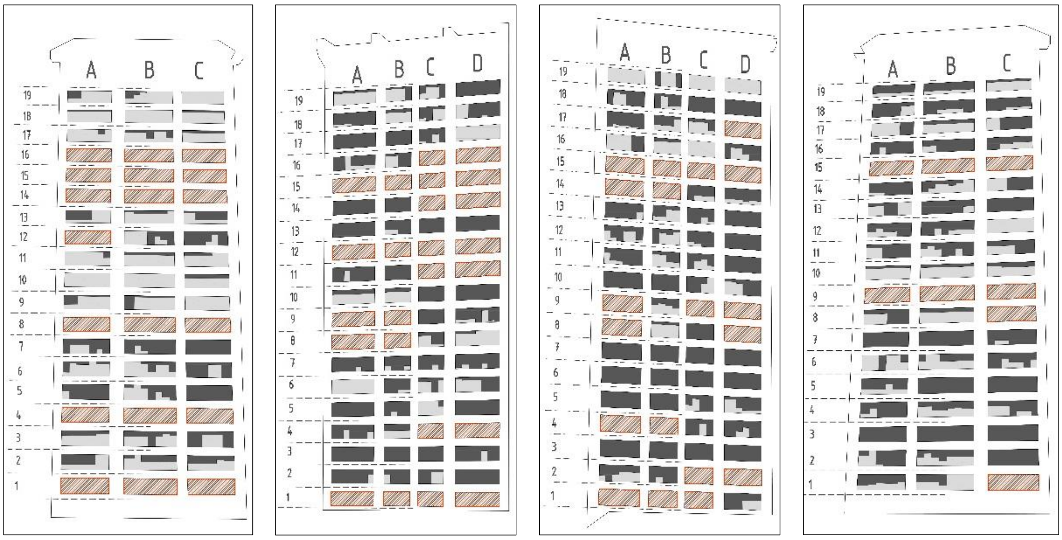
Case 3: Platin Tower

The building facades face the North, South, West and East directions orthogonally, because the angle between building and X-axis is 4° only, as shown in Figure 4.7. All of the four facades were observed. The North and South facade consists of three parts, while, West and East facade have four parts, as shown in Figure 4.14 and 4.15. Nineteen floors of the building were observed. First four floors that are located under the tower, were not observed, since they are used as commercial; while top two floors could not be observed because of perspective view.



North West East South

Figure 4.14. Facade mapping of Platin Tower for winter season



North West East South

Figure 4.15. Facade mapping of Platin Tower for summer season

There were empty units in the building, since Platin Tower is not a public building and some of the apartments may not be rented. These units were not included in the calculations. They were indicated as red bold lines and hatch in the drawings and as ‘X’ in the Table 0.6 and Table 0.7 (Appendix B).

The rate of closed areas for winter season were given in the Table 0.6 (Appendix B). According to results 27.33% of North facade, 52.92% of West facade, 47.31% of East facade and 53.38% of South facade were closed. The maximum closed area was observed on the South facade, whereas the minimum rate of closed area belonged to the North facade, on 20th of January, at around 11 o'clock.

Results of summer season were given in the Table 0.7 (Appendix B); i.e., 35.38% of North facade, 73.47% of West facade, 66.12% of East facade and 65.01% of South facade was closed. The maximum rate of closed area belonged to the West facade, while the minimum rate belonged to North facade on 12th August, at around 13 o'clock.

The comparison of summer and winter season curtained area for Platin Tower is shown in the graph (Figure 4.16). According to graph the maximum change (nearly 53% to 74%) of curtained area was observed on West facade, while the minimum change (at around 27% to 35%) was observed on North facade. Additionally, the total curtained area rates are approximately 45 % in winter and 60% in summer.

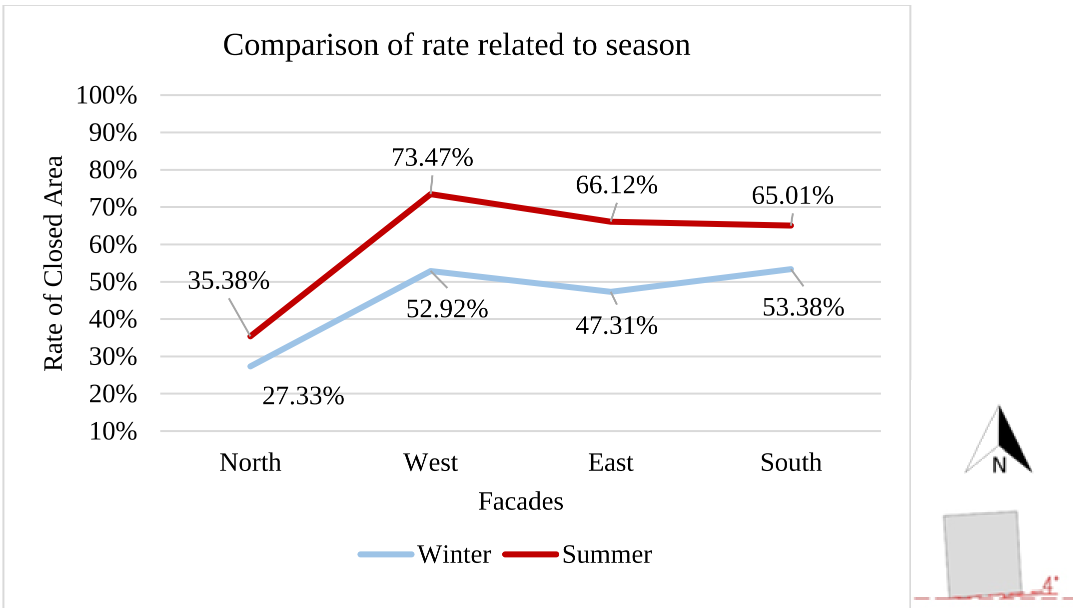


Figure 4.16. Summer and winter season curtained area rates of Platin Tower with its sketch that shows the orientation

Case 4: Next Level

Next Level has four facades with glazing on Northwest, Southwest, Southeast and Northeast directions, because the angle between building and X-axis is 26° as shown in Figure 4.6. Since the Southeast and Northwest facades were not clearly visible, only the Southwest and Northeast facade was observed. Both the Southwest and Northeast facades consist of one part as shown in Figure 4.17. Twenty-six floors on the Southwest and twenty-eight floors on the Northeast facade were examined. First four floors under the tower block, were not observed, since they are used as shopping center.

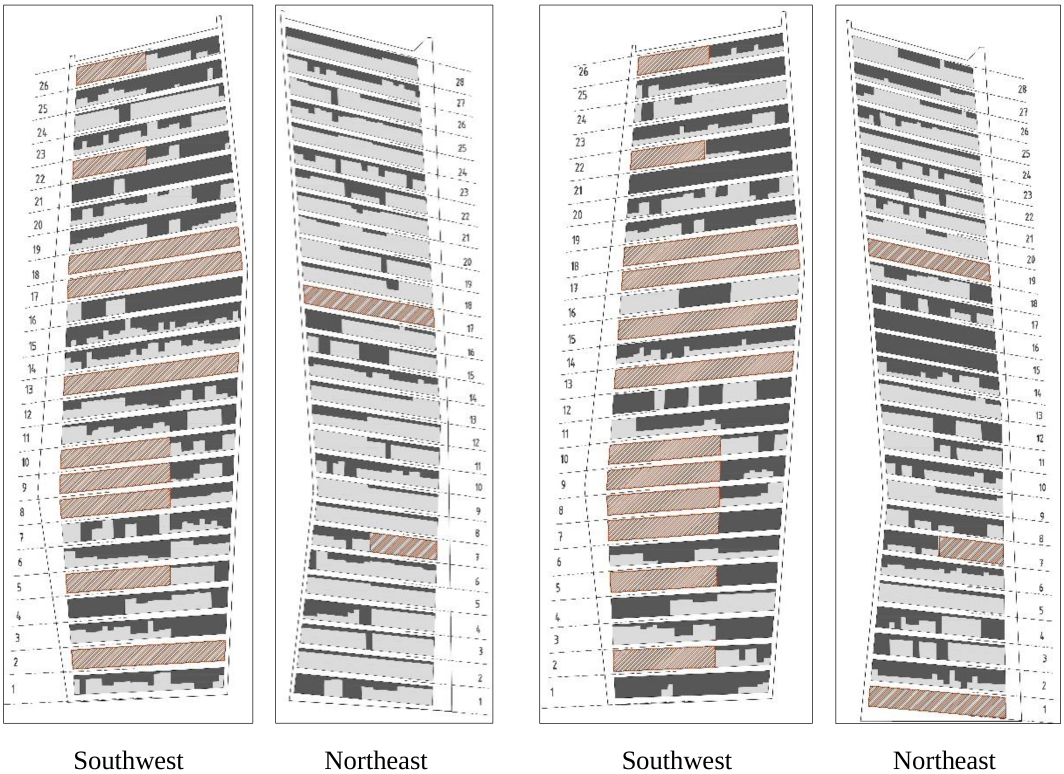


Figure 4.17. Facade mapping of Next Level for winter (left) and summer (right) season

According to observations, some of the units were not occupied. The empty units are shown by bold red lines and hatch in Figure 4.17. In winter season, 2nd, 17th and 18th floors were totally; 5th, 8th, 9th, 10th, 22nd and 26th floors were partially empty on Southwest facade. On the Northeast facade, 7th floor was partially, 17th floor was totally empty. In summer season, 2nd and 7th floor was partially and 15th floor was totally empty on Southwest facade while, 1st floor was totally empty on Northeast facade unlike winter season.

The curtained area rates for winter and summer seasons are given in the Table 0.8 (Appendix B). The rates of curtained area in winter season were 58.03% on the Southeast facade and 28.06% on the Northeast facade, while the rates in summer season were 66.53% on the Southeast facade and 44.29% on the Northeast facade. Both in winter and summer the curtained area rate was greater on Southwest facade.

The comparison of summer and winter season results are given in the graph (Figure 4.18). The change in rates according to season is greater for Northeast facade than Southwest facade, since the change in duration of sun rays' effect between summer and winter is lesser on Southwest facade. Additionally, the total curtained area rate was around 43 % in winter, while the rate was around 55% in summer season.

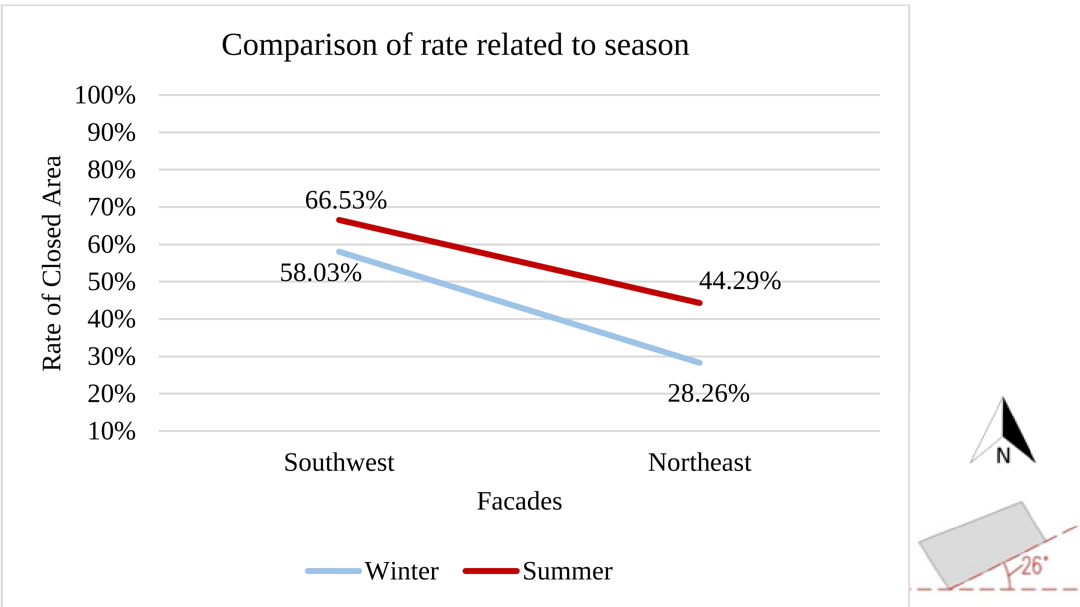
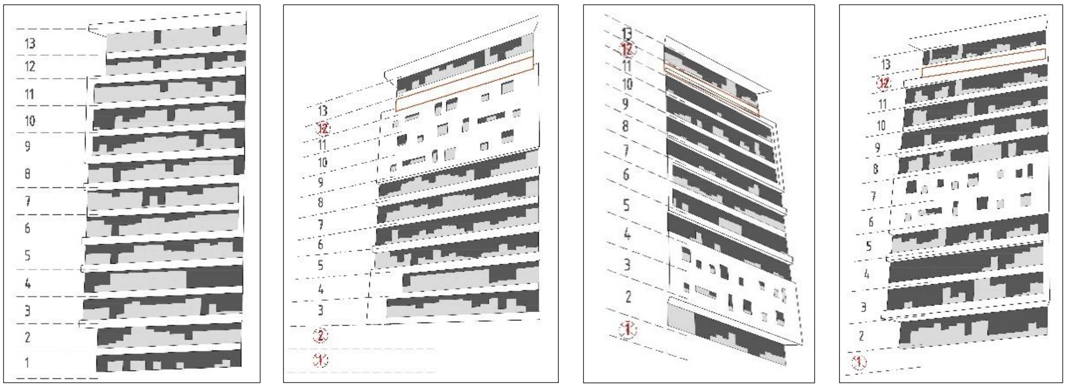


Figure 4.18. Summer and winter season curtained area rates of Next Level with its sketch that shows the orientation

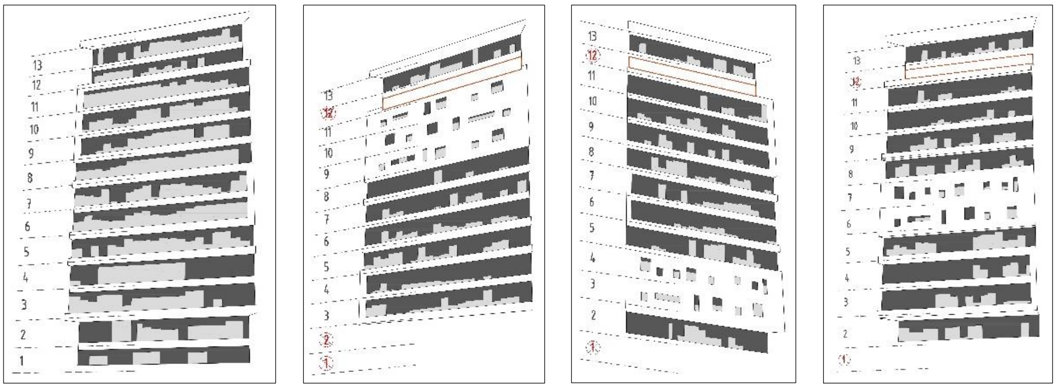
Case 5: İlaç Ve Tibbi Cihaz Kurumu (ITCK)

The building has four facades with glazing on East, West, North and South direction, the angle between building and X-axis is 4° as shown in Figure 4.7. All of the facades were examined. All facades have a part, as shown in Figure 4.19 and 4.20. Top thirteen floors on the North facade were observed. Twelfth floor on the East, South and West facades could not be observed because of perspective view. The first two floors on the East facade; first floor on the South and West facades could not be observed, because there are trees that prevent to see some part of the facade. Additionally, there are three floors under the tower block. These floors were not observed, since they were used as commercial area.



North East South West

Figure 4.19. Facade mapping of ITCK for winter season



North East South West

Figure 4.20. Facade mapping of ITCK for summer season

Since the building belongs to government office, all of the units in the building are occupied. However, some of the floors could not be observed because of obstructions; they are indicated on Figures 4.19 and 4.20 signed with red circle and cross. For example, 1st, 2nd and 12th floor on East facade; 1st and 12th floor on South facade and on West facade could not be observed and were not calculated.

The curtained area rates were given in the Table 0.9 (Appendix B). In winter season, 41.08% of the North facade; 45.13% of the East facade; 75.61% of the South facade and 65.59% of the West facade were closed with curtain. The South facade had the maximum curtained area, while the North facade had the minimum curtained area on 20th of January, at around 11 o'clock.

In summer season the maximum rate of curtained area belonged to West facade by 75.32%, while the minimum rate belonged to the North facade that had 50.93% curtained area. The South facade had 70.31% and the East facade has 69.99% curtained area on 12th August, at around 13 o'clock, as given in the Table 0.10 (Appendix B).

The comparison of curtained area according to season is given in the graph (Figure 4.21). The maximum change belongs to East facade, while the minimum change belongs to South facade. In fact, the curtained area rate of South facade is greater in winter than in summer. The lower angle of the sun path during winter could cause glare and effect the rate of using internal shading. Additionally, total rates of curtained area for this case building were approximately 57% in winter and 67% in summer.

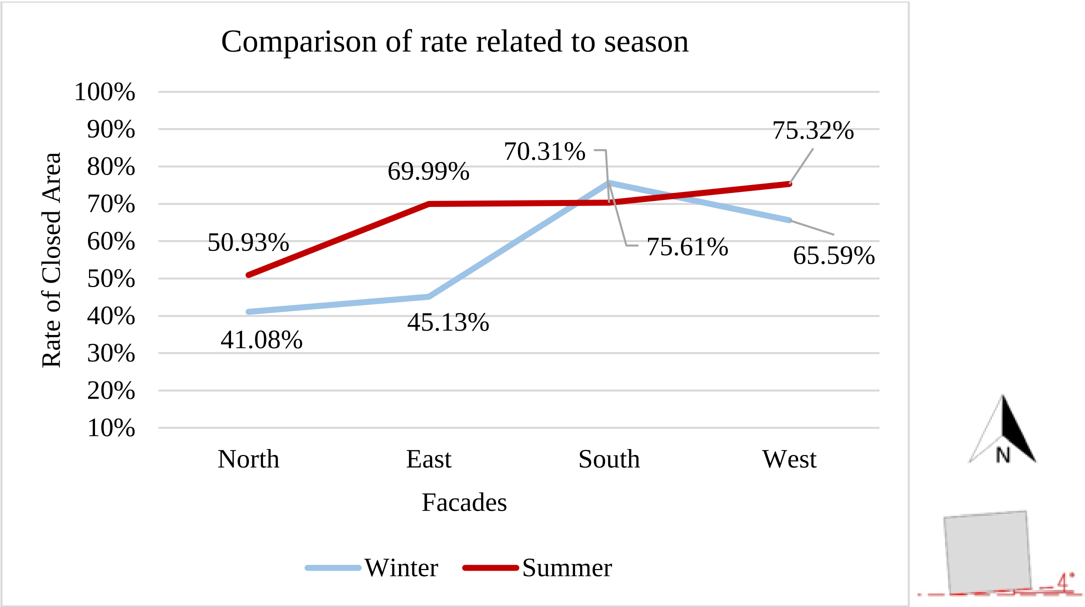


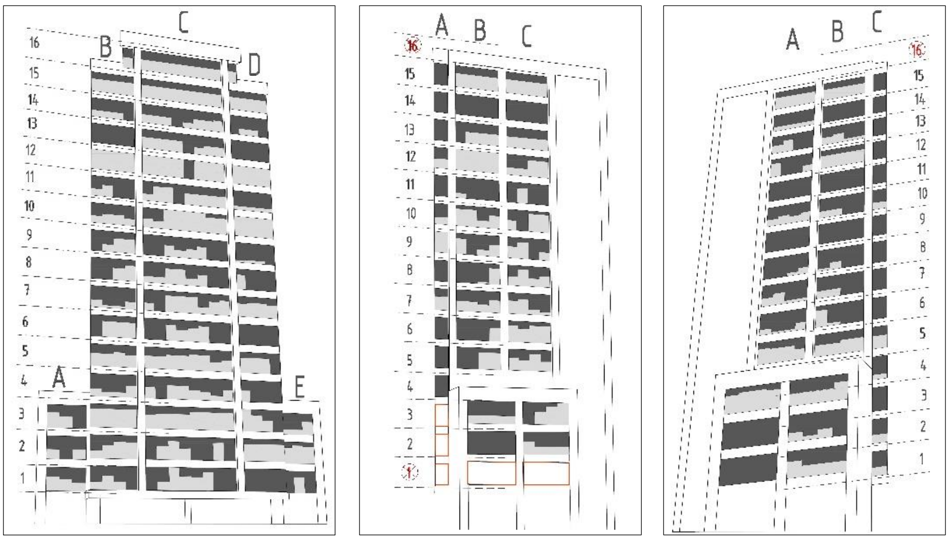
Figure 4.21. Summer and winter season curtained area rates of ITCK with its sketch that shows the orientation

Case 6: KGK

KGK has three facades that have significant glazed area. Therefore, these facades were drawn as shown in Figure 4.22 and 4.23. The angle between building plan and X-axis is 3° as shown in Figure 4.7, so the facades are South, East and West directions. The South facade consists of five parts (A, B, C, D and E), whereas, the East and West facade have three parts (A, B and C). In meantime, sixteen floors of the building were observed.

South East West

Figure 4.22. Facade mapping of KGK for winter season



South East West

Figure 4.23. Facade mapping of KGK for summer season

The building belongs to government office, so all units are occupied. However, some of them could not be observed because of obstructions. For example, 1st and 16th floors could not be observed totally; 2nd and 3rd floors could not be observed partially, on the East facade, while 16th floor could not be examined on the West facade, because of obstruction of the perspective view.

Results for winter season were given in the Table 0.11 (Appendix B). The maximum curtained area rate belonged to the West facade by 62.44%, while the minimum rate belonged to the East facade by 55.39%. The rate of South facade that is 55.85%, is slightly greater than the rate of East facade.

The summer season results were given in the Table 0.12 (Appendix B). Rate of curtained area was 55.16% on South facade; 64.90% on East facade and 77.82% on West facade. The maximum rate belonged to West facade, while the minimum rate belonged to South facade.

The change of curtained area rate according to season is given in the graph (Figure 4.24). The maximum change in curtained area rate according to seasons, belongs to the West facade, whereas the minimum change belongs to South facade. Like the ITCK building, winter season rate is slightly higher than summer season rate on the South facade. The slanted angle of the sun path during winter could cause glare on South facade. Total curtained area rate is nearly 58% in winter and nearly 66% in summer.

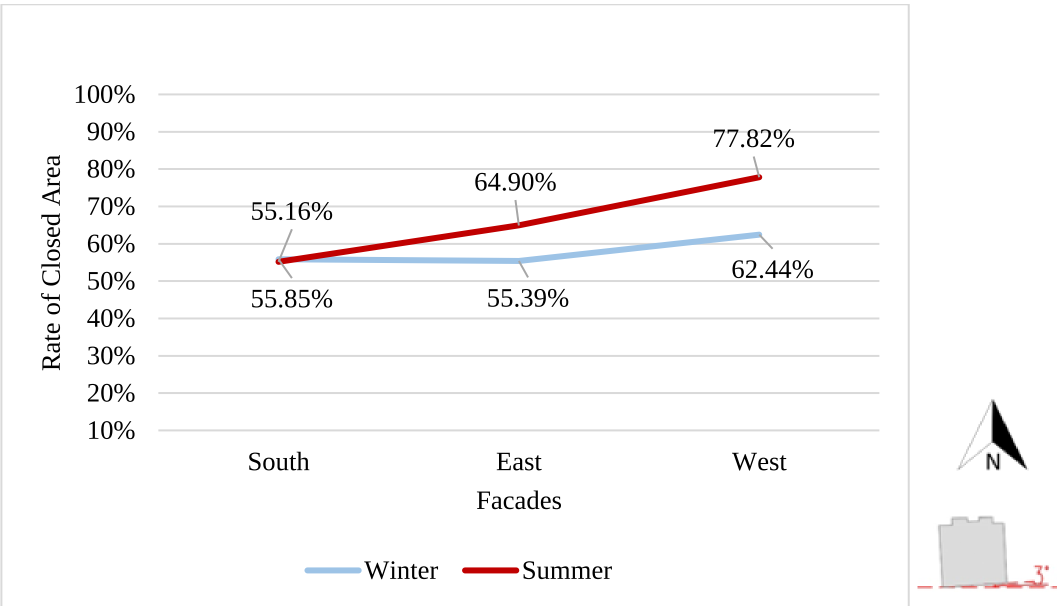
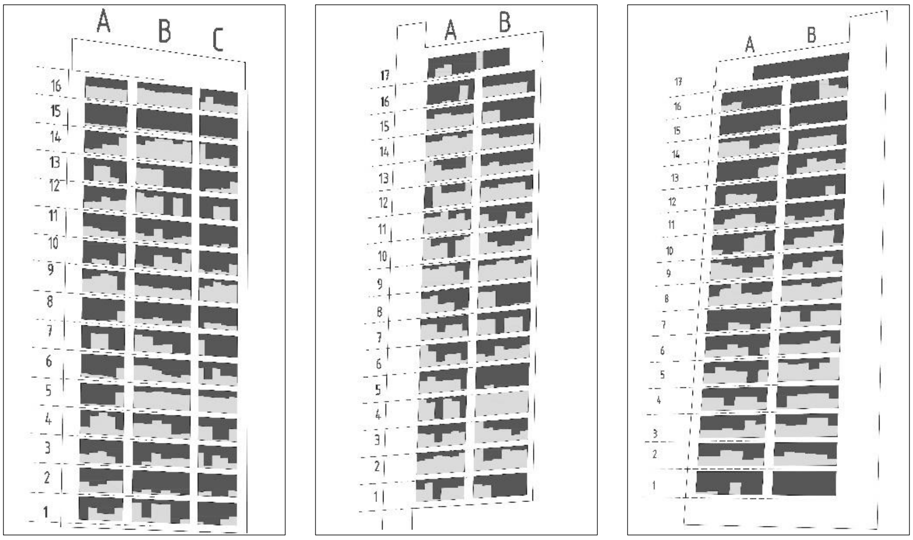


Figure 4.24. Summer and winter season curtained area rates of KGK with its sketch that shows the orientation

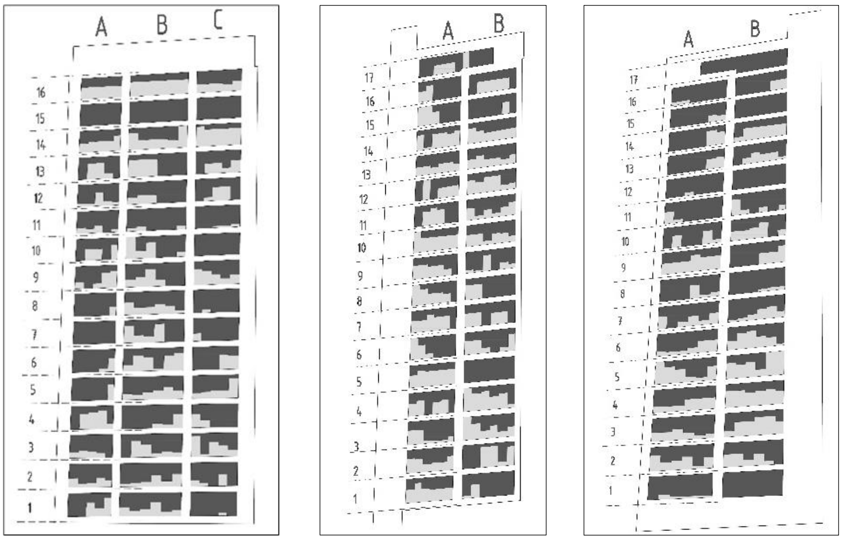
Case 7: İlbank

The building has four facades on Southwest, Northwest, Southeast and Northeast direction. The angle between building and X-axis is 41° as shown in Figure 4.6. However, the Northeast facade has not significant glazed area, so this facade was not observed. The Southwest facade consists of three parts (A, B and C), while the Northwest and Southeast facades consist of two parts (A and B) as shown in Figure 4.25 and 4.26. Top sixteen floors of Southwest facade and top seventeen floors of Northwest and Southeast were observed. There are two more floors, first two floors, that were not observed. Since the ground floor is used as entrance hall and the first floor could not be observed because of obstruction of perspective view.



Southwest Northwest Southeast

Figure 4.25. Facade mapping of Ilbank for winter season



Southwest Northwest Southeast

Figure 4.26. Facade mapping of Ilbank for summer season

Results of winter season were given in the Table 0.13 (Appendix B). The rate of curtained area was 63.73% on Southwest facade; 47.25% on Northwest facade; 61.60% on Southeast facade. The maximum rate belonged to Southwest facade, while the minimum rate belonged to Northwest facade.

Results of summer season were given in the Table 0.14 (Appendix B). The maximum rate belonged to Southeast facade which had 72.52% rate of curtained area. The minimum rate was 59.06% which was the rate of Northwest facade. The rate of Southwest facade was 72.41% which is slightly lesser than the rate of Southeast facade.

Comparison between summer and winter season curtained area rates are given in graph (Figure 4.27). The maximum change belongs to Northwest facade, whereas, the minimum change belongs to Southwest facade. The curtained area varies between around 47% and 59% on the Northwest facade and varies between nearly 64% and 72% on the Southwest facade. The change of curtained area on Southwest facade is lesser, since the duration of sun rays on Southwest facade does not change much between summer and winter season as compared to the other facades. Total curtained area rates were nearly 62% in winter and nearly 68% in summer.

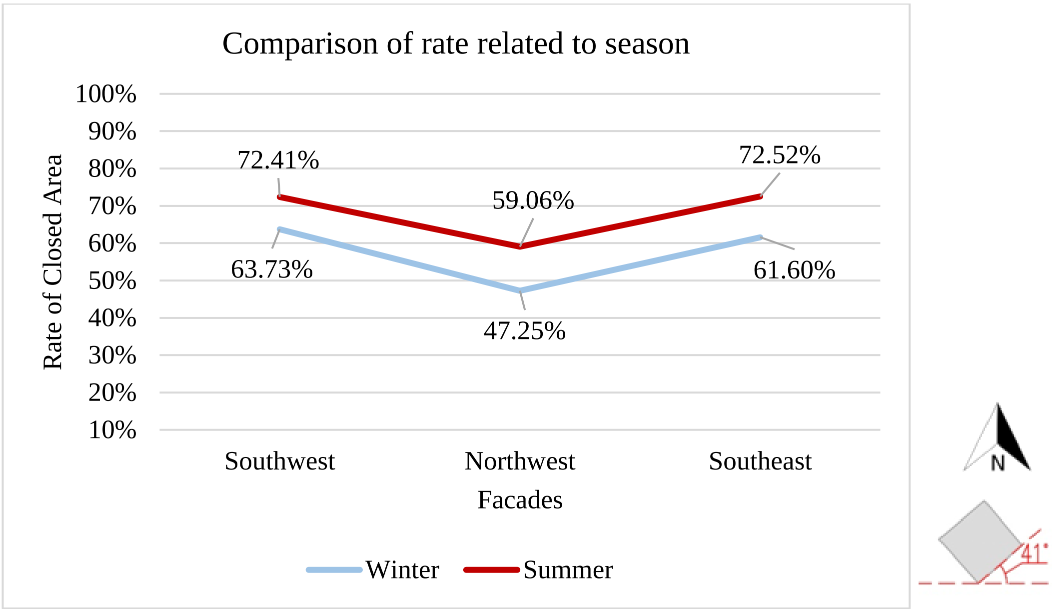
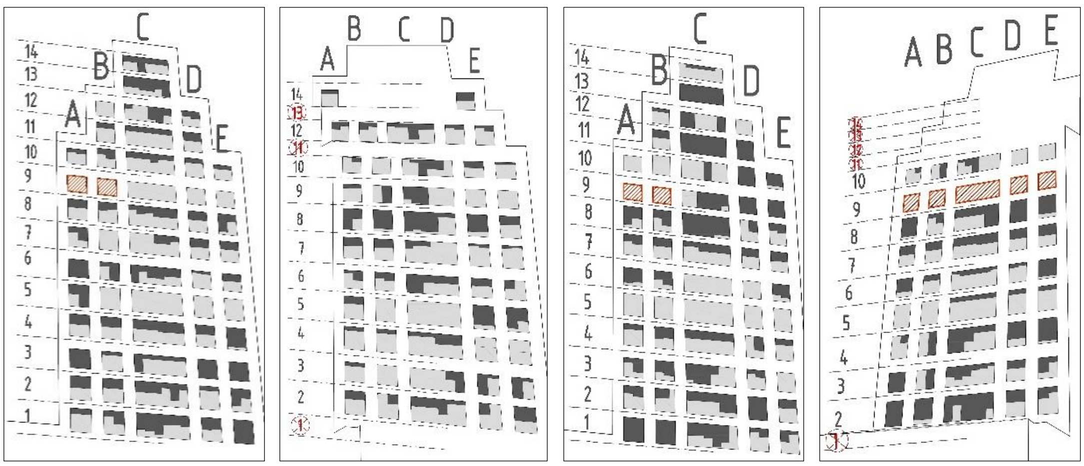


Figure 4.27. Summer and winter season curtained area rates of İlbank with its sketch that shows the orientation

Case 8: Farilya Business Center

Farilya Business Center has four facades on Northwest, Northeast, Southeast and Southwest directions. The angle between building and X-axis is 40° as shown in Figure 4.6. All of them were observed by separating into five parts (A, B, C, D and E) as shown in Figures 4.28 and 4.29. In meantime, fourteen floors were examined for each facade.



Northwest Northeast Southeast Southwest

Figure 4.28. Facade mapping of Farilya Business Center for winter season

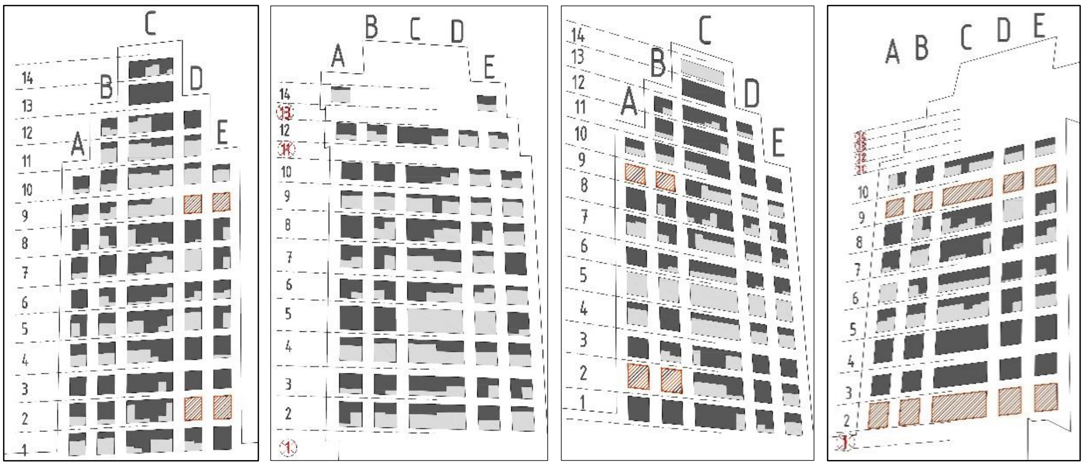


Figure 4.29. Facade mapping of Farilya Business Center for summer season

Results for winter season were given in the Table 0.15 (Appendix B). In winter season, 42.28% of the Northwest facade, 33.68% of the Northeast facade, 52.96% of the Southeast facade and 45.10% of the Southwest facade were closed with internal shading element. The maximum rate belonged to Southeast facade, while the minimum rate belonged to Northeast facade on 20th of January, at around 11 o'clock.

The results of the summer season were given in the Table 0.16 (Appendix B). According to results, the maximum rate was 71.79% that belonged to Southwest facade. The minimum rate belonged to Northeast facade that had the rate of 57.38%. The rate of curtained area was 65.02% on the Northwest facade and 63.22% on the Southeast facade on 12th August, at around 13 o'clock.

The comparison between rates in summer and winter season is shown in graph (Figure 4.30). The maximum change in rates according to season is observed on the Southwest facade. The rate increases from 45% to 72% approximately. The minimum change is observed on the Southeast facade. The rate was nearly 53% in winter and 63% in summer. Additionally, total rate of curtained area is about 44% in winter and 64% in summer.

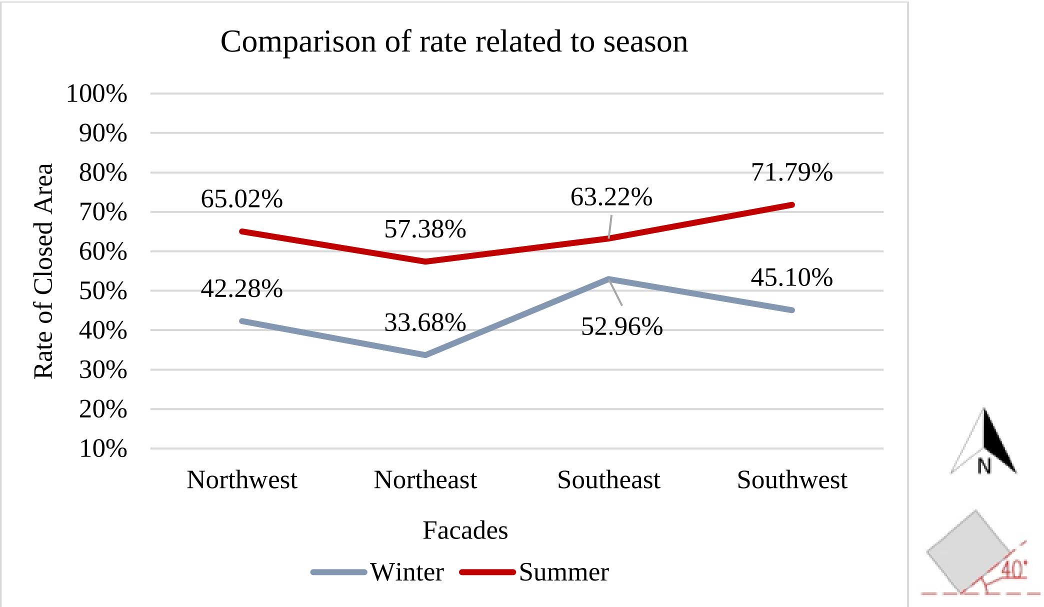


Figure 4.30. Summer and winter season curtained area rates of Farilya with its sketch that shows the orientation

4.3. Comparison of Results Related to Facade Orientations and Seasons

Rates of curtained area of all case buildings were compared according to facade direction, in bar charts (Figure 4.31, 4.32, 4.33 and 4.34). The direction of the facades was determined with the angle between a facade of the building and X-axis on plan view, as shown in Figures 4.6 and 4.7. According to directions of facades, the case buildings were divided into two groups. The first group contains Besa Kule, Farilya and İlbank that have facades on the Northwest, Southwest, Southeast and Northeast directions. The second group consists of KGK, Platin Tower and ITCK that have facades on the North, West, South and East directions. Next Level and Via Twins were not included in this comparison, since the orientations of these buildings was not compatible with the orientations of other case building. Additionally, the comparison was made for summer and winter seasons separately.

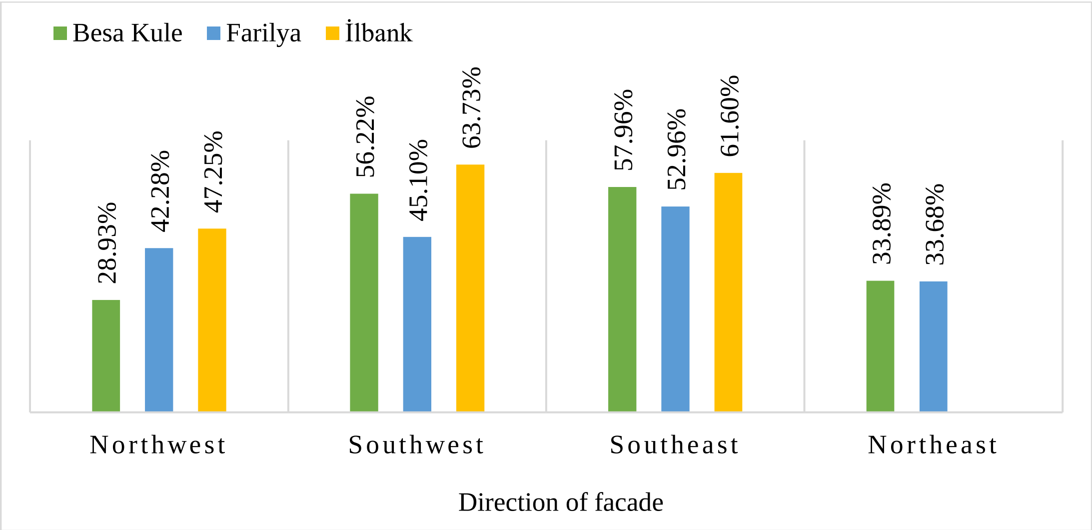


Figure 4.31. Curtained area rate of Besa Kule, Farilya and İlbank according to facade direction in winter

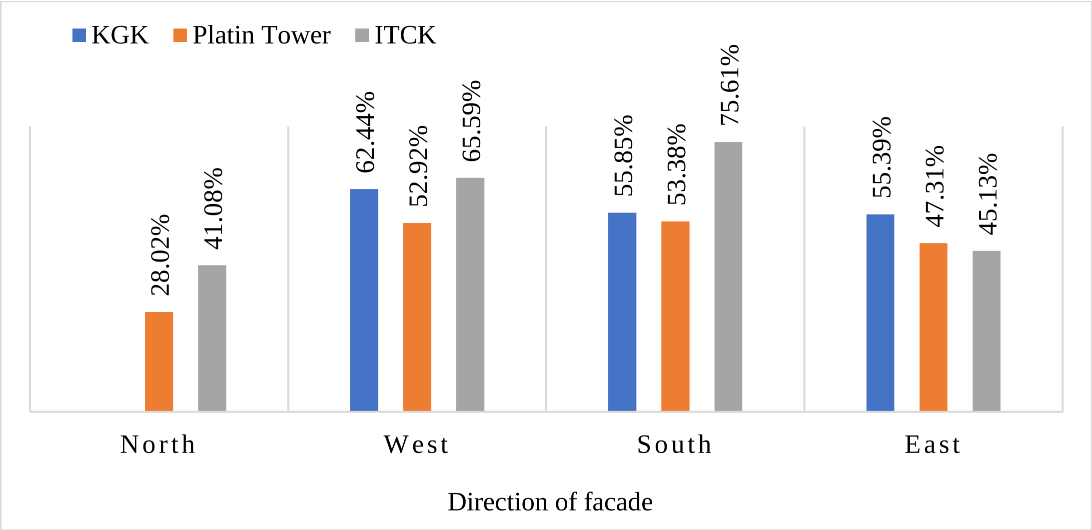


Figure 4.32. Curtained area rate of KGK, Platin Tower and ITCK according to facade direction in winter

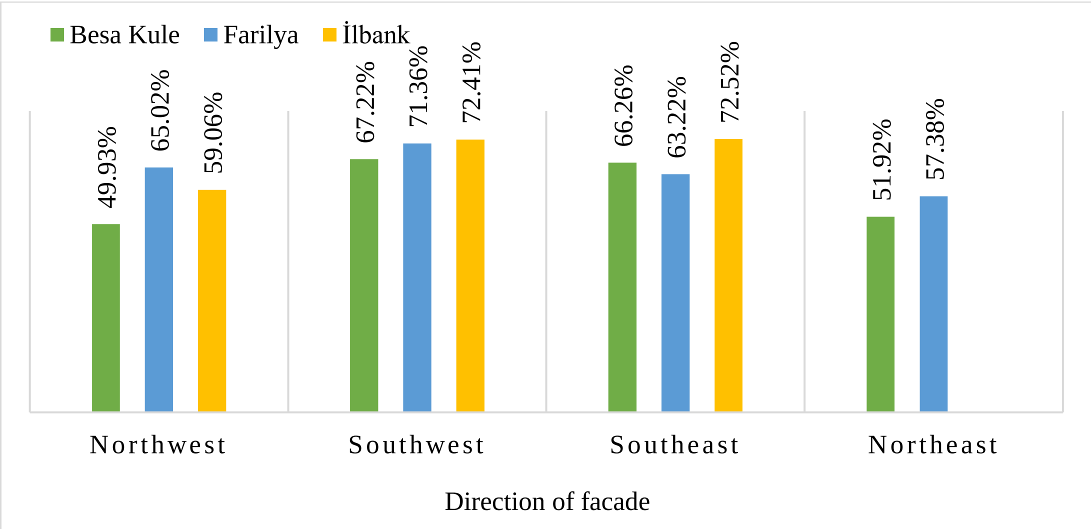


Figure 4.33. Curtained area rate of Besa Kule, Farilya and İlbank according to facade direction in summer

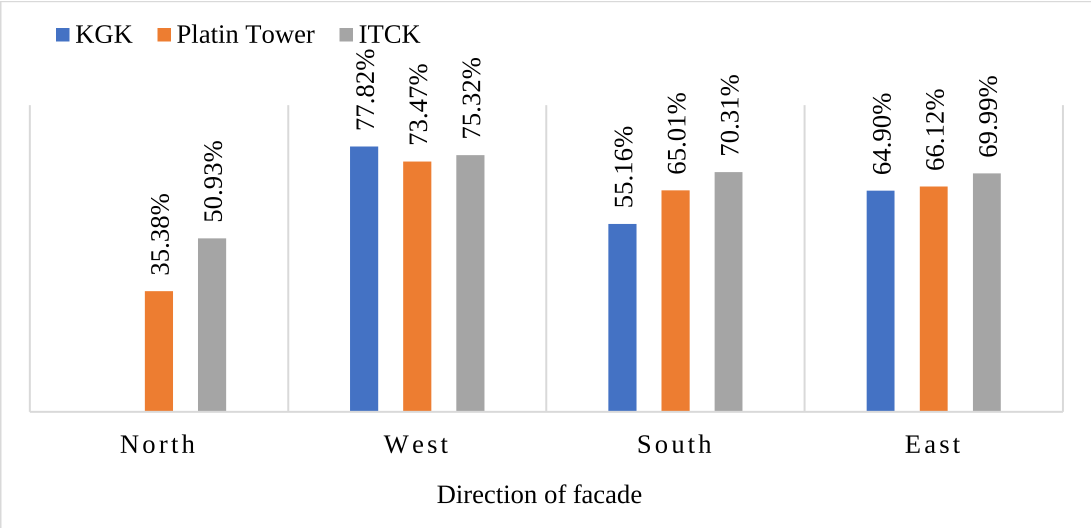


Figure 4.34. Curtained area rate of KGK, Platin Tower and ITCK according to facade direction in summer

According to results of the buildings that have facades on intercardinal directions, the Southeast and the Southwest facades have the maximum curtained area rates in winter season, while the Northeast facades have the minimum rates. Again, the Southeast and Southwest facades have the maximum values in summer, whereas the Northwest and Northeast facades have lower values. In the buildings that have facades on cardinal directions, the maximum curtained area rates belong to the South and West facades in winter and the maximum rates belong to South facades that are slightly higher than the West and East facades in summer. The minimum rates were observed in the North facade both in summer and winter.

According to overall results, the highest rate of curtained area belongs to the West facade of KGK in summer season, with 77.82% of curtained area. This facade is followed by the South facade of ITCK in winter with 75.61%; the west facade of ITCK in summer with 75.32%, the west facade of the Platin Tower in summer with 73.47%. All summer results are greater than winter results except two of them. The first one is South facade of the ITCK that was curtained at 75.61% rate in winter and at 70.31% rate in summer. The second one is South facade of KGK of which 55.85% in winter and 55.16% in summer was curtained. So, the dense use of internal shading elements may not only be related to the prevention of heat gain, but also prevention of uncontrolled glare.

4.4. Relation Between Glass Properties and Total Curtained Area of Four Case Study Buildings in Summer Season

As mentioned earlier, the aim of the research was to determine the impact of buildings having glass curtain walls on the thermal performance of the buildings and user satisfaction. Widespread use of internal shading elements in buildings with glass curtain wall is an indication of the probable thermal and visual discomfort and user dissatisfaction. Some properties of glass have direct relationship with rate of internal shading element use. These properties are visible light transmission, solar factor and U-value. In order to test the claim about this relationship, a regression analysis was made in Microsoft Excel. Four of the case buildings of which glass properties were available, were evaluated.

Firstly, relation between visible light transmission and curtained area rate was determined. Significance (α) value was selected as 0.05.

Table 4.2. *Raw data table showing curtained area rates and visible light transmission of glass*

Buildings	**Visible Light Transmission (%)**	**Total Curtained Area Rate in Summer (%)**
Besa Kule	51%	58.83%
Via Twins	40%	52.56%
Platin Tower	64%	59.99%
Next Level	35%	55.41%

Table 4.3. *Results of the regression analysis on the relation between visible light transmission and total curtained area rate in summer*

Regression Statistics	
Multiple R	0.8358
R Square	0.6985
Adjusted R Square	0.5477
Standard Error	0.0866
Observations	4.0000

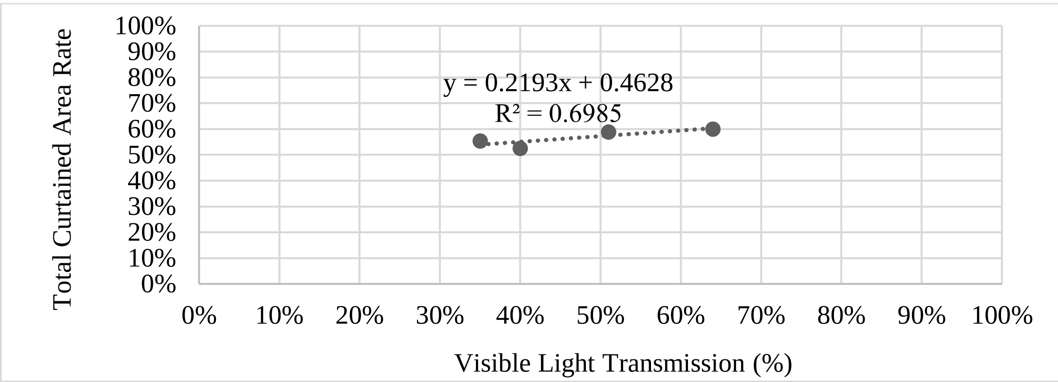


Figure 4.35. The graph of relation between visible light transmission and total curtained area rate in summer

In the test result, since P-value is higher than alpha value, null hypothesis is not rejected. So, there is relation between visible light transmission and rate of curtained area approximately at 70% according to R square value.

The second test was made between solar factor and curtained area rate. Significance (α) value was selected as 0.05.

Table 4.4. *Raw data table of curtained area rates and solar factor of glass*

Buildings	**Solar Factor (%)**	**Total Curtained Area Rate in Summer (%)**
Besa Kule	28%	58.83%
Via Twins	29%	52.56%
Platin Tower	39%	59.99%
Next Level	26%	55.41%

Table 4.5. *Relation between solar factor and total curtained area rate in summer*

Regression Statistics	
Multiple R	0.5898
R Square	0.3479
Adjusted R Square	0.0218
Standard Error	0.0334
Observations	4.0000

In the result of this test, null hypothesis is rejected, because alpha value is higher than P value. So, there is not significant relation between two variables. Related with R Square, there is relation approximately at 34% between variables.

The last test was made between U-value and curtained area rate. Significance (α) value was selected as 0.05.

Table 4.6. *Raw data table showing curtained area rates and U-value of glass*

Buildings	**U-value (W/m2K)**	**Total Curtained Area Rate in Summer (%)**
Besa Kule	1.3	58.83%
Via Twins	1.4	52.56%
Platin Tower	1.3	59.99%
Next Level	1.4	55.41%

Table 4.7. *Relation between U-value and total curtained area rate in summer*

Regression Statistics	
Multiple R	0.9281
R Square	0.8614
Adjusted R Square	0.7922
Standard Error	0.0154
Observations	4.0000

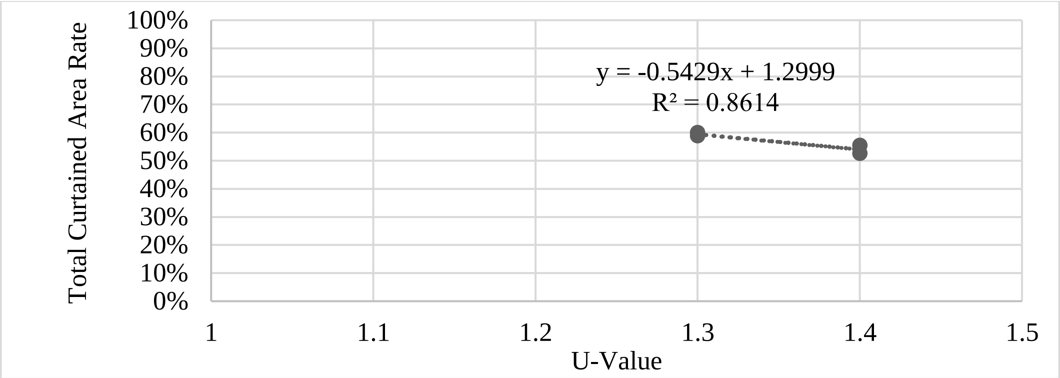


Figure 4.36. The graph of relation between U-value and total curtained area rate in summer

As the result, null hypothesis is not rejected, since P-value is higher than alpha value. So, there is relation between U-value and rate of curtained area approximately at 86% according to R square value.

CHAPTER 5

CONCLUSION

The glass curtain wall systems have been used widely since the beginning of the last century. It has been the symbol of modern architecture besides some advantages like providing natural lighting to interior, easy construction, providing unity in facade aesthetically and wide angle of view to outside for occupants. On the other hand, glass curtain wall system reduces the thermal performance of the buildings and cause thermal and visual discomfort when facade is not designed by considering climatic conditions. The lesser thermal performance means lesser energy saving, while thermal and visual discomfort means possible health disorder of occupants. It was observed that this situation forces the user to take precaution like using roller blinds as internal shading device which is not as effective as external shading strategies. So, it may not solve the problem completely in terms of thermal comfort, because it can store the heat that comes with solar rays and can cause increase in air temperature inside, especially near the facade. The rate of internal roller blind use has been analyzed by the help of selected case buildings and the conclusions that were obtained from this study are given in this chapter.

There are many buildings with glass curtain walls in Ankara. Eight of them were selected to examine the facades in detail. The selection criteria were shading type of the building and visibility of the internal shading devices from outside, as mentioned earlier. The selected buildings were Via Twins, KGK, Platin Tower, the building of Pharmaceutical and Medical Device Establishment (İlaç ve Tıbbi Cihaz Kurumu binası), Besa Kule, İlbank, Farilya and Next Level. The photos of all facades of these eight buildings were taken in fall, winter, spring and summer seasons and the rate of curtained area were compared in Appendix C by the help of taken photos. The results show that the rate of curtained area increased gradually from winter to summer and decreased from summer to winter.

Further, the facade mapping of eight buildings was made for summer and winter season to get numeric data about rate of curtained area. The results show that the glass curtain walls without any shading systems is not efficient for climate of Ankara. The curtained area rates changed between approximately 28-75% in winter and 35-75% in summer. The minimum rates generally belong to the North, the Northeast and the Northwest facades. The maximum rates generally belong to the West, the Southwest and the South facades.

According to results, the maximum rate obtained from the West facade of KGK building in summer season. The low angle of the sun rays on the West direction can causes increasing solar heat gains and visual disability due to glare. The curtained area rate of the West facades in summer is greater than in winter, although the angle of the sun rays is lower in winter. This shows the discomfort of occupant can be caused by solar heat gain mostly for this building. The curtained area rates for summer season is generally greater than rates for the winter season except for two of them. The South facade of ITCK and the South facade of KGK had higher curtained areas in winter than in summer. This is caused by lower angle of the sun rays that can lead to visual discomfort.

The properties of the glass are also important factors in terms of thermal performance. In order to determine this importance, four cases of which glass properties could be obtained were compared with curtained area rates for summer season. These case buildings were Besa Kule, Via Twins, Platin Tower and Next Level. According to results visible light transmission and U-value have significant impact on the curtained area while the solar factor of the glazing does not have the same effect.

There are many advantages of glass curtain walls, especially in aesthetic aspects, while there are variety of disadvantages that effect the user comfort directly. Ankara has steppe climate which causes extremely high temperatures in summer and low temperatures in winter. The temperature difference between the day and night is high. Hence, the glass that used for curtain walls, should be able to slow down heat transfer for observed buildings. Double pane glazing with higher U-value and with reflective film can be preferred. However, only deciding on glass properties will not be sufficient to maintain the user comfort efficiently. Exterior shading strategies should be developed besides the interior roller blinds. The shading strategies should be considered according to facade directions. For the East, West and North facades vertical shading elements can be decided while for the South facade horizontal elements can be selected. The angle of the elements can be determined according to the angle of sun rays or more complicated pattern can be designed and tested by the help of building thermal performance programs. The shading devices should be designed by considering overcast days, in order to provide sufficient natural lighting. For this reason, movable shading devices can be more efficient. The exterior shading devices can be supported by interior shading elements, but their material should be decided properly in order to prevent solar heat gains.

For the further studies, the facade mapping method can be combined with occupant comfort survey to determine the exact reason behind the dense use of internal shading elements. The buildings can be observed all day long and the facade mapping can be drawn for the different phases of the day. The change in facade mapping pattern according to angle of the sun rays can be observed. Data loggers can be used to determine the thermal condition of the buildings. The numerical data that is obtained from data loggers can be compared with results of the facade mapping to determine the relation between thermal condition of the interior space and the use of internal shading element. A similar comparison can be done between lighting condition and facade mapping results.

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APPENDICES

A. Sun Path Diagrams

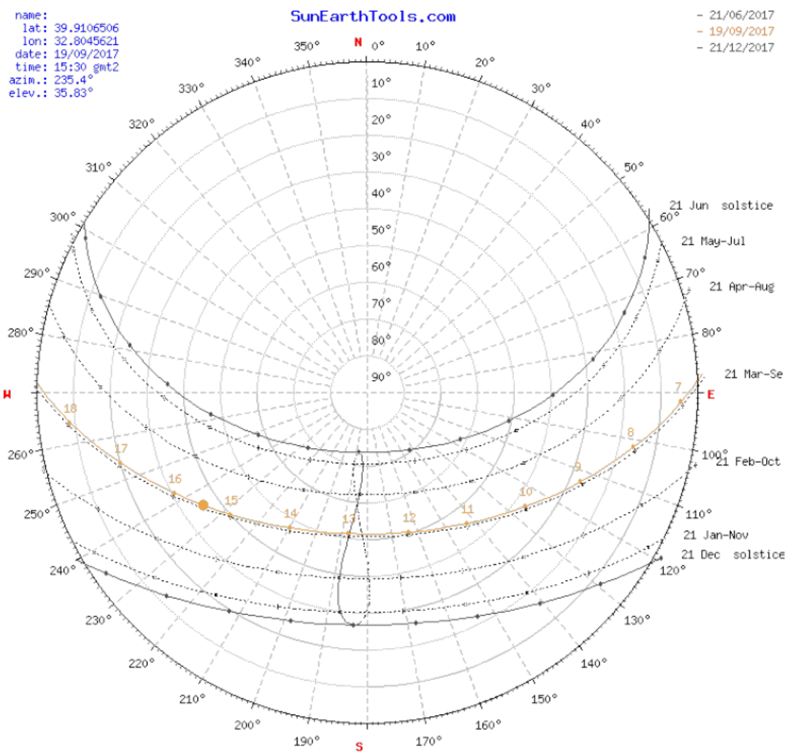


Figure 0.1. Sun path diagram at 15:30 in 19.09.2017

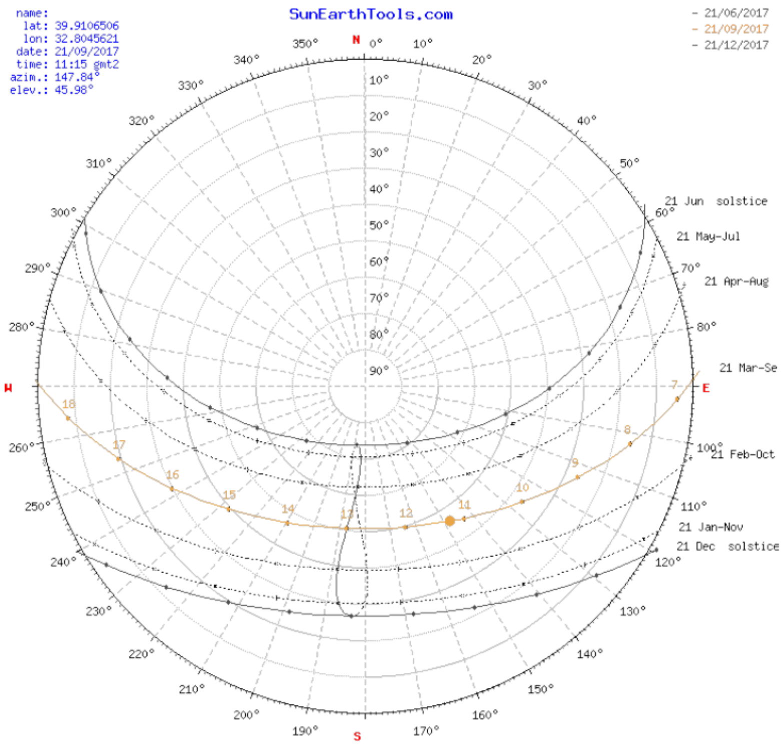


Figure 0.2. Sun path diagram at 11:15 in 21.09.2017

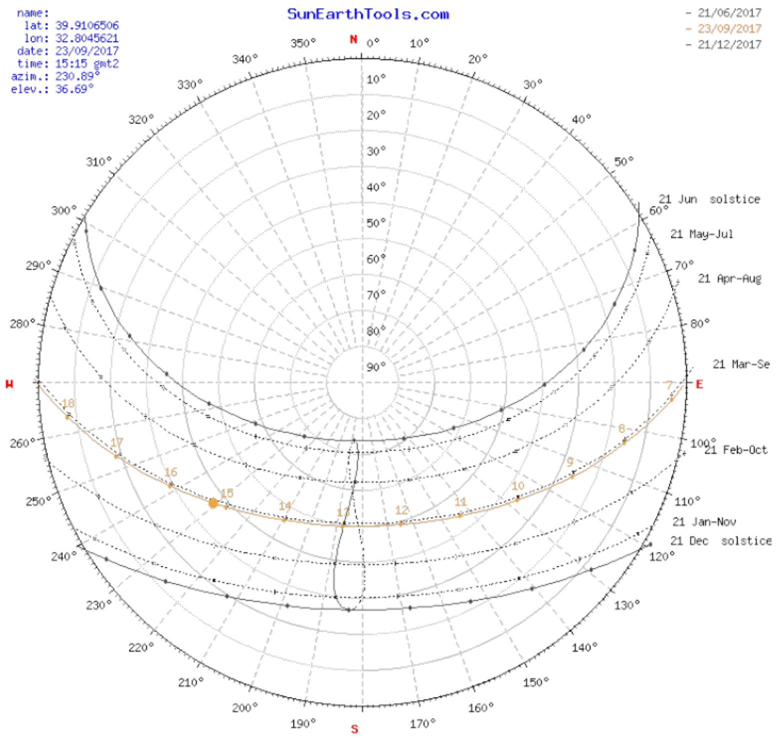


Figure 0.3. Sun path diagram at 15:15 in 23.09.2017

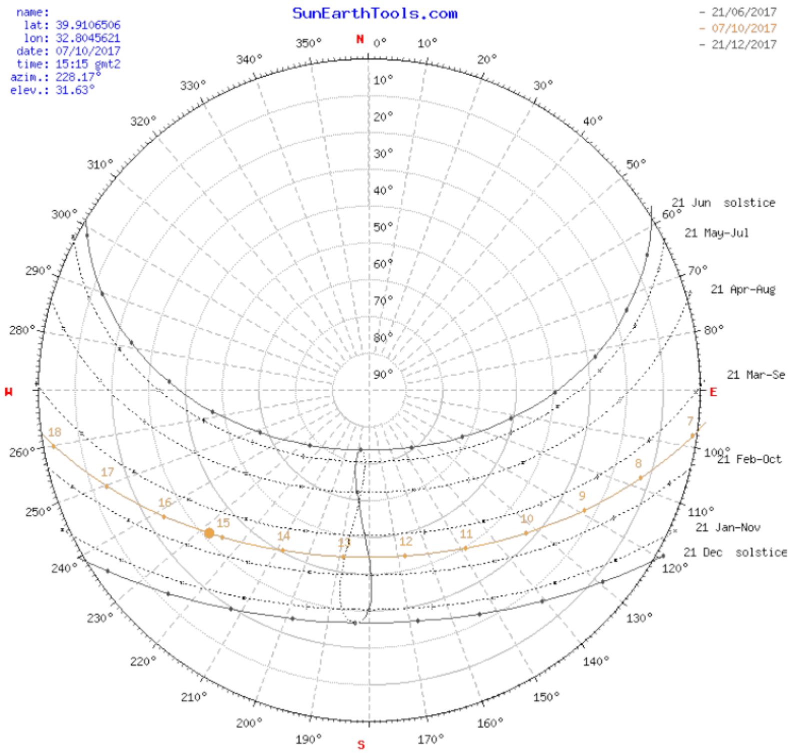


Figure 0.4. Sun path diagram at 15:15 in 7.10.2017

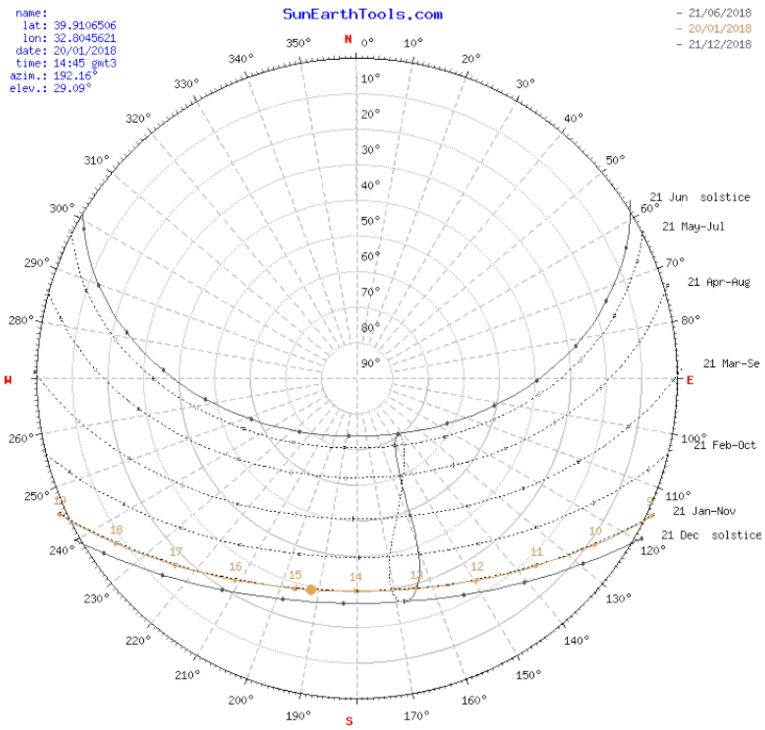


Figure 0.5. Sun path diagram at 14:45 in 20.01.2018

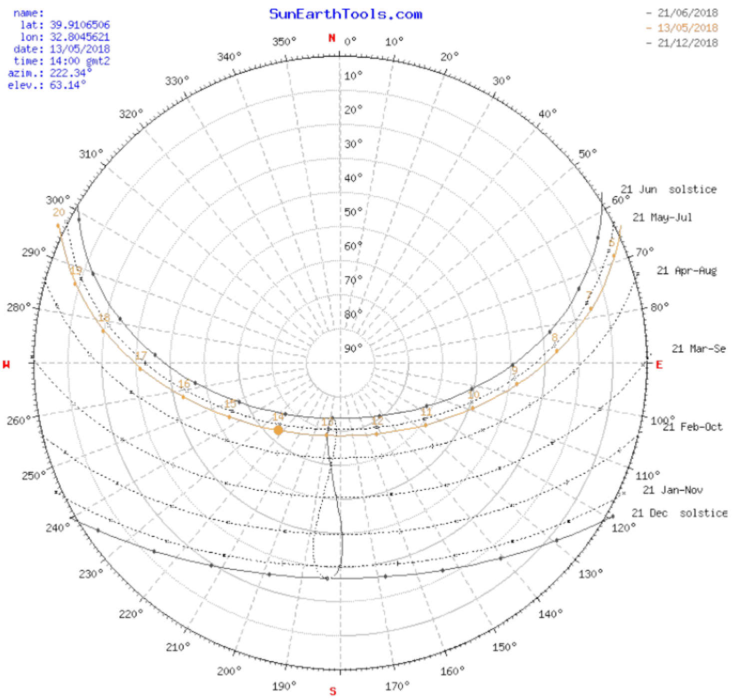


Figure 0.6. Sun path diagram at 14:00 in 13.05.2018

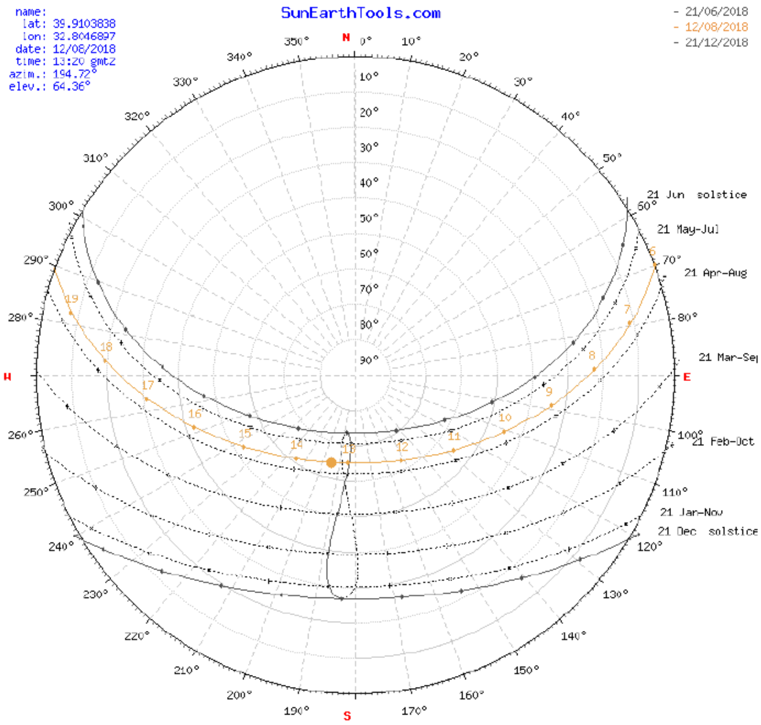


Figure 0.7. Sun path diagram at 13:15 in 12.08.2018

B. Raw Data Tables of Results

Table 0.1. *Legend for the tables*

-	NO FLOOR
X	NO OCCUPANCY
	CAN NOT BE OBSERVED

Table 0.2. *Winter results of Besa Kule*

FLOOR	NORTHWEST			SOUTHWEST						SOUTHEAST			NORTHEAST					
	A			A			B			A			A			B		
	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate
1	55345	25258	45,64%	19454	9598	49,34%	14313	9320	65,12%	81453	50302	61,76%	29444	4936	16,76%	28078	9353	33,31%
2	55300	15350	27,76%	19309	9839	50,96%	14344	4970	34,65%	79711	46786	58,69%	29033	7134	24,57%	27691	4763	17,20%
3	55143	3944	7,15%	X	X	X	14116	7823	55,42%	46835	15352	32,78%	29492	1782	6,04%	28166	5618	19,95%
4	55565	13576	24,43%	19081	7036	36,87%	X	X	X	46295	20896	45,14%	16365	4160	25,42%	28292	5813	20,55%
5	44498	4694	10,55%	9821	3434	34,97%	14316	6153	42,98%	73755	36614	49,64%	28670	7124	24,85%	28006	0	0,00%
6	54167	32557	60,10%	19023	14168	74,48%	14435	11214	77,69%	71374	53459	74,90%	28182	17926	63,61%	27526	21275	77,29%
7	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
8	35699	3339	9,35%	19710	6974	35,38%	14499	11667	80,47%	46136	33341	72,27%	X	X	X	X	X	X
9	53433	13826	25,88%	19064	5437	28,52%	14407	14407	100,00%	68347	34178	50,01%	27002	5428	20,10%	26405	6102	23,11%
10	53413	27152	50,83%	19320	8135	42,11%	14511	9221	63,54%	66749	38735	58,03%	27079	10970	40,51%	26387	26387	100,00%
11	52818	13797	26,12%	19382	14576	75,20%	14191	13116	92,42%	67647	49562	73,27%	26697	12272	45,97%	25053	13135	52,43%
12	52984	16121	30,43%	19626	7454	37,98%	14577	10510	72,10%	66211	41360	62,47%	26387	11838	44,86%	24771	5968	24,09%
13	X	X	X	X	X	X	14498	5812	40,09%	66152	37464	56,63%	25957	7320	28,20%	X	X	X
	Total rate		28,93%	Total rate		46,58%	Total rate		65,86%	Total rate		57,96%	Total rate		30,99%	Total rate		36,79%
	Total rate for the facade		28,93%	Total rate for the facade				56,22%		Total rate for the facade		57,96%	Total rate for the facade				33,89%	
	Total rate for the building 44,25%																	

Table 0.3. *Summer results of Besa Kule*

FLOOR	NORTHWEST			SOUTHWEST						SOUTHEAST			NORTHEAST					
	A			A			B			A			A			B		
	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate
1	66245	30082	45,41%	27053	12005	44,38%	19715	16475	83,57%	92153	42730	46,37%	29700	8723	29,37%	27926	15258	54,64%
2	66876	24164	36,13%	27188	18197	66,93%	19377	7453	38,46%	91189	57290	62,83%	29515	7387	25,03%	27866	11834	42,47%
3	65525	16931	25,84%	26476	4582	17,31%	19294	17877	92,66%	53754	37201	69,21%	29571	7804	26,39%	27585	9597	34,79%
4	65328	40787	62,43%	26434	19999	75,66%	19351	17413	89,99%	85861	52300	60,91%	14444	3725	25,79%	26915	7012	26,05%
5	65368	20122	30,78%	12867	5204	40,44%	19364	16869	87,12%	87451	46421	53,08%	28398	8475	29,84%	27032	8122	30,05%
6	64111	58598	91,40%	26017	22633	86,99%	19162	18656	97,36%	84748	73285	86,47%	28574	25188	88,15%	26782	22387	83,59%
7	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
8	43186	5999	13,89%	26294	10857	41,29%	18718	14992	80,09%	56014	48959	87,40%	X	X	X	X	X	X
9	63186	27800	44,00%	25539	19179	75,10%	X	X	X	84208	50971	60,53%	28548	18108	63,43%	27412	13665	49,85%
10	62439	40261	64,48%	25384	13275	52,30%	18395	12426	67,55%	84581	42693	50,48%	28390	13454	47,39%	27733	27733	100,00%
11	61598	31944	51,86%	25555	19952	78,07%	18323	8493	46,35%	85695	50144	58,51%	27852	0	0,00%	26031	12161	46,72%
12	62072	38652	62,27%	25211	19742	78,31%	18131	14768	81,45%	85543	77462	90,55%	28689	25731	89,69%	26529	18707	70,52%
13	20055	14173	70,67%	15114	8751	57,90%	18071	10704	59,23%	85793	58991	68,76%	27881	23451	84,11%	25644	24210	94,41%
	Total rate		49,93%	Total rate		59,56%	Total rate		74,89%	Total rate		66,26%	Total rate		46,29%	Total rate		57,55%
	Total rate for the facade		**49,93%**	**Total rate for the facade**				**67,22%**		**Total rate for the facade**		**66,26%**	**Total rate for the facade**				**51,92%**	
	Total rate for the building 58,83%																	

Table 0.4. *Winter results of Via Twins*

FLOOR	SOUTHWEST								
	A			B			C		
	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate
1	21132	15293	72,37%	50002	41100	82,20%	22741	13058	57,42%
2	19435	5386	27,71%	48139	14428	29,97%	22538	14178	62,91%
3	19875	15123	76,09%	47334	31478	66,50%	22558	12307	54,56%
4	19697	0	0,00%	45289	15919	35,15%	21234	10768	50,71%
5	19443	11994	61,69%	42806	13521	31,59%	22145	13698	61,86%
6	19921	19921	100,00%	43405	30207	69,59%	20382	8861	43,47%
7	18863	3560	18,87%	40943	25030	61,13%	20637	13563	65,72%
8	18980	10301	54,27%	39516	38072	96,35%	19785	19785	100,00%
9	18233	17358	95,20%	39846	12496	31,36%	19951	5583	27,98%
10	18210	2298	12,62%	40330	20916	51,86%	18657	7771	41,65%
11	16820	8033	47,76%	38264	9977	26,07%	17888	8173	45,69%
12	17022	2909	17,09%	36585	10815	29,56%	18496	6856	37,07%
13	16439	2199	13,38%	35198	16784	47,68%	17963	13873	77,23%
14	17075	9512	55,71%	35070	16209	46,22%	16881	7971	47,22%
15	15751	6294	39,96%	34507	19653	56,95%	17413	4705	27,02%
16	15354	8939	58,22%	33033	17236	52,18%	15745	8266	52,50%
17	14743	9601	65,12%	32528	14329	44,05%	16399	8016	48,88%
18	14780	7663	51,85%	31584	14583	46,17%	16810	11630	69,19%
19	14336	8618	60,11%	30810	15513	50,35%	14647	7904	53,96%
20	13487	5807	43,06%	29649	16816	56,72%	15306	5308	34,68%
21	13545	8452	62,40%	28512	13695	48,03%	14691	7531	51,26%
22	13648	6698	49,08%	27800	11172	40,19%	14254	10448	73,30%
23	12760	5759	45,13%	27996	11817	42,21%	13417	6874	51,23%
24	13754	8320	60,49%	26881	21551	80,17%	13239	7875	59,48%
25	11267	570	5,06%	24917	11010	44,19%	12779	7190	56,26%
	Total rate		47,73%	Total rate		50,66%	Total rate		54,05%
	Total rate for the facade				50,81%				

FLOOR	SOUTHEAST			NORTHWEST		
	A			A		
	Total	Curtained	Rate	Total	Curtained	Rate
1	101995	17222	16,89%	121570	30886	25,41%
2	96444	39362	40,81%	115757	52287	45,17%
3	97091	23649	24,36%	110305	56201	50,95%
4	99331	30673	30,88%	107928	67471	62,51%
5	98260	42597	43,35%	99944	31947	31,96%
6	89434	37413	41,83%	98071	59763	60,94%
7	92178	41181	44,68%	94953	83349	87,78%
8	87909	59149	67,28%	87697	23609	26,92%
9	84379	62581	74,17%	80025	23556	29,44%
10	X	X	X	X	X	X
11	78750	27131	34,45%	77054	6115	7,94%
12	74493	35912	48,21%	71038	24168	34,02%
13	70180	29763	42,41%	67376	3884	5,76%
14	67806	19770	29,16%	62307	9235	14,82%
15	63015	22916	36,37%	60356	14739	24,42%
16	61360	34196	55,73%	56958	15305	26,87%
17	58450	47282	80,89%	53067	21998	41,45%
18	57175	45260	79,16%	50120	28943	57,75%
19	X	X	X	X	X	X
20	47298	34869	73,72%	43914	11538	26,27%
21	42143	11935	28,32%	40625	11010	27,10%
22	41460	22389	54,00%	36161	12029	33,27%
23	37508	19819	52,84%	34536	9251	26,79%
24	37328	30793	82,49%	33558	8141	24,26%
25	32727	11703	35,76%	29585	10751	36,34%
	Total rate		48,60%	Total rate		35,14%
	Total rate for the facade		48,60%	Total rate for the facade		35,14%

FLOOR	NORTHEAST								
	A			B			C		
	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate
1									
2									
3									
4									
5									
6									
7	36023	5619	15,60%	73876	11854	16,05%	31714	2940	9,27%
8	34312	11277	32,87%	70799	13283	18,76%	29964	12694	42,36%
9	32209	15761	48,93%	68187	19812	29,06%	28138	4494	15,97%
10	32249	15857	49,17%	68090	20662	30,35%	25744	4311	16,75%
11	31635	14388	45,48%	64051	22793	35,59%	27418	3693	13,47%
12	31914	0	0,00%	62556	11889	19,01%	25365	0	0,00%
13	28988	11133	38,41%	60512	18185	30,05%	26482	11001	41,54%
14	28942	0	0,00%	57128	14020	24,54%	24891	7059	28,36%
15	28028	7683	27,41%	56250	10067	17,90%	22023	0	0,00%
16	27257	8174	29,99%	55446	20379	36,75%	22172	7831	35,32%
17	26124	19699	75,41%	53543	29516	55,13%	23932	9388	39,23%
18	26215	7544	28,78%	50744	10681	21,05%	20926	11990	57,30%
19	24842	2166	8,72%	49899	15893	31,85%	20273	0	0,00%
20	24239	1759	7,26%	49098	9906	20,18%	20811	0	0,00%
21	23437	0	0,00%	46858	9452	20,17%	20908	3412	16,32%
22	24105	4808	19,95%	47180	14278	30,26%	19546	4747	24,29%
23	21468	7938	36,98%	45244	12293	27,17%	19112	1144	5,99%
24	21460	0	0,00%	44404	15314	34,49%	18274	0	0,00%
25	21235	14328	67,47%	40797	6732	16,50%	18542	4248	22,91%
	Total rate		28,02%	Total rate		27,10%	Total rate		19,42%
	Total rate for the facade						24,85%		

Total rate for the building 39,85%

Table 0.5. *Summer results of Via Twins*

FLOOR	SOUTHWEST								
	A			B			C		
	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate
1	27112	18885	69,66%	62033	37941	61,16%	30093	20935	69,57%
2	25583	8701	34,01%	59380	9850	16,59%	27943	12955	46,36%
3	25652	18180	70,87%	59654	41259	69,16%	29373	20988	71,45%
4	24254	17656	72,80%	58160	18270	31,41%	24287	18262	75,19%
5	24845	10378	41,77%	57233	17599	30,75%	29068	11705	40,27%
6	24044	20207	84,04%	55987	31344	55,98%	27184	11141	40,98%
7	23480	14401	61,33%	54604	25773	47,20%	25862	21111	81,63%
8	22725	11487	50,55%	54804	10795	19,70%	26237	18222	69,45%
9	21960	14143	64,40%	52455	19858	37,86%	26524	10067	37,95%
10	22278	15471	69,45%	51952	32289	62,15%	24158	13618	56,37%
11	22487	7803	34,70%	50099	19464	38,85%	24473	9201	37,60%
12	21782	17015	78,11%	50288	12717	25,29%	24132	8523	35,32%
13	21577	13012	60,30%	49090	27356	55,73%	24170	21534	89,09%
14	21981	14367	65,36%	50342	28869	57,35%	26153	10434	39,90%
15	21608	9256	42,84%	49013	29534	60,26%	24187	0	0,00%
16	21175	15051	71,08%	47359	25393	53,62%	23424	12719	54,30%
17	20726	11925	57,54%	47678	34269	71,88%	24413	4518	18,51%
18	20795	13944	67,05%	47766	22963	48,07%	23788	8630	36,28%
19	21234	13127	61,82%	45162	30530	67,60%	22403	13874	61,93%
20	19376	13393	69,12%	48056	17669	36,77%	23497	8477	36,08%
21	19613	14360	73,22%	44687	19769	44,24%	23281	7397	31,77%
22	19585	12272	62,66%	44695	25409	56,85%	22535	9935	44,09%
23	18717	8760	46,80%	44280	20645	46,62%	22280	14296	64,17%
24	19119	0	0,00%	41070	21418	52,15%	22049	7965	36,12%
25	17784	12575	70,71%	42651	34752	81,48%	19120	9428	49,31%
	Total rate		59,21%	Total rate		49,15%	Total rate		48,95%
	Total rate for the facade				**52,43%**				

FLOOR	SOUTHEAST			NORTHWEST			NORTHEAST								
	A			A			A			B			C		
	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate
1	70591	44015	62,35%	77723	61772	79,48%									
2	79057	52104	65,91%	76807	36558	47,60%									
3	77419	27112	35,02%	82225	29110	35,40%									
4	74924	39176	52,29%	86180	56984	66,12%									
5	78072	43025	55,11%	82749	45084	54,48%									
6	81870	23225	28,37%	83196	61979	74,50%									
7	74243	45142	60,80%	84793	75025	88,48%	51262	13559	26,45%	125949	54008	42,88%	45221	0	0,00%
8	76616	44387	57,93%	82753	49385	59,68%	54312	33190	61,11%	114948	51176	44,52%	44574	35586	79,84%
9	74842	63074	84,28%	81884	42883	52,37%	54403	45735	84,07%	107574	32817	30,51%	42813	10057	23,49%
10	X	X	X	X	X	X	53493	23694	44,29%	101885	16458	16,15%	37832	19915	52,64%
11	77610	47837	61,64%	85211	39913	46,84%	51846	17354	33,47%	96454	32978	34,19%	37846	5516	14,57%
12	79011	47136	59,66%	80474	56162	69,79%	50869	0	0,00%	94402	17930	18,99%	35516	24927	70,19%
13	76851	40616	52,85%	79249	60538	76,39%	44984	19045	42,34%	86846	24124	27,78%	33897	13740	40,53%
14	71241	40055	56,22%	79046	29975	37,92%	45694	41818	91,52%	84410	18257	21,63%	31774	31774	100,00%
15	67883	40944	60,32%	81522	43638	53,53%	40880	25953	63,49%	81660	18700	22,90%	32557	0	0,00%
16	69506	50403	72,52%	76498	31290	40,90%	39812	22889	57,49%	78400	16444	20,97%	29604	0	0,00%
17	68605	48044	70,03%	76126	39122	51,39%	37724	28950	76,74%	72982	52109	71,40%	29849	10651	35,68%
18	65580	63802	97,29%	71195	53560	75,23%	35124	16253	46,27%	70354	16908	24,03%	27192	11430	42,03%
19	X	X	X	X	X	X	36704	6943	18,92%	67520	26069	38,61%	25852	4955	19,17%
20	59310	54107	91,23%	68614	28350	41,32%	34847	5076	14,57%	61803	12941	20,94%	26522	6618	24,95%
21	58005	26310	45,36%	64098	35219	54,95%	31085	11599	37,31%	59493	16031	26,95%	24394	0	0,00%
22	56646	38970	68,80%	65520	28318	43,22%	30128	5040	16,73%	59273	14847	25,05%	23521	14598	62,06%
23	54910	41631	75,82%	60316	43090	71,44%	29183	14003	47,98%	53789	13210	24,56%	20369	0	0,00%
24	52440	39871	76,03%	59636	26443	44,34%	29435	8239	27,99%	52730	31324	59,40%	21478	6137	28,57%
25	48194	30257	62,78%	56602	40159	70,95%	26414	19612	74,25%	51362	14944	29,10%	18471	4376	23,69%
	Total rate		63,16%	Total rate		58,10%	Total rate		45,53%	Total rate		31,61%	Total rate		32,50%
	Total rate for the facade		**63,16%**	**Total rate for the facade**		**58,10%**	**Total rate for the facade**					**36,54%**			

Total rate for the building 52,56%

Table 0.6. *Winter results of Platin Tower*

FLOOR	NORTH									WEST											
	A			B			C			A			B			C			D		
	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate
1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
3	27773	7024	25,29%	31898	10742	33,68%	27893	20917	74,99%	28433	20055	70,53%	17371	4610	26,54%	16328	7221	44,22%	26725	9473	35,45%
4	X	X	X	X	X	X	X	X	X	27667	21707	78,46%	17133	8824	51,50%	X	X	X	X	X	X
5	26776	8300	31,00%	30947	16416	53,05%	27235	24366	89,47%	27131	27131	100,00%	16514	15390	93,19%	15185	15185	100,00%	25993	13345	51,34%
6	26062	10060	38,60%	30038	1019	3,39%	X	X	X	26773	26773	100,00%	16658	5775	34,67%	15696	1500	9,56%	25713	3148	12,24%
7	25799	13850	53,68%	29407	21966	74,70%	25570	25570	100,00%	26524	23237	87,61%	15541	12397	79,77%	14812	12899	87,08%	24973	19928	79,80%
8	25360	0	0,00%	29269	7878	26,92%	25750	5180	20,12%	X	X	X	X	X	X	16343	5711	34,94%	24731	7493	30,30%
9	24662	4519	18,32%	28783	1789	6,22%	25586	0	0,00%	X	X	X	15650	0	0,00%	14764	2521	17,08%	24371	11461	47,03%
10	24669	1842	7,47%	27726	3057	11,03%	23816	2924	12,28%	25178	7209	28,63%	14598	5357	36,70%	13492	6565	48,66%	24002	11339	47,24%
11	23586	3922	16,63%	X	X	X	24468	0	0,00%	24730	14705	59,46%	15061	8493	56,39%	X	X	X	X	X	X
12	23968	0	0,00%	27707	15088	54,46%	24444	21905	89,61%	X	X	X	X	X	X	X	X	X	X	X	X
13	22579	6729	29,80%	25782	6473	25,11%	22499	9673	42,99%	23966	16155	67,41%	13818	3149	22,79%	12713	3584	28,19%	22792	10095	44,29%
14	X	X	X	X	X	X	X	X	X	X	X	X	14861	7488	50,39%	X	X	X	X	X	X
15	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
16	X	X	X	X	X	X	X	X	X	23267	12781	54,93%	12053	9045	75,04%	X	X	X	X	X	X
17	21970	543	2,47%	25622	5463	21,32%	22822	1838	8,05%	X	X	X	14265	5849	41,00%	13557	10873	80,20%	21191	10828	51,10%
18	21030	3144	14,95%	24817	0	0,00%	22341	3101	13,88%	21770	7333	33,68%	13440	5202	38,71%	12618	4425	35,07%	21239	9199	43,31%
19	20215	2585	12,79%	23437	3731	15,92%	20779	0	0,00%	21365	2445	11,44%	12678	7116	56,13%	X	X	X	20838	5685	27,28%
	Total rate		19,31%	Total rate		27,15%	Total rate		37,62%	Total rate		62,92%	Total rate		47,34%	Total rate		48,50%	Total rate		42,67%
	Total rate for the facade					**28,02%**				**Total rate for the facade**						**52,92%**					

FLOOR	EAST												SOUTH								
	A			B			C			D			A			B			C		
	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate
1	X	X	X	X	X	X	24634	11548	46,88%	31540	22086	70,03%	38619	29666	76,82%	44226	10727	24,25%	X	X	X
2	X	X	X	X	X	X	24385	24385	100,00%	31027	10459	33,71%	41677	19521	46,84%	X	X	X	X	X	X
3	34673	29526	85,16%	24400	16150	66,19%	X	X	X	30847	28328	91,83%	51704	51704	100,00%	47274	24998	52,88%	36942	31330	84,81%
4	X	X	X	X	X	X	22953	5514	24,02%	29584	16299	55,09%	39792	25465	64,00%	43777	27229	62,20%	35434	16566	46,75%
5	34182	33546	98,14%	23888	22099	92,51%	23246	16116	69,33%	29867	14745	49,37%	40790	30664	75,18%	46002	18477	40,17%	38452	38452	100,00%
6	X	X	X	X	X	X	22179	0	0,00%	28531	20618	72,27%	41183	31538	76,58%	45312	39189	86,49%	37135	35190	94,76%
7	X	X	X	X	X	X	X	X	X	X	X	X	36808	0	0,00%	40745	19128	46,95%	33815	25240	74,64%
8	31985	22941	71,72%	22575	4317	19,12%	22116	7530	34,05%	28940	7827	27,05%	35959	14083	39,16%	40318	5452	13,52%	X	X	X
9	X	X	X	22018	10859	49,32%	21414	0	0,00%	X	X	X	X	X	X	40471	0	0,00%	33353	0	0,00%
10	29071	2683	9,23%	X	X	X	X	X	X	26131	5993	22,93%	33169	10962	33,05%	37065	14716	39,70%	31448	15510	49,32%
11	X	X	X	21553	0	0,00%	20739	6096	29,39%	26808	25854	96,44%	33159	15402	46,45%	36203	24883	68,73%	29919	15192	50,78%
12	30094	16997	56,48%	21413	14380	67,16%	20718	1968	9,50%	27059	27059	100,00%	33671	31503	93,56%	36561	9102	24,90%	29962	9289	31,00%
13	26958	7722	28,64%	19181	4223	22,02%	18545	5158	27,81%	24283	14013	57,71%	28510	8999	31,56%	32150	28392	88,31%	29787	20727	69,58%
14	X	X	X	X	X	X	19750	9250	46,84%	25690	5788	22,53%	28230	14358	50,86%	31958	13825	43,26%	27283	2070	7,59%
15	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
16	24871	12861	51,71%	20076	6581	32,78%	X	X	X	22857	19064	83,41%	24959	13861	55,54%	27804	17867	64,26%	26404	1843	6,98%
17	27558	13052	47,36%	19944	6788	34,04%	19183	0	0,00%	X	X	X	27296	2748	10,07%	30283	16066	53,05%	25129	7528	29,96%
18	27425	26916	98,14%	19505	8764	44,93%	18589	9220	49,60%	24315	24315	100,00%	29365	29365	100,00%	32051	17572	54,83%	26034	22435	86,18%
19	25355	22037	86,91%	17841	7772	43,56%	17518	10937	62,43%	23609	6624	28,06%	22862	20171	88,23%	26236	14126	53,84%	23025	10972	47,65%
	Total rate		63,35%	Total rate		42,87%	Total rate		35,70%	Total rate		60,69%	Total rate		55,47%	Total rate		47,95%	Total rate		56,72%
	Total rate for the facade						**47,31%**						**Total rate for the facade**					**53,38%**			
	Total rate for the building 45,41%																				

Table 0.7. *Summer results of Platin Tower*

FLOOR	NORTH								
	A			B			C		
	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate
1	X	X	X	X	X	X	X	X	X
2	29169	13407	45,96%	32053	11288		27839	12767	45,86%
3	29254	8464	28,93%	32903	13404	40,74%	29247	18998	64,96%
4	X	X	X	X	X	X	X	X	X
5	28279	26105	92,31%	31489	16452	52,25%	27821	27821	100,00%
6	28065	6436	22,93%	31582	7924	25,09%	28216	21205	75,15%
7	27165	19290	71,01%	29944	26976	90,09%	26294	26294	100,00%
8	X	X	X	X	X	X	X	X	X
9	25844	6643	25,70%	28473	7966	27,98%	25070	0	0,00%
10	25523	0	0,00%	28081	0	0,00%	24733	6831	27,62%
11	25521	1739	6,81%	28041	5489	19,57%	24705	3430	13,88%
12	X	X	X	27480	11646	42,38%	24494	20917	85,40%
13	23079	10274	44,52%	25287	4697	18,57%	22292	12312	55,23%
14	X	X	X	X	X	X	X	X	X
15	X	X	X	X	X	X	X	X	X
16	X	X	X	X	X	X	X	X	X
17	21902	1332	6,08%	23547	7572	32,16%	20526	4214	20,53%
18	22044	3287	14,91%	24442	0	0,00%	21947	3838	17,49%
19	20924	4163	19,90%	23197	3804	16,40%	20858	0	0,00%
	Total rate		31,59%	Total rate		30,44%	Total rate		44,10%
	Total rate for the facade					**35,38%**			

FLOOR	WEST											
	A			B			C			D		
	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate
1	X	X	X	X	X	X	X	X	X	X	X	X
2	23743	21813	91,87%	15044	12655	84,12%	14680	8832	60,16%	26375	26375	100,00%
3	24135	24135	100,00%	15240	15240	100,00%	14873	14873	100,00%	26592	23997	90,24%
4	23862	19876	83,30%	15031	6613	44,00%	X	X	X	X	X	X
5	24079	24079	100,00%	15118	14151	93,60%	14769	1302	8,82%	26179	26179	100,00%
6	24353	0	0,00%	15292	13768	90,03%	14982	6562	43,80%	26521	14134	53,29%
7	23797	22780	95,73%	15014	12638	84,17%	14799	13553	91,58%	26282	23691	90,14%
8	X	X	X	X	X	X	14994	7941	52,96%	26304	2162	8,22%
9	X	X	X	X	X	X	14727	14727	100,00%	25947	19831	76,43%
10	24393	7588	31,11%	15290	4056	26,53%	15119	15119	100,00%	26561	26561	100,00%
11	24303	21668	89,16%	15081	15081	100,00%	X	X	X	X	X	X
12	X	X	X	X	X	X	X	X	X	X	X	X
13	23703	23703	100,00%	14827	12333	83,18%	14755	14755	100,00%	25753	25753	100,00%
14	23768	23768	100,00%	14774	14774	100,00%	X	X	X	X	X	X
15	X	X	X	X	X	X	X	X	X	X	X	X
16	23386	16390	70,08%	14512	8618	59,39%	X	X	X	X	X	X
17	23772	23772	100,00%	14733	14733	100,00%	14713	11938	81,14%	25300	0	0,00%
18	22587	21070	93,28%	14195	3413	24,04%	14359	8036	55,96%	24996	17595	70,39%
19	23601	4104	17,39%	14466	4867	33,64%	14398	6911	48,00%	24410	24410	100,00%
	Total rate		76,57%	Total rate		73,05%	Total rate		70,20%	Total rate		74,06%
	Total rate for the facade						**73,47%**					

FLOOR	EAST											
	A			B			C			D		
	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate
1	X	X	X	X	X	X	X	X	X	24640	17506	71,05%
2	26715	15327	57,37%	18726	17098	91,31%	X	X	X	X	X	X
3	27516	27516	100,00%	18924	18924	100,00%	18382	18382	100,00%	23769	23769	100,00%
4	X	X	X	X	X	X	18332	15208	82,96%	24303	20411	83,99%
5	26088	26088	100,00%	18347	18347	100,00%	18104	13002	71,82%	23990	14309	59,65%
6	26557	26557	100,00%	18392	18392	100,00%	17890	17890	100,00%	23338	23338	100,00%
7	25885	25885	100,00%	18205	18205	100,00%	17911	17911	100,00%	23759	23759	100,00%
8	X	X	X	17650	3145	17,82%	17343	17343	100,00%	X	X	X
9	X	X	X	17551	7993	45,54%	X	X	X	X	X	X
10	24949	24949	100,00%	17624	17624	100,00%	17324	10702	61,78%	23117	13977	60,46%
11	24632	20303	82,43%	17497	7619	43,54%	17252	10956	63,51%	23162	23162	100,00%
12	23923	14306	59,80%	16923	7533	44,51%	16604	14717	88,64%	22210	22210	100,00%
13	23853	21879	91,72%	16897	8100	47,94%	16573	14241	85,93%	22210	22210	100,00%
14	X	X	X	X	X	X	16494	12334	74,78%	22364	17029	76,14%
15	X	X	X	X	X	X	X	X	X	X	X	X
16	23783	7895	33,20%	16824	3570	21,22%	16408	0	0,00%	21988	15172	69,00%
17	23020	21140	91,83%	16344	8572	52,45%	15964	5703	35,72%	X	X	X
18	22447	16496	73,49%	16053	10965	68,30%	15748	15748	100,00%	21358	21358	100,00%
19	21014	0	0,00%	15083	6462	42,84%	14818	0	0,00%	20180	0	0,00%
	Total rate		72,23%	Total rate		53,11%	Total rate		73,03%	Total rate		78,48%
	Total rate for the facade						**66,12%**					

FLOOR	SOUTH								
	A			B			C		
	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate
1	29714	17662	59,44%	36420	10256	28,16%	X	X	X
2	30182	20698	68,58%	36505	16535	45,30%	32739	32739	100,00%
3	28474	28474	100,00%	34873	34873	100,00%	31663	31663	100,00%
4	29224	24859	85,06%	34955	15675	44,84%	30930	19147	61,90%
5	29459	18864	64,03%	35125	35125	100,00%	30949	30949	100,00%
6	28752	6926	24,09%	34220	11644	34,03%	30069	22108	73,52%
7	26452	26452	100,00%	32125	32125	100,00%	28827	26393	91,56%
8	27129	17321	63,85%	32311	8747	27,07%	X	X	X
9	X	X	X	X	X	X	X	X	X
10	24451	4216	17,24%	29658	6446	21,73%	26516	8991	33,91%
11	24847	17959	72,28%	29643	20394	68,80%	26012	16696	64,19%
12	23872	16874	70,69%	29000	22603	77,94%	25931	0	0,00%
13	22569	8946	39,64%	27543	24693	89,65%	24730	24730	100,00%
14	21780	20017	91,91%	26366	9365	35,52%	23453	13300	56,71%
15	X	X	X	X	X	X	X	X	X
16	20434	18659	91,31%	24963	21601	86,53%	22387	14472	64,64%
17	21873	7068	32,31%	25819	7353	28,48%	22278	15807	70,95%
18	22778	17604	77,29%	26247	21904	83,45%	21997	19568	88,96%
19	18867	13369	70,86%	22860	16276	71,20%	20275	4030	19,88%
	Total rate		61,21%	Total rate		66,86%	Total rate		66,94%
	Total rate for the facade					**65,01%**			

Total rate for the building 59,99%

Table 0.8. *Winter and summer results of Next Level*

WINTER						
FLOOR	SOUTHWEST			NORTHEAST		
	Total	Curtained	Rate	Total	Curtained	Rate
1	132176	70201	53,11%	153970	78227	50,81%
2				151988	21325	14,03%
3	136908	88126	64,37%	147864	28678	19,39%
4	140711	85960	61,09%	146641	62728	42,78%
5	52027	18644	35,84%	138978	22005	15,83%
6	145522	75448	51,85%	138022	39769	28,81%
7	147129	85134	57,86%	64112	33512	52,27%
8	54213	29085	53,65%	129893	24165	18,60%
9	55363	37350	67,46%	129289	11616	8,98%
10	56400	30667	54,37%	128589	62292	48,44%
11	150208	73232	48,75%	131138	20249	15,44%
12	147179	80807	54,90%	134299	39312	29,27%
13				135386	22856	16,88%
14	145572	75077	51,57%	134623	49987	37,13%
15	150545	107246	71,24%	134708	58218	43,22%
16	142285	117643	82,68%	132251	52938	40,03%
17						
18				132306	22582	17,07%
19	147852	90589	61,27%	134616	24382	18,11%
20	131944	50976	38,63%	133137	10607	7,97%
21	129496	122242	94,40%	130349	22570	17,32%
22	66948	53579	80,03%	131542	54430	41,38%
23	124756	49953	40,04%	133163	53123	39,89%
24	119180	21938	18,41%	131538	24486	18,62%
25	117236	90179	76,92%	130855	33000	25,22%
26	59706	34816	58,31%	128659	25788	20,04%
27	-	-	-	131203	49255	37,54%
28	-	-	-	163927	62002	37,82%
	Total rate for the facade		58,03%	Total rate for the facade		28,26%
	Total rate for the building 43,15%					

SUMMER						
FLOOR	SOUTHWEST			NORTHEAST		
	Total	Curtained	Rate	Total	Curtained	Rate
1	139695	125633	89,93%			
2	49841	20012	40,15%	159208	104917	65,90%
3	141253	77231	54,68%	150288	56819	37,81%
4	143722	70554	49,09%	146330	86534	59,14%
5	52685	52685	100,00%	140577	20871	14,85%
6	145867	100306	68,77%	135482	56175	41,46%
7	54726	54726	100,00%	61456	46046	74,93%
8	54446	24165	44,38%	126160	80799	64,04%
9	55159	47039	85,28%	118902	19478	16,38%
10	55335	21578	39,00%	121052	66083	54,59%
11	147183	103980	70,65%	120531	26663	22,12%
12	144559	99363	68,74%	128465	68584	53,39%
13				128774	25006	19,42%
14	142841	98541	68,99%	123335	68902	55,87%
15				126798	126798	100,00%
16	145495	41988	28,86%	126045	126045	100,00%
17				116650	79408	68,07%
18				117541	48466	41,23%
19	137372	98684	71,84%			
20	132395	53926	40,73%	114618	7971	6,95%
21	131176	131176	100,00%	114214	32230	28,22%
22	66674	60965	91,44%	110472	53115	48,08%
23	119607	77585	64,87%	109617	43805	39,96%
24	116554	13699	11,75%	109349	31727	29,01%
25	113861	93752	82,34%	107051	36588	34,18%
26	56385	37149	65,88%	107299	22189	20,68%
27	-	-	-	107615	60121	55,87%
28	-	-	-	137673	31873	23,15%
	Total rate for the facade		66,53%	Total rate for the facade		44,29%
	Total rate for the building 55,41%					

Table 0.9. *Winter results of ITCK*

FLOOR	NORTH			EAST			SOUTH			WEST		
	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate
1	63051	49788	78,96%									
2	75034	29326	39,08%				56409	33083	58,65%	133996	71950	53,70%
3	85395	44703	52,35%	96135	43213	44,95%	9492	4818	50,76%	108105	74492	68,91%
4	84069	46132	54,87%	87572	29069	33,19%	8876	5072	57,14%	105527	84967	80,52%
5	81881	32851	40,12%	92600	56924	61,47%	45620	41171	90,25%	93830	60013	63,96%
6	79414	24687	31,09%	93975	56843	60,49%	42295	35855	84,77%	17729	8078	45,56%
7	78416	24296	30,98%	92024	44784	48,67%	41008	27762	67,70%	17596	10142	57,64%
8	77029	27859	36,17%	81935	38941	47,53%	36032	32803	91,04%	77879	40299	51,75%
9	75743	35197	46,47%	15251	4618	30,28%	32881	31431	95,59%	77699	62538	80,49%
10	81141	38353	47,27%	15313	7210	47,08%	36690	29234	79,68%	82657	62767	75,94%
11	75844	23371	30,81%	13916	3708	26,65%	32045	30606	95,51%	71650	48647	67,90%
12	58958	23370	39,64%									
13	68376	4236	6,20%	66874	34085	50,97%	26869	16296	60,65%	54550	40962	75,09%
	Total rate for the facade		41,08%	Total rate for the facade		45,13%	Total rate for the facade		75,61%	Total rate for the facade		65,59%
	Total rate for the building 56,85%											

Table 0.10. *Summer results of ITCK*

FLOOR	NORTH			EAST			SOUTH			WEST		
	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate
1	90818	67038	73,82%									
2	122019	63369	51,93%				105893	82157	77,58%	155048	105747	68,20%
3	132888	68949	51,89%	106950	76443	71,48%	19743	4211	21,33%	153115	121043	79,05%
4	127535	75982	59,58%	109043	96340	88,35%	19001	6974	36,70%	151632	130322	85,95%
5	117567	56766	48,28%	103474	74526	72,02%	102206	76637	74,98%	145829	89677	61,49%
6	113274	40444	35,70%	101724	81418	80,04%	95875	86525	90,25%	25573	16515	64,58%
7	109386	56245	51,42%	98877	81586	82,51%	95549	73258	76,67%	25032	15065	60,18%
8	106413	37761	35,49%	92154	86888	94,29%	90386	64750	71,64%	134163	95442	71,14%
9	98116	51838	52,83%	16550	5670	34,26%	88170	73740	83,63%	135220	105460	77,99%
10	101739	47171	46,36%	16694	9797	58,69%	89048	70118	78,74%	131811	119655	90,78%
11	96463	35978	37,30%	14777	6835	46,25%	88680	76884	86,70%	128158	115787	90,35%
12	61511	41746	67,87%									
13	81071	40243	49,64%	71182	51270	72,03%	70303	52878	75,21%	107101	84420	78,82%
	Total rate for the facade		50,93%	Total rate for the facade		69,99%	Total rate for the facade		70,31%	Total rate for the facade		75,32%
	Total rate for the building 66,64%											

Table 0.11. *Winter results of KGK*

FLOOR	SOUTH														
	A			B			C			D			E		
	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate
1	14651	8565	58,46%	19978	9573	47,92%	43480	32689	75,18%	22695	22695	100,00%	18875	18875	100,00%
2	14455	8270	57,21%	19714	12564	63,73%	43309	31471	72,67%	22783	4553	19,98%	18790	16753	89,16%
3	14496	7263	50,10%	19193	9359	48,76%	41795	17796	42,58%	21954	14140	64,41%	18652	6108	32,75%
4	-	-	-	19118	14409	75,37%	41744	25116	60,17%	21790	16028	73,56%	-	-	-
5	-	-	-	19015	7872	41,40%	41744	17033	40,80%	21916	19983	91,18%	-	-	-
6	-	-	-	18676	11514	61,65%	41054	28879	70,34%	21592	7500	34,74%	-	-	-
7	-	-	-	18683	8422	45,08%	40800	17341	42,50%	21324	6010	28,18%	-	-	-
8	-	-	-	18070	9264	51,27%	39837	26942	67,63%	21028	20327	96,67%	-	-	-
9	-	-	-	18242	12644	69,31%	39825	31893	80,08%	20823	16496	79,22%	-	-	-
10	-	-	-	18075	11421	63,19%	39477	12790	32,40%	20658	8688	42,06%	-	-	-
11	-	-	-	17290	14458	83,62%	38032	14033	36,90%	20053	20053	100,00%	-	-	-
12	-	-	-	17066	4868	28,52%	37993	25625	67,45%	20281	0	0,00%	-	-	-
13	-	-	-	16949	14925	88,06%	37327	17304	46,36%	19721	4031	20,44%	-	-	-
14	-	-	-	16830	15207	90,36%	36938	24528	66,40%	19454	19454	100,00%	-	-	-
15	-	-	-	17342	5501	31,72%	38330	12136	31,66%	20338	5867	28,85%	-	-	-
16	-	-	-	4020	1093	27,19%	38768	17936	46,26%	5283	2148	40,66%	-	-	-
		Total rate	55,26%		Total rate	57,32%		Total rate	54,96%		Total rate	57,50%		Total rate	73,97%
	Total rate for the facade					55,85%									
	Total rate for the building 57,89%														

FLOOR	EAST									WEST								
	A			B			C			A			B			C		
	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate
1										46957	22767	48,48%	46076	24634	53,46%	8984	8984	100,00%
2				23435	15097	64,42%	23545	9354	39,73%	44091	35332	80,13%	43455	28147	64,77%	8505	5510	64,79%
3				23065	13684	59,33%	23013	6172	26,82%	42043	16705	39,73%	41967	12907	30,76%	8062	8062	100,00%
4	5195	5195	100,00%													7553	7553	100,00%
5	5428	5428	100,00%	18981	11651	61,38%	18777	6950	37,01%	31572	5679	17,99%	30898	14304	46,29%	8167	3484	42,66%
6	5353	2205	41,19%	18637	6117	32,82%	18446	7649	41,47%	26379	16321	61,87%	25787	12654	49,07%	7677	7677	100,00%
7	5223	0	0,00%	18096	6292	34,77%	17906	2351	13,13%	24709	10157	41,11%	23986	18477	77,03%	7180	4762	66,32%
8	5194	5194	100,00%	17904	14033	78,38%	17708	4512	25,48%	22798	13190	57,86%	22441	12023	53,58%	6612	4220	63,82%
9	5145	0	0,00%	17577	10693	60,84%	17276	7286	42,17%	21155	11075	52,35%	20762	17608	84,81%	6083	2392	39,32%
10	4979	2109	42,36%	17061	6981	40,92%	16955	10044	59,24%	19680	6467	32,86%	19152	9334	48,74%	5520	3520	63,77%
11	4906	4906	100,00%	16714	16032	95,92%	16583	16583	100,00%	18251	11047	60,53%	17953	12924	71,99%	5211	3323	63,77%
12	4819	2622	54,41%	16336	4177	25,57%	16198	5603	34,59%	17033	17033	100,00%	16756	0	0,00%	4837	4837	100,00%
13	4737	4737	100,00%	16014	6877	42,94%	15922	8461	53,14%	15910	8855	55,66%	15613	9867	63,20%	4652	4652	100,00%
14	4689	4689	100,00%	15739	13569	86,21%	15588	14683	94,19%	14914	9234	61,91%	14674	13553	92,36%	4279	4279	100,00%
15	4950	1406	28,40%	16534	6268	37,91%	16338	6797	41,60%	14412	4105	28,48%	14418	6206	43,04%	4270	1566	36,67%
16																		
		Total rate	63,86%		Total rate	55,49%		Total rate	46,81%		Total rate	52,78%		Total rate	55,65%		Total rate	78,89%
	Total rate for the facade				55,39%					Total rate for the facade					62,44%			

Table 0.12. *Summer results of KGK*

FLOOR	SOUTH														
	A			B			C			D			E		
	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate
1	24313	12599	51,82%	28692	19549	68,13%	53755	31454	58,51%	24097	24097	100,00%	16880	12548	74,34%
2	23622	16834	71,26%	28811	11887	41,26%	53247	35326	66,34%	23565	5513	23,39%	16561	3200	19,32%
3	23532	14627	62,16%	28026	5554	19,82%	51677	13993	27,08%	22837	10181	44,58%	16259	10244	63,01%
4	-	-	-	27041	18555	68,62%	50028	29712	59,39%	22204	19660	88,54%	-	-	-
5	-	-	-	26090	10467	40,12%	48023	18125	37,74%	21223	9580	45,14%	-	-	-
6	-	-	-	25303	11678	46,15%	46816	31018	66,26%	20819	20819	100,00%	-	-	-
7	-	-	-	24868	19035	76,54%	45884	20825	45,39%	20366	6546	32,14%	-	-	-
8	-	-	-	24560	16601	67,59%	45594	28647	62,83%	20383	17104	83,91%	-	-	-
9	-	-	-	23726	13865	58,44%	44034	33401	75,85%	19698	17785	90,29%	-	-	-
10	-	-	-	22556	13121	58,17%	42297	8394	19,85%	19137	0	0,00%	-	-	-
11	-	-	-	22301	17090	76,63%	41427	19498	47,07%	18585	14826	79,77%	-	-	-
12	-	-	-	21739	0	0,00%	39988	5074	12,69%	17776	0	0,00%	-	-	-
13	-	-	-	21308	21308	100,00%	39723	21301	53,62%	17917	17917	100,00%	-	-	-
14	-	-	-	20516	15057	73,39%	38727	23098	59,64%	17702	14748	83,31%	-	-	-
15	-	-	-	20806	6904	33,18%	39345	12975	32,98%	18034	6206	34,41%	-	-	-
16	-	-	-	5212	2368	45,43%	40052	17346	43,31%	4039	1672	41,40%	-	-	-
	Total rate		61,75%	Total rate		54,59%	Total rate		48,03%	Total rate		59,18%	Total rate		52,22%
	Total rate for the facade					55,16%									
	Total rate for the building 65,96%														

FLOOR	EAST									WEST								
	A			B			C			A			B			C		
	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate
1										39449	39449	100,00%	41847	22083	52,77%	9749	6246	
2				28162	28162	100,00%	26692	15719	58,89%	38132	38132	100,00%	40263	31835	79,07%	9452	6027	63,76%
3				27924	17825	63,83%	26219	10511	40,09%	36045	8230	22,83%	38293	17422	45,50%	9117	9117	100,00%
4	7426	7426	100,00%													8704	6826	78,42%
5	7488	7488	100,00%	24245	14694	60,61%	22944	9396	40,95%	26339	9376	35,60%	27609	11745	42,54%	8210	3427	41,74%
6	7553	7553	100,00%	24180	20460	84,62%	22658	5277	23,29%	24762	19930	80,49%	26088	20037	76,81%	7915	7915	100,00%
7	7443	2684	36,06%	23867	12574	52,68%	22554	12874	57,08%	24091	16585	68,84%	25199	20600	81,75%	7644	7644	100,00%
8	7318	7318	100,00%	23181	18153	78,31%	21661	9704	44,80%	23436	20905	89,20%	24591	21714	88,30%	7511	7511	100,00%
9	7186	0	0,00%	23231	14071	60,57%	22480	12826	57,06%	21946	21946	100,00%	22898	22898	100,00%	7000	7000	100,00%
10	7185	4701	65,43%	22972	8085	35,20%	22020	10133	46,02%	20547	12143	59,10%	21836	17823	81,62%	6793	4356	64,12%
11	7252	7252	100,00%	22908	21657	94,54%	21722	17688	81,43%	19727	19727	100,00%	20661	20661	100,00%	6393	6393	100,00%
12	7216	3917	54,28%	22797	0	0,00%	21750	9110	41,89%	18660	13570	72,72%	19399	5655	29,15%	5999	5999	100,00%
13	7278	7278	100,00%	22622	13039	57,64%	21217	9648	45,47%	17426	12293	70,54%	18403	12438	67,59%	5781	5781	100,00%
14	7091	7091	100,00%	22261	22261	100,00%	21309	21309	100,00%	16320	12059	73,89%	17094	17094	100,00%	5363	5363	100,00%
15	7457	7457	100,00%	23250	8276	35,60%	22177	7811	35,22%	17106	5679	33,20%	17654	6558	37,15%	5506	5506	100,00%
16																		
	Total rate		79,65%	Total rate		63,35%	Total rate		51,71%	Total rate		71,23%	Total rate		73,91%	Total rate		88,31%
	Total rate for the facade				64,90%					Total rate for the facade					77,82%			

Table 0.13. *Winter results of İlbank*

FLOOR	SOUTHWEST									NORTHWEST						SOUTHEAST					
	A			B			C			A			B			A			B		
	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate
1	23019	15183	65,96%	29890	15541	51,99%	20097	16866	83,92%	31237	14867	47,59%	35255	28264	80,17%	75341	65973	87,57%	75404	75404	100,00%
2	23862	13962	58,51%	30258	26705	88,26%	19896	17121	86,05%	30833	7457	24,19%	34994	9453	27,01%	74196	39127	52,73%	72016	38014	52,79%
3	23340	15272	65,43%	29895	20862	69,78%	19876	11785	59,29%	30726	14233	46,32%	34154	14227	41,66%	72448	37903	52,32%	70772	25935	36,65%
4	23397	8862	37,88%	30351	15434	50,85%	20438	13038	63,79%	30588	11647	38,08%	34119	0	0,00%	71801	36922	51,42%	69210	33763	48,78%
5	21574	17592	81,54%	28493	6664	23,39%	19549	5822	29,78%	30906	15170	49,08%	35156	34273	97,49%	68650	35228	51,32%	67400	14482	21,49%
6	22718	18542	81,62%	29521	16106	54,56%	19968	10109	50,63%	31017	14901	48,04%	34103	18163	53,26%	67438	44664	66,23%	65873	32089	48,71%
7	22088	15917	72,06%	28282	17556	62,07%	18879	16898	89,51%	30281	13448	44,41%	34191	17704	51,78%	65938	56694	85,98%	64126	23834	37,17%
8	21540	19316	89,68%	28387	21616	76,15%	19497	15576	79,89%	30420	17891	58,81%	34107	24964	73,19%	65691	24827	37,79%	633756	16577	2,62%
9	22552	8169	36,22%	29201	16411	56,20%	19747	4622	23,41%	29911	8124	27,16%	33505	6739	20,11%	63230	23875	37,76%	62276	32850	52,75%
10	21604	17432	80,69%	28279	15818	55,94%	19343	15303	79,11%	29255	9457	32,33%	32941	15327	46,53%	61776	41448	67,09%	60735	30923	50,91%
11	22343	15430	69,06%	28418	19299	67,91%	18926	17774	93,91%	28876	6878	23,82%	32605	19428	59,59%	60745	35547	58,52%	59056	43591	73,81%
12	21535	12439	57,76%	29376	13931	47,42%	18713	13809	73,79%	29372	10578	36,01%	33022	11621	35,19%	59313	44821	75,57%	57579	53378	92,70%
13	21491	14438	67,18%	26879	16589	61,72%	19003	14671	77,20%	29245	8973	30,68%	33012	18852	57,11%	58540	48120	82,20%	57376	34107	59,44%
14	21436	12408	57,88%	27954	4121	14,74%	19134	12235	63,94%	29678	6738	22,70%	32320	14442	44,68%	56931	22366	39,29%	55709	34454	61,85%
15	21667	19372	89,41%	26513	23848	89,95%	19178	17446	90,97%	29127	10781	37,01%	32705	26362	80,61%	56157	52817	94,05%	54780	53913	98,42%
16	20699	8747	42,26%	27104	8894	32,81%	18662	10611	56,86%	27975	23602	84,37%	32605	18274	56,05%	55087	48263	87,61%	53954	34914	64,71%
17	-	-	-	-	-	-	-	-	-	45820	36571	79,81%	-	-	-	-	-	-	111116	111116	100,00%
	Total rate		65,82%	Total rate		56,48%	Total rate		68,88%	Total rate		42,97%	Total rate		51,53%	Total rate		64,22%	Total rate		58,99%
	Total rate for the facade					63,73%				Total rate for the facade				47,25%		Total rate for the facade				61,60%	
	Total rate for the building 61,60%																				

Table 0.14. *Summer results of İlbank*

FLOOR	SOUTHWEST									NORTHWEST						SOUTHEAST					
	A			B			C			A			B			A			B		
	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate
1	31679	21669	68,40%	45767	30970	67,67%	34815	33957	97,54%	38356	16785	43,76%	42333	37706	89,07%	64884	58747	90,54%	65637	65637	100,00%
2	31506	22731	72,15%	45458	32363	71,19%	34574	28905	83,60%	36936	19355	52,40%	41581	23217	55,84%	65642	38439	58,56%	62572	42090	67,27%
3	31364	24500	78,12%	45203	31269	69,17%	34383	18674	54,31%	36513	25825	70,73%	40517	18768	46,32%	62667	43214	68,96%	60716	25191	41,49%
4	31063	15282	49,20%	44810	37885	84,55%	34156	28203	82,57%	36215	21857	60,35%	41076	14131	34,40%	61184	38537	62,99%	58238	20989	36,04%
5	30458	27166	89,19%	44094	28775	65,26%	33773	20040	59,34%	34481	11225	32,55%	38300	38300	100,00%	59466	27368	46,02%	57756	17880	30,96%
6	30002	26289	87,62%	43368	21410	49,37%	33205	24754	74,55%	33315	22866	68,64%	38221	23693	61,99%	57644	39970	69,34%	55015	28486	51,78%
7	29711	29711	100,00%	42962	27234	63,39%	32945	30848	93,63%	33449	15795	47,22%	37817	23272	61,54%	57000	39470	69,25%	54128	38496	71,12%
8	30108	28285	93,95%	43285	28098	64,91%	33038	32187	97,42%	31543	13980	44,32%	35544	27149	76,38%	55060	46516	84,48%	52205	48758	93,40%
9	29712	18866	63,50%	43622	30773	70,54%	34046	18547	54,48%	31661	16708	52,77%	35232	26214	74,40%	54074	21984	40,66%	51444	37342	72,59%
10	28423	19313	67,95%	40620	25423	62,59%	30888	30888	100,00%	31351	8949	28,54%	35740	20839	58,31%	51319	39628	77,22%	48589	29043	59,77%
11	28503	23266	81,63%	41045	37654	91,74%	31494	29724	94,38%	30458	18929	62,15%	34285	20722	60,44%	50886	44952	88,34%	48078	37084	77,13%
12	28436	21475	75,52%	40990	33513	81,76%	31523	22874	72,56%	29726	17082	57,46%	33474	14843	44,34%	45436	44165	97,20%	44222	44222	100,00%
13	28608	18707	65,39%	41191	25080	60,89%	31678	20887	65,94%	29174	16777	57,51%	32883	18811	57,21%	44597	36562	81,98%	42534	29338	68,98%
14	27748	13646	49,18%	39919	17335	43,43%	30711	6263	20,39%	29253	11373	38,88%	33219	15605	46,98%	45230	34182	75,57%	42183	18147	43,02%
15	27760	27760	100,00%	39845	39845	100,00%	30620	30620	100,00%	27755	15355	55,32%	31650	28650	90,52%	42978	38373	89,29%	40912	40912	100,00%
16	26879	11820	43,97%	38765	12461	32,14%	29972	18150	60,56%	29225	22803	78,03%	32162	19297	60,00%	41203	38822	94,22%	40339	33416	82,84%
17	-	-	-	-	-	-	-	-	-	43530	33055	75,94%	-	-	-	-	-	-	54988	54988	100,00%
	Total rate		74,11%	Total rate		67,41%	Total rate		75,70%	Total rate		54,50%	Total rate		63,61%	Total rate		74,66%	Total rate		70,38%
	Total rate for the facade				72,41%		Total rate for the facade						59,06%			Total rate for the facade				72,52%	
	Total rate for the building 67,99%																				

Table 0.15. *Winter results of Farilya*

FLOOR	NORTHWEST														
	A			B			C			D			E		
	Total	Closed	Rate	Total	Closed	Rate	Total	Closed	Rate	Total	Closed	Rate	Total	Closed	Rate
1	8181	1905	23,29%	8044	3231	40,17%	20465	12317	60,19%	7515	3731	49,65%	7475	7475	100,00%
2	8178	4014	49,08%	7990	3257	40,76%	20162	8629	42,80%	7360	1354	18,40%	7269	4075	56,06%
3	6413	6413	100,00%	6287	1159	18,43%	15968	5356	33,54%	5880	5880	100,00%	5825	5825	100,00%
4	7338	3383	46,10%	7188	3249	45,20%	18269	8189	44,82%	6748	5867	86,94%	6675	5902	88,42%
5	7239	5302	73,24%	7079	0	0,00%	17973	0	0,00%	6647	0	0,00%	6560	0	0,00%
6	5774	5774	100,00%	5637	3508	62,23%	14299	8527	59,63%	5294	741	14,00%	5214	2389	45,82%
7	6412	3040	47,41%	6316	0	0,00%	16262	3046	18,73%	6126	2563	41,84%	6083	2391	39,31%
8	6432	2320	36,07%	6324	2327	36,80%	16260	6361	39,12%	6131	2604	42,47%	6073	3586	59,05%
9	X	X	X	X	X	X	12681	0	0,00%	4782	0	0,00%	4724	0	0,00%
10	4770	1274	26,71%	5611	2267	40,40%	14579	4611	31,63%	5555	1415	25,47%	4252	1193	28,06%
11	-	-	-	5756	1570	27,28%	14694	3982	27,10%	5576	2444	43,83%	-	-	-
12	-	-	-	4433	0	0,00%	11399	4882	42,83%	4410	1795	40,70%	-	-	-
13	-	-	-	-	-	-	12921	9002	69,67%	-	-	-	-	-	-
14	-	-	-	-	-	-	10707	5214	48,70%	-	-	-	-	-	-
		Total rate	55,77%		Total rate	28,30%		Total rate	37,05%		Total rate	38,61%		Total rate	51,67%
	Total rate for the facade				42,28%										

FLOOR	NORTHEAST														
	A			B			C			D			E		
	Total	Closed	Rate	Total	Closed	Rate	Total	Closed	Rate	Total	Closed	Rate	Total	Closed	Rate
1															
2	9939	3522	35,44%	10110	2080	20,57%	27896	9579	34,34%	11362	2463	21,68%	11450	6333	55,31%
3	8001	1579	19,74%	8139	0	0,00%	22425	5428	24,21%	9103	5012	55,06%	9202	5247	57,02%
4	9229	1587	17,20%	9367	1685	17,99%	25669	7894	30,75%	10341	4158	40,21%	10466	5089	48,62%
5	9043	2971	32,85%	9194	0	0,00%	25221	0	0,00%	10149	8365	82,42%	10323	7235	70,09%
6	7122	2425	34,05%	7268	2822	38,83%	20015	11750	58,71%	8070	3164	39,21%	8263	1810	21,90%
7	8165	3262	39,95%	8345	3420	40,98%	23005	3113	13,53%	9264	1156	12,48%	9538	912	9,56%
8	8126	5871	72,25%	8258	7264	87,96%	22520	14650	65,05%	8953	7027	78,49%	9192	3584	38,99%
9	6534	1489	22,79%	6643	3378	50,85%	18099	7939	43,86%	7175	0	0,00%	7392	0	0,00%
10	5907	892	15,10%	6005	0	0,00%	16330	6490	39,74%	6448	2539	39,38%	6649	923	13,88%
11															
12	6655	1956	29,39%	6958	2053	29,51%	18484	6503	35,18%	7569	1667	22,02%	7564	1612	21,31%
13				-	-	-	-	-	-	-	-	-			
14	5727	1314	22,94%	-	-	-	-	-	-	-	-	-	6453	3145	48,74%
		Total rate	31,06%		Total rate	28,67%		Total rate	34,54%		Total rate	39,09%		Total rate	35,04%
	Total rate for the facade				33,68%										

FLOOR	SOUTHEAST														
	A			B			C			D			E		
	Total	Closed	Rate	Total	Closed	Rate	Total	Closed	Rate	Total	Closed	Rate	Total	Closed	Rate
1	6287	6287	100,00%	6088	6088	100,00%	15281	8575	56,12%	5493	1510	27,49%	5361	1697	31,65%
2	5916	2298	38,84%	5797	1717	29,62%	14895	7836	52,61%	5463	5463	100,00%	5389	2036	37,78%
3	4905	2440	49,75%	4796	3215	67,04%	12344	6746	54,65%	4520	1324	29,29%	4444	0	0,00%
4	5458	1335	24,46%	5308	2781	52,39%	13638	5112	37,48%	4965	1695	34,14%	4851	1327	27,36%
5	5508	0	0,00%	5387	0	0,00%	14029	0	0,00%	5157	0	0,00%	5059	0	0,00%
6	4407	3550	80,55%	4241	2650	62,49%	10843	0	0,00%	3899	0	0,00%	3760	2647	70,40%
7	5061	2021	39,93%	4860	1993	41,01%	12459	4391	35,24%	4472	1811	40,50%	4300	2017	46,91%
8	5106	3521	68,96%	4941	2771	56,08%	12885	12295	95,42%	4690	1234	26,31%	4537	1718	37,87%
9	X	X	X	X	X	X	9692	60779	627,10%	3589	3589	100,00%	3503	3103	88,58%
10	3640	0	0,00%	4359	0	0,00%	11244	1913	17,01%	4018	4018	100,00%	3180	2555	80,35%
11	-	-	-	4300	1764	41,02%	11410	11410	100,00%	4178	4178	100,00%	-	-	-
12	-	-	-	3434	754	21,96%	8894	4425	49,75%	3169	0	0,00%	-	-	-
13	-	-	-	-	-	-	9371	9371	100,00%	-	-	-	-	-	-
14	-	-	-	-	-	-	7895	1220	15,45%	-	-	-	-	-	-
		Total rate	44,72%		Total rate	42,87%		Total rate	88,63%		Total rate	46,48%		Total rate	42,09%
	Total rate for the facade				52,96%										

FLOOR	SOUTHWEST														
	A			B			C			D			E		
	Total	Closed	Rate	Total	Closed	Rate	Total	Closed	Rate	Total	Closed	Rate	Total	Closed	Rate
1															
2	5644	5644	100,00%	6282	5179	82,44%	17448	14608	83,72%	6849	3030	44,24%	7192	2214	30,78%
3	4259	4259	100,00%	4725	2217	46,92%	13204	5278	39,97%	5195	1988	38,27%	5480	2745	50,09%
4	4971	765	15,39%	5477	2486	45,39%	15345	8836	57,58%	6027	4150	68,86%	6372	5732	89,96%
5	4984	0	0,00%	5436	0	0,00%	15175	2851	18,79%	5917	1087	18,37%	6245	1134	18,16%
6	3837	2761	71,96%	4144	1247	30,09%	11526	2548	22,11%	4461	793	17,78%	4700	4114	87,53%
7	4170	1837	44,05%	4496	1796	39,95%	12631	5369	42,51%	4917	2200	44,74%	5219	2563	49,11%
8	4263	3780	88,67%	4549	1427	31,37%	12736	7351	57,72%	4921	4921	100,00%	5214	4244	81,40%
9	X	X	X	X	X	X	9508	0	0,00%	X	X	X	X	X	X
10	2847	411	14,44%	3003	1319	43,92%	8457	2225	26,31%	3262	0	0,00%	3474	0	0,00%
11															
12															
13															
14															
		Total rate	54,31%		Total rate	40,01%		Total rate	38,75%		Total rate	41,53%		Total rate	50,88%
	Total rate for the facade				45,10%										

Total rate for the building 43,50%

Table 0.16. *Summer results of Farilya*

FLOOR	NORTHWEST														
	A			B			C			D			E		
	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate
1	7802	2659	34,08%	8375	2287	27,31%	22745	14367	63,17%	8454	5151	60,93%	8766	8766	100,00%
2	7780	4700	60,41%	8276	6528	78,88%	22470	14439	64,26%	X	X	X	X	X	X
3	6432	6432	100,00%	6806	6806	100,00%	18558	16922	91,18%	6926	6926	100,00%	7101	7101	100,00%
4	7743	3795	49,01%	8086	3886	48,06%	21919	14450	65,92%	8133	8133	100,00%	8243	7043	85,44%
5	7626	4874	63,91%	7941	3657	46,05%	21722	14324	65,94%	8132	1575	19,37%	8233	5623	68,30%
6	6358	6358	100,00%	6583	3934	59,76%	18073	12871	71,22%	6790	4559	67,14%	6844	4154	60,70%
7	7384	5446	73,75%	7589	6889	90,78%	20904	11809	56,49%	7878	0	0,00%	7898	5969	75,58%
8	7349	6590	89,67%	7525	4724	62,78%	20888	15695	75,14%	7932	7598	95,79%	7934	5942	74,89%
9	5891	3435	58,31%	5986	2807	46,89%	16628	2396	14,41%	X	X	X	X	X	X
10	5828	4371	75,00%	7310	4826	66,02%	20186	6062	30,03%	7624	2029	26,61%	6054	1767	29,19%
11	-	-	-	7114	2086	29,32%	19969	5516	27,62%	7664	1969	25,69%	-	-	-
12	-	-	-	5818	3407	58,56%	16369	9701	59,26%	6296	6296	100,00%	-	-	-
13	-	-	-	-	-	-	18906	18906	100,00%	-	-	-	-	-	-
14	-	-	-	-	-	-	15506	11459	73,90%	-	-	-	-	-	-
	Total rate		70,42%	Total rate		59,53%	Total rate		61,33%	Total rate		59,55%	Total rate		74,26%
	Total rate for the facade				**65,02%**										

FLOOR	NORTHEAST														
	A			B			C			D			E		
	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate
1															
2	13352	8421	63,07%	12986	5479	42,19%	32636	11869	36,37%	12282	7329	59,67%	12548	2524	20,11%
3	10552	7906	74,92%	10289	9086	88,31%	25878	17075	65,98%	9767	6572	67,29%	9952	6886	69,19%
4	12218	4144	33,92%	11943	2281	19,10%	30041	9570	31,86%	11369	4898	43,08%	11543	5695	49,34%
5	12249	12249	100,00%	11969	11969	100,00%	29990	0	0,00%	11333	0	0,00%	11438	9255	80,91%
6	9639	7996	82,95%	9428	7035	74,62%	23582	14581	61,83%	8915	2501	28,05%	8959	1884	21,03%
7	11293	6642	58,82%	11079	7549	68,14%	27734	12068	43,51%	10522	2141	20,35%	10541	10541	100,00%
8	11108	11108	100,00%	10903	3824	35,07%	27224	18248	67,03%	10326	6474	62,70%	10292	3674	35,70%
9	8668	2186	25,22%	8545	1913	22,39%	21407	8002	37,38%	8165	2300	28,17%	8131	1258	15,47%
10	8263	8263	100,00%	8126	8128	100,02%	20230	15913	78,66%	7683	2211	28,78%	7590	3663	48,26%
11															
12	7764	5330	68,65%	7631	3657	47,92%	19003	15534	81,74%	7171	20942	292,04%	6986	2124	30,40%
13				-	-	-	-	-	-	-	-	-			
14	6791	1163	17,13%	-	-	-	-	-	-	-	-	-	6485	3583	55,25%
	Total rate		65,88%	Total rate		59,78%	Total rate		50,44%	Total rate		63,01%	Total rate		47,79%
	Total rate for the facade				**57,38%**										

FLOOR	SOUTHEAST														
	A			B			C			D			E		
	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate
1	7713	7713	100,00%	7363	7363	100,00%	17361	15093	86,94%	5673	4237	74,69%	5498	2212	40,23%
2	X	X	X	X	X	X	16873	9223	54,66%	5545	5545	100,00%	5363	2261	42,16%
3	6212	6212	100,00%	5879	3380	57,49%	13805	8802	63,76%	4513	4513	100,00%	4324	4324	100,00%
4	6943	1909	27,50%	6534	6534	100,00%	15297	3803	24,86%	4997	2018	40,38%	4755	1626	34,20%
5	6936	0	0,00%	6559	0	0,00%	15544	0	0,00%	5153	0	0,00%	4923	0	0,00%
6	5200	5200	100,00%	4907	3735	76,12%	11647	7350	63,11%	3875	3513	90,66%	3691	3353	90,84%
7	6042	1794	29,69%	5695	4411	77,45%	13560	5864	43,24%	4537	2906	64,05%	4311	2867	66,50%
8	6090	6090	100,00%	5714	4228	73,99%	13579	10896	80,24%	4545	2229	49,04%	4293	2980	69,42%
9	X	X	X	X	X	X	10614	5364	50,54%	3578	762	21,30%	3378	864	25,58%
10	4357	2346	53,84%	5054	2930	57,97%	12054	9276	76,95%	4068	4068	100,00%	3106	3106	100,00%
11	-	-	-	5040	3740	74,21%	12005	10798	89,95%	4055	4055	100,00%	-	-	-
12	-	-	-	4072	3155	77,48%	9522	8244	86,58%	3218	2136	66,38%	-	-	-
13	-	-	-	-	-	-	10496	10496	100,00%	-	-	-	-	-	-
14	-	-	-	-	-	-	8774	0	0,00%	-	-	-	-	-	-
	Total rate		63,88%	Total rate		69,47%	Total rate		58,63%	Total rate		67,21%	Total rate		56,89%
	Total rate for the facade				**63,22%**										

FLOOR	SOUTHWEST														
	A			B			C			D			E		
	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate	Total	Curtained	Rate
1															
2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
3	7599	7599	100,00%	7965	7965	100,00%	22554	22554	100,00%	9149	9149	100,00%	9487	9487	100,00%
4	8529	8529	100,00%	9001	9001	100,00%	25773	25773	100,00%	10529	10529	100,00%	11015	11015	100,00%
5	8230	3719	45,19%	8681	3707	42,70%	24853	9275	37,32%	10113	8197	81,05%	10594	5243	49,49%
6	6335	6335	100,00%	6701	3828	57,13%	19280	11137	57,76%	7856	7188	91,50%	8266	6798	82,24%
7	7190	5974	83,09%	7625	1600	20,98%	22031	18233	82,76%	8978	8165	90,94%	9487	4741	49,97%
8	7282	7282	100,00%	7659	2094	27,34%	21875	14610	66,79%	8781	0	0,00%	9221	6800	73,74%
9	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
10	4994	1890	37,85%	5257	5257	100,00%	15050	7660	50,90%	6011	2395	39,84%	6339	2793	44,06%
11															
12															
13															
14															
	Total rate		80,87%	Total rate		64,02%	Total rate		70,79%	Total rate		71,91%	Total rate		71,36%
	Total rate for the facade				**71,79%**										

Total rate of the building 64,35%

C. Photographs for Fall, Winter, Spring and Summer Seasons

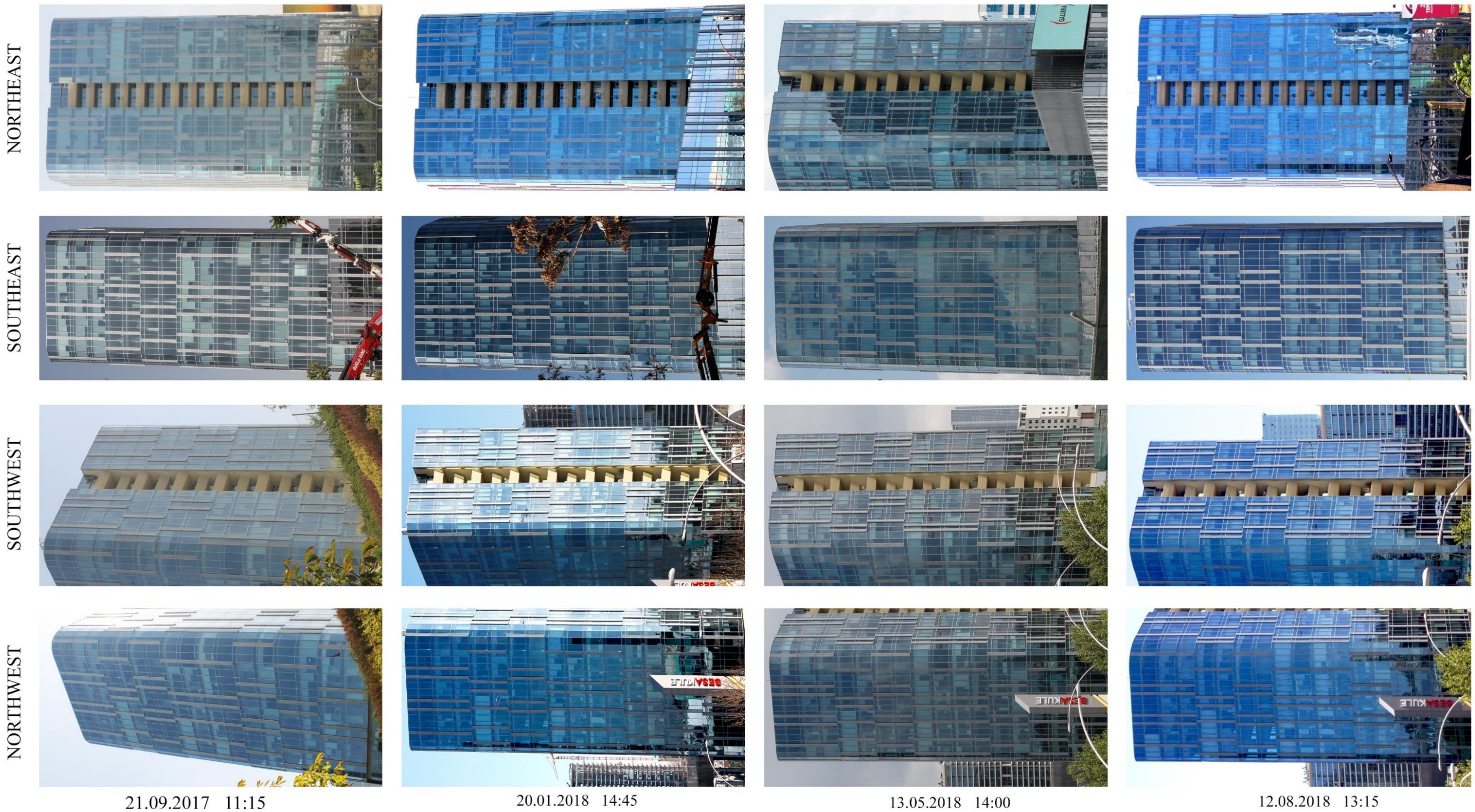
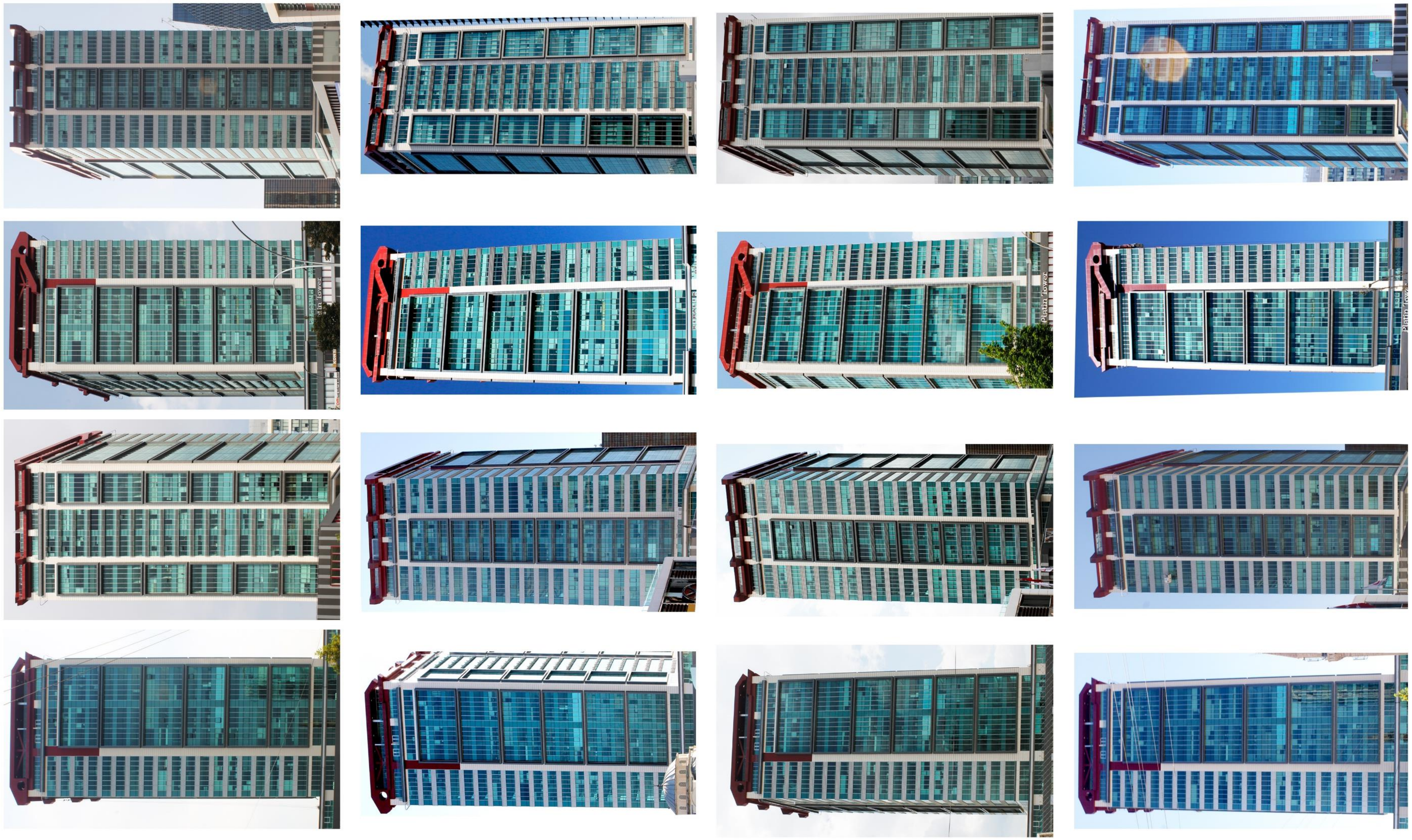


Figure 0.8. Photographs of Besa Kule

NORTHEAST
SOUTHEAST
SOUTHWEST
NORTHWEST

23.09.2017 15:15
20.01.2018 14:45
13.05.2018 14:00
12.08.2018 13:15

Figure 0.9. Photographs of Via Twins



EAST
SOUTH
WEST
NORTH

19.09.2017 15:30 | 20.01.2018 14:45 | 13.05.2018 14:00 | 12.08.2018 13:15

Figure 0.10. Photographs of Platin Tower

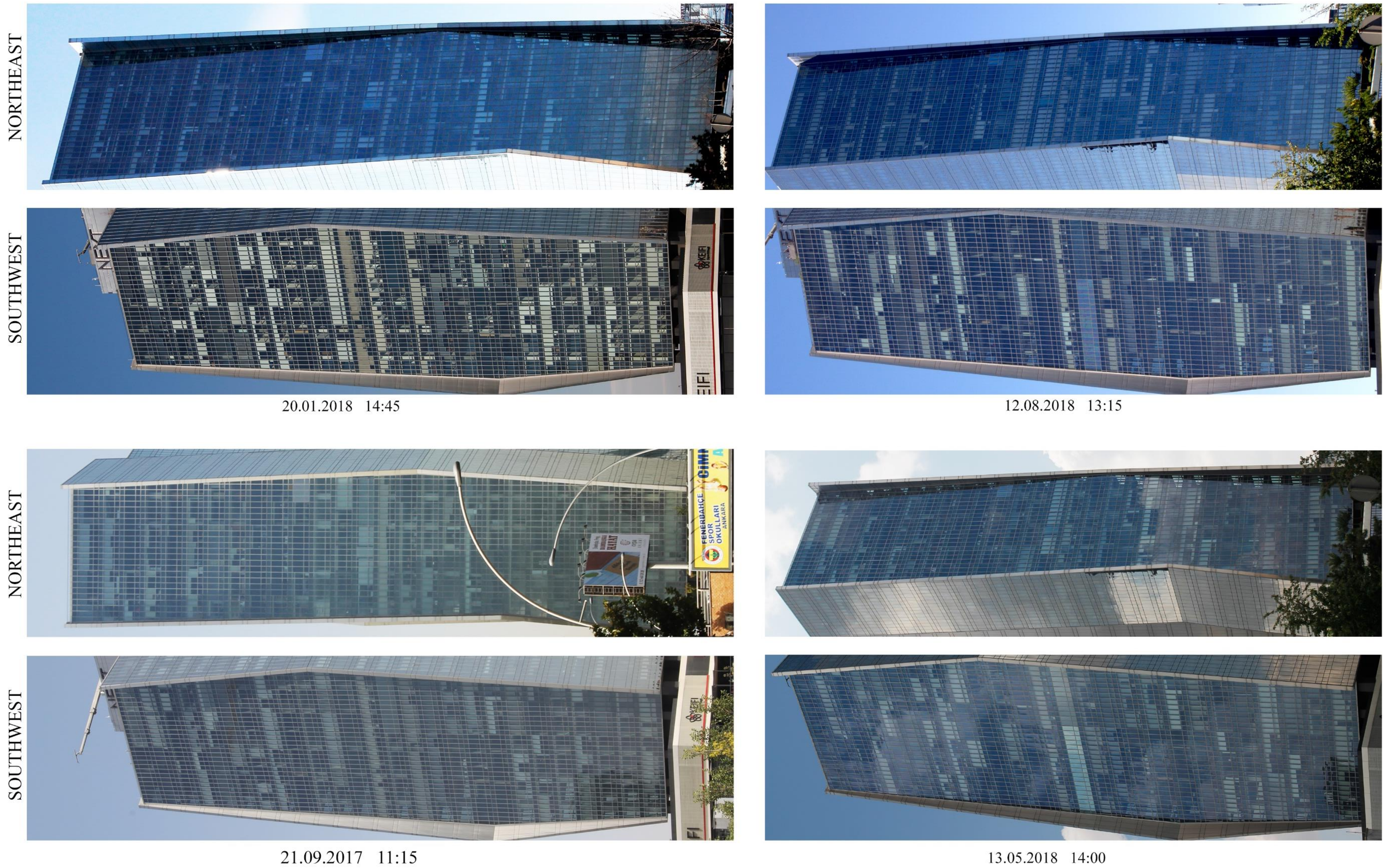


Figure 0.11. Photographs of Next Level

Figure 0.12. Photographs of ITCK

EAST

SOUTH

WEST

19.09.2017 15:30 | 20.01.2018 14:45 | 13.05.2018 14:00 | 12.08.2018 13:15

Figure 0.13. Photographs of KGK

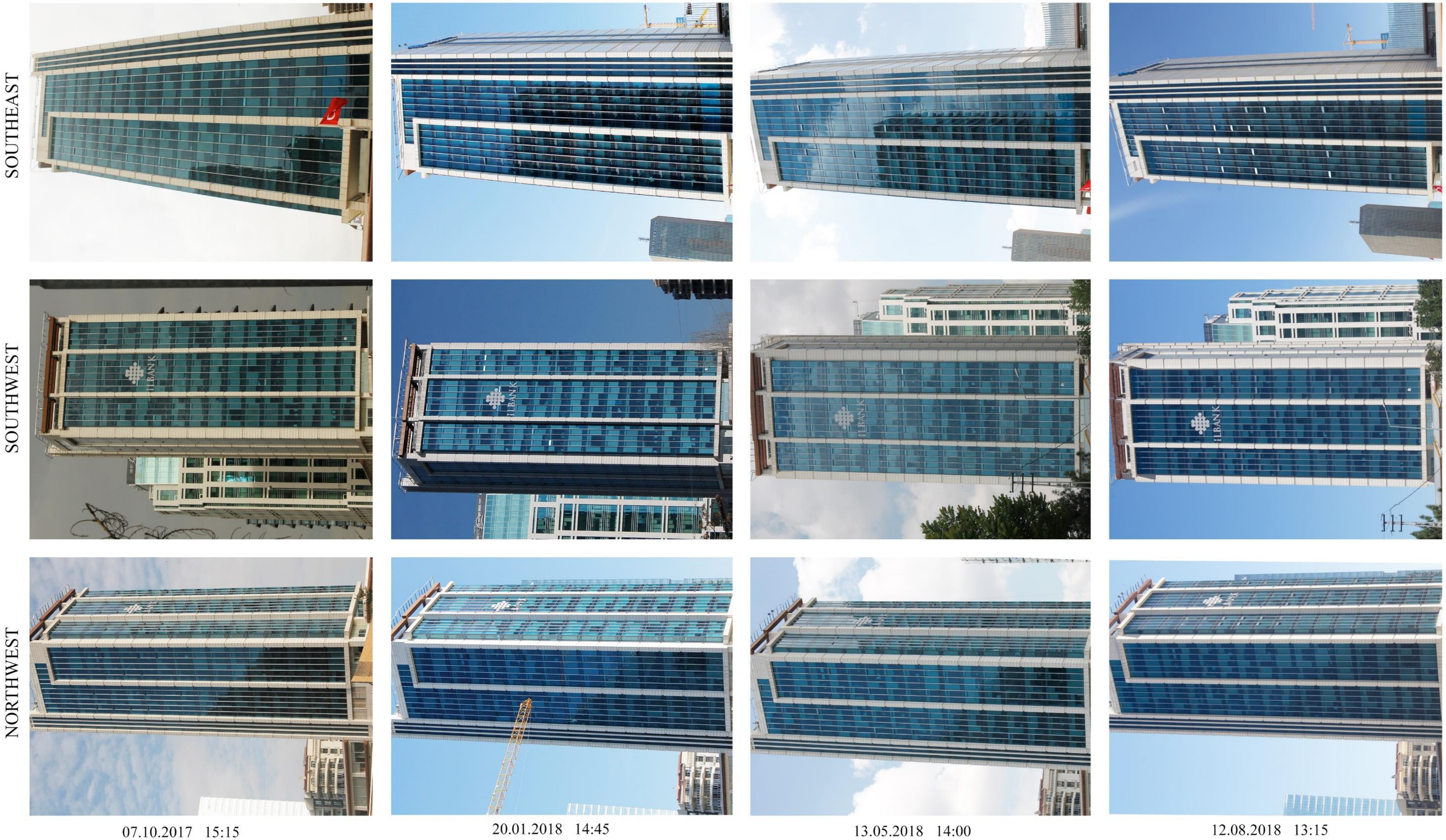


Figure 0.14. Photographs of Ilbank

Figure 0.15. Photographs of Farilya