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Positioning of Buildings According to the Optimal Benefit from the Sun in the Sustainable Design of Housing Areas

Konut Alanlarının Sürdürülebilir Tasarımında Yapıların Güneşten Optimum Yararlanmasına Göre Konumlandırılması

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ABSTRACT:

If environmental design is viewed in the terms of sustainability, as in all sectors the basic factors of sustainable thinking such as economy, nature conservation, saving and effective use of energy come to the forefront. The solutions for the design of buildings and settlements based on these sustainability factors unite with the goal of *maximum use of the sun*. In this regard, when designing residential areas, it is essential to understand the maximum benefit from the sun that can apply to each dwelling. First of all, in residential areas, the positioning of the dwellings on the site plan is the most effective primary step to reduce and increase the natural impact of the sun on the buildings. Utilization of solar energy with effective and active methods in the design of residential buildings, depends on taking this first step correctly. The aim of this article is to evaluate the passive effect of the sun on the positioning of houses and blocks of flats in the design of residential areas. Therefore, in thise article; The relationships between design parameters regarding the optimal utilization of passive effect of the sun as orientation of the buildings, the sun shine duration, the distances between the buildings and the slope of the terrain have been firstly held. Then a selected pilot residential area has been evaluated with regard to these parameters.

KEYWORDS: Utilization of Sun, Positioning of Buildings, Orientation to the Sun, Solar Control

ÖZ:

Çevre tasarımı, sürdürülebilirlik açısından ele alındığında, her dalda olduğu gibi ekonomi, doğanın korunması, enerjinin tasarrufu ve etkin kullanımı gibi sürdürülebilir yaklaşımın temel faktörleri ön plana çıkmaktadır. Gerek bina gerekse yerleşimlerin, söz konusu sürdürülebilirlik faktörlerine dayalı tasarımlarına yönelik çözümler, *güneşten maksimum yararlanma* amacında birleşmektedir. Bu bağlamda, konut alanlarının tasarımında da her bir konut için geçerli olabilen güneşten maksimum yararlanma anlayışı kaçınılmazdır. Konut alanlarında her şeyden önce, konut yapılarının vaziyet planı üzerindeki konumlanması, güneşin yapılara olan doğal etkisinin azaltıp, çoğalmasında en etkin birincil adımdır. Konutların tasarımındaki güneş enerjisinden etkin ve aktif yöntemlerle yararlanma ise, bu birincil adımın doğru atılmasına bağlıdır. Bu yazının amacı, konut alanları tasarımındaki konutların ve konut bloklarının konumlandırılmasında güneşin pasif etkisinin değerlendirilmesidir. Bu amaçla, yazıda önce; yapıların yönlendirilmesi, güneşlenme süreleri, yapılar arasındaki mesafeler ve arazinin eğimi olarak belirtilen güneşin pasif etkisinden optimum yararlanmaya yönelik tasarım parametreleri arasındaki ilişkiler ortaya konmaktadır. Daha sonra seçilen bir pilot konut bölgesinin bu parametreler açısından değerlendirilmesi yapılmaktadır.

Anahtar Kelimeler: *Güneşten Yararlanma, Binaların Konumlandırılması, Güneşe Yönlenme, Güneş Kontrolu*

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INTRODUCTION:

In the process of globalization, which is viewed as an economic, cultural and political integration process (Ney., Donahue. 2000), the impact of energy consumption varies from country to country, depending on the level of development of each country, but it shows that energy consumption will be shifted in the long term with globalization (Oluç., Güzel. 2021). Considering the economic and environmental damage caused by high energy consumption on a global scale under these conditions, energy saving is an important part of building design criteria. Sustainable environmental design approaches such as energy efficient structures, ecological structures, zero energy structures, etc. have led to the development of active and passive approaches to harnessing solar energy. These designs, developed with the aim of using solar energy effectively, are determined according to parameters such as climate, topography, location, orientation of buildings, distance between buildings, building envelope and location of buildings. In addition to these parameters, the use of the sun is optimized by taking the spatial arrangement, construction methods, material selection, thermal comfort conditions and relationships with neighboring buildings when planning the building in to account (Bayır, Kasapseçkin, Karaçar., Gümer. Benli, 2022). These approaches developed to harvest energy from the sun are categorized into active solar systems such as solar cells, solar collectors, and passive solar systems such as large-scale sun-facing areas of glass and the creation of conservatories. (Demircan, Gültekin. 2017). In this study, the building positioning and the sunning distances between the buildings considered within the framework of passive systems are examined and the necessary distances are determined in order to optimally use the sun on the residential areas located on the hillside property. When aligning buildings during the design of residential areas, wind, landscape, aspect and sun factors, which are essential for the orientation of the buildings, are evaluated. The optimal orientation of housing is the situation when the appropriate directions for each factor overlap. However, the topographical conditions in terms of slope and orientation in the residential area, the prevailing wind direction or the landscape view direction can conflict with each other. For example, in an area with strong northerly visibility in the northern hemisphere, it can be difficult to orientate the buildings by the sun. It can also be discussed which factor gains importance in the orientation of the houses in an area whose slope direction is not suitable for the direction of the sun. This article focuses on the importance of the sun in designing sustainable residential areas. Therefore, as the goal of maximizing the benefit of the sun gains importance in sustainable positioning, the selection of land surfaces that can overlap in terms of orientation factors also gains importance. If the choice of land is appropriate in this sense, the parameters for maximum solar benefit become more important. In this case, the design steps of sustainable residential areas can be determined depending on these parameters.

1. Design Parameters for Maximum Sun Benefits

In order to benefit from the sun during planning, the relationships of the volumes and buildings to the sun is first taken into account. Taking these relationships into account, it should be planned to evaluate the design parameters such as "sunshine durations", "distances between buildings" and "land slope". These parameters are explained in the following sections for the maximum use of the sun for buildings.

1.1. Sunshine Durations

Sunshine durations are of great importance in terms of providing the heating requirement with the "direct gain systems", which are the most widely used in passive solar architecture (Smil, 2008). Because it is obvious that windows, walls, or all glass surfaces, including the roof, that allow solar radiation to directly enter the volume to be heated, must face to the sun. Therefore, the energy gain in both the storage of solar energy and its immediate direct use depends on the adequacy of the average annual sunshine duration to be obtained from the sun-facing surfaces of the buildings (Roaf, Fuentes, Thomas, 2004).

In addition, the life and protection of plants used in various combinations in buildings to take advantage of the benefits of plants also requires optimization of the total solar radiation received by the building throughout the year, and therefore the sun exposure times (Karagüler (Türkpençe), 1994).

Sunshine durations vary by season, hours, and orientation of buildings or volumes, based on the region's location on Earth (Anon, 2018). Therefore, in architecture; Sun masks are used to determine annual sunshine durations. These masks are prepared separately for each latitude. By using these masks; In today's world, where the importance of sustainable understanding has increased, "solar movement studies" are now carried out regarding the latitude of the project location in solar architectural design works that minimize energy (Guzowski, 2017). For the 400 latitudes where this study area is located, “sun masks”, the example of which can be seen in Figure 1, were used (Berköz, 1973). The sunshine durations mentioned in this article are considered to be the entry times of the sun's rays into the building volume average daily throughout the year. Therefore, the sun masks utilized are used separately according to the direction of each volume in a building, revealing the different annual sunshine durations for each volume. For this reason, the determination of the year-round average daily sunshine duration of the most used volume can be used as a basis for the general orientation of the building (Türkpençe, 1979). In the study, the most used volume for individual dwellings and apartments of flats is assessed by assuming the livingroom.

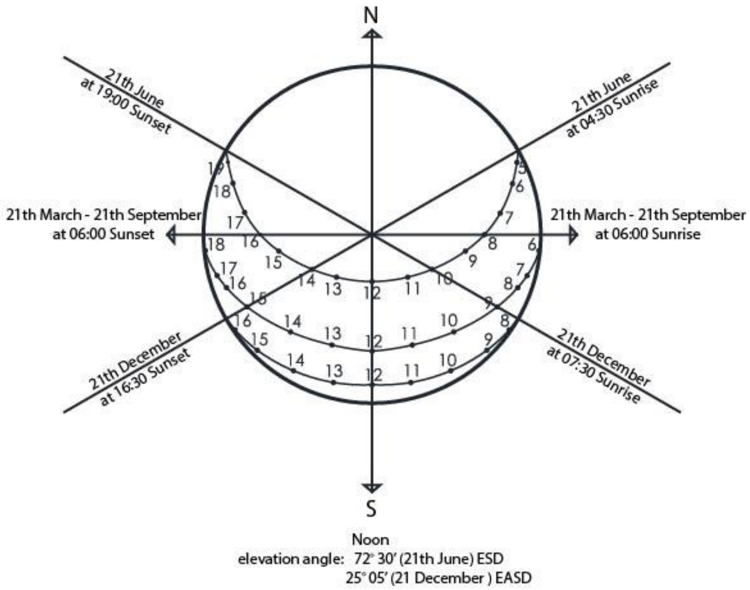

Figure 1. Sun Orbit Diagram (mask) at latitude 40° (Berköz, 1973).

By the help of a sun mask, the average sunshine durations of the shortest day in winter, the longest day in summer and at equinoxes in the living room of a house can be taken as the *average daily sunshine duration throughout the year* (Türkpençe. 1979). In this case, these sunshine durations can be specified separately for each house or apartment of flats with differently oriented living volumes in the residential area planning. The number of residences facing the same direction and the average daily sunshine duration throughout the year for that direction are multiplied. This process is calculate separately for each direction and the number of residences. By dividing the total of them to the total number of residences, the average year-round daily sunshine duration of that residential area can be determined. The evaluation of this average time is made in the following sections along with other design parameters.

1.2. Distances Between Buildings

When planning residential areas, the distances between the buildings should be changed depending on the building height so that the solar radiation is used to the maximum (Zeren. 1978). This change can be seen in Figure 2. The receive ability the sun's rays in the direction that building faced for each floor of it, depends on whether it is not blocked by the other building in the same direction. In this case, the distances between buildings should be adjusted so that they do not block the sun's rays. Otherwise, although the facades of the most used volumes of the houses are oriented to make the most of the sun's rays, the average hours of sunshine given in the section, 2.1. cannot be achieved. To a certain extent, this situation coincides with the longest distance of shadow that the obstacle can leave behind the building (Çalışkan, Manioğlu, Akşit, 2014).

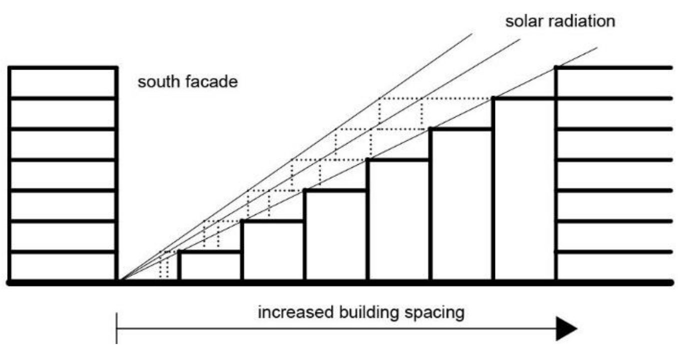

Figure 2. Variation in sun access distances between buildings based on Obstacle Building Height (Türkpençe, 1979).

1.3. Slope of the Land

Distances between buildings Section 2-2 (Figure 10) As mentioned above, the distance between blocks pointing in the same direction in flat land (slope = 00) changes depending on the angle of rise of the winter sun at noon when it comes to sloped land. Analyzing this change for 40 degrees of latitude, it can be formulated using the expression in Figure 4.

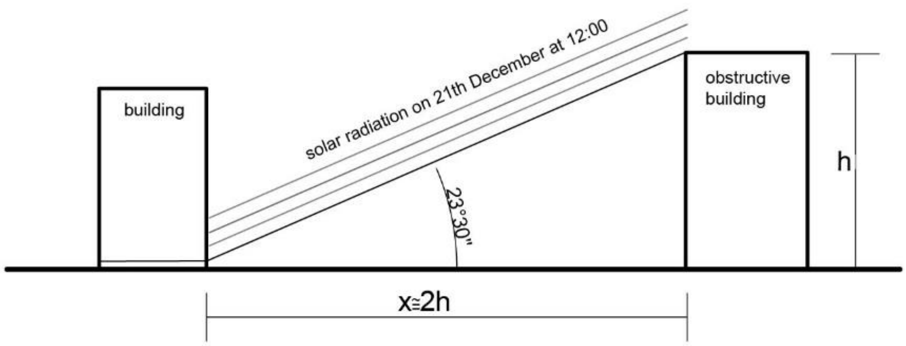

Figure 3. Variation in distances between buildings where the midday sun is not blocked in cold season at 40 degrees north latitude at tilt = 0, according to the height of the blocking building (Drawn by authors)

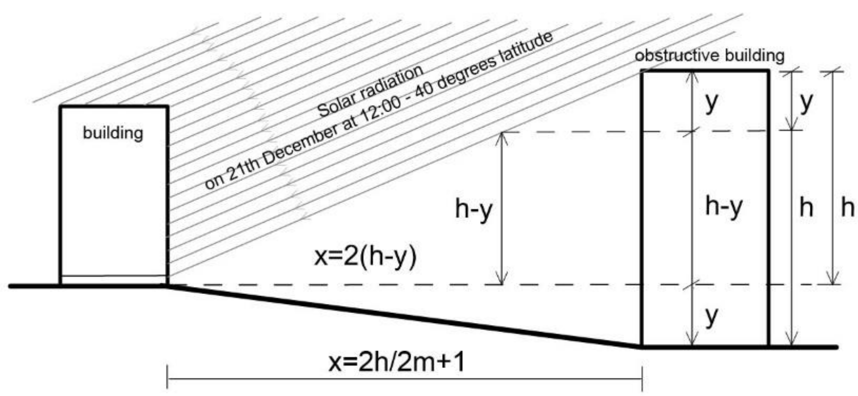

Figure 4. Variation and decrease of the distances between buildings where the noon sun is not blocked in winter at 400 North Latitude according to different values of the slope (m) on sloping land (Drawn by authors)

As can be seen in Figure 3, the angle of rise of the noon sun at the 400 latitudes on December 21st is 23° 30'. If the slope of the land is 0 (m = 0), the distance (x) between the two blocks must be twice the height (h) of the other block in the direction of sunlight, so that the lowest floor of a block can receive sunlight according to this angle. If the land is sloping, the following equations can be written according to the drawing in Figure 4.

While (m=0): x=2h, y=0

In m>0 ….values:

x=2(h-y) …………….(1)

m=y/x , y=mx…….(2)

x=2(h-mx)………….(3)

From formulas (1), (2) and (3)

X=2h/2m+1……….(4) formula a can be written

According to the formula 4, the distance (x) between the buildings for different land slopes can be calculated, the following values can be found, and the graph showing the curve x=2h/2m+1 in Figure 5 can be drawn according to these values.

m=y/x

while m=0, x=2h

while m>0 , x=2h/2m+1

if m=%10, x=≈1,6h

if m=%15, x≈1,4h

if m=%30, x≈1,25h …….Depending on the inclination, the distances between the buildings that should be suitable for the incidence of sunlight can be calculated in the form of obstacle building heights.

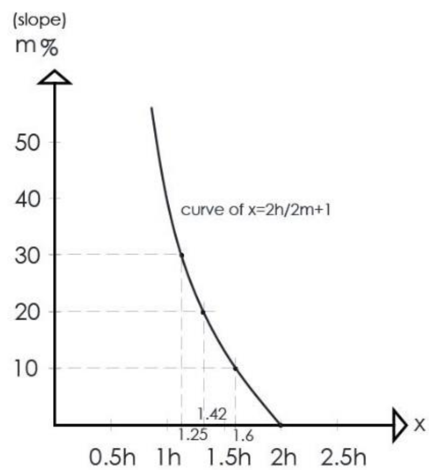

Figure 5. Curve of variation of distances between buildings in terms of obstacle building height, decreasing at different land slopes (Drawn by authors)

The distances between buildings will decrease as the slope increases if the land is sloping. This decrease is seen in the curvilinear graph in Figure 5, where the distances (x) between buildings on sloping lands are expressed in terms of the height of the building (h) that prevents sunlight. When planning a residential area, the greatest possible benefit from the sun can be achieved if the distances between the houses or apartments of flats, which are based on the sunshine duration mentioned in Section 2.1, are designed according to the land slope. In other words, unless these distances are specified as necessary, placing the blocks in a position appropriate for the sunshine duration does not make sense in terms of maximizing the benefit of the sun.

One of the world's first energy conservation projects, "Solar Community" planning in Freiburg was completed in 2006. This passive and ecological project was built at the residential area settlement scale, and its most used volumes are positioned to face the southerly directions, where the sun is used the most. The distances between residential buildings are also kept at a sufficient level to allow direct sunlight to be taken. In this way, it is stated that the primary energy consumption of all houses in the settlement has decreased to significant values (Voss., Musall. 2013).

2. Evaluation of the Parameters with Regard to the Optimal Direction

When planning a residential area, the direction of the living rooms of the houses is very important, in terms of arranging the orientation convenient for passively benefitting from the sun. This direction is the direction that ensures the blocks receive minimum total solar radiation during the hottest period and maximum solar radiation during the least hot period of the year and is considered the optimal direction (6). The optimal direction is different for each latitude. For a residential layout at latitude 40° (temperate zone), where this study was conducted, the optimal direction is 10° east from south, which receives the most total solar radiation in winter and the least in summer (6), as can be seen in the graph in figure 6. This direction is the direction in which 85% of the total annual solar radiation received by a building is received (11 Bolak. 1967). In other words. For the temperate zone, the term "maximum solar use" is synonymous with "optimal solar use". The determination of the year-round sunshine duration of a facade in optimal orientation from the "Solar Orbit Diagram" of the 40th parallel is shown in Figure 7.

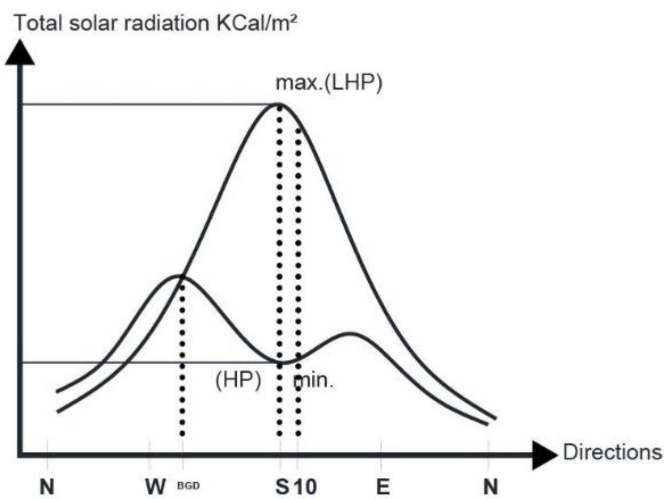

Figure 6. Determination of the optimal direction in the cyclic distribution of total solar radiation according to the directions at the 40th degree of north latitude (Olgyay, 1963).

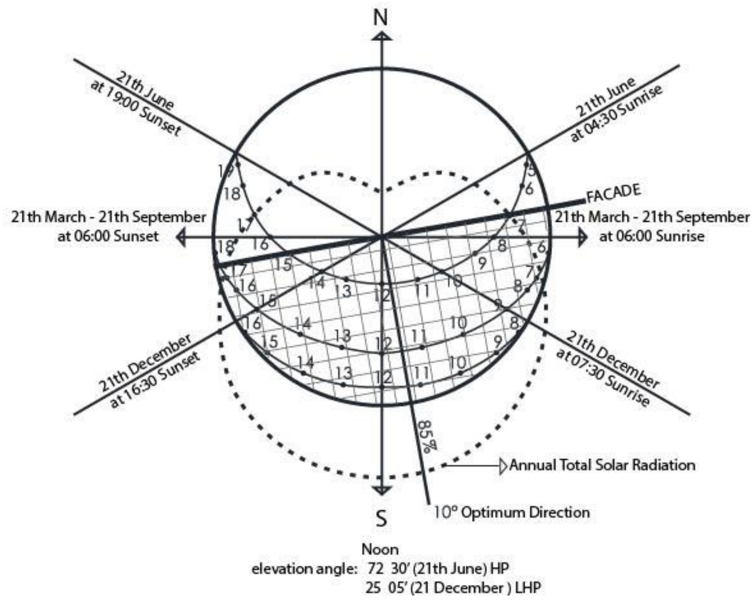

Figure 7. Diagram of the solar orbit showing the year-round average daily sunshine duration in the optimal direction at latitude 40°N (Berköz, 1973).

In the light of the above explanations, it was concluded that if the most used volumes of the residential blocks face the optimum or near-optimal directions, the distances between the buildings are correct and the slope of the land can be adjusted appropriately, the sun will be utilized at the maximum level. If Fig. 6 is examined, showing the year-round sunshine status of the daily living volumes pointing in the optimal direction, it can be seen that the annual mean sunshine duration for the optimal direction at latitude 40° is about 9 hours. In this case, a comparison can be made of the "average year-round daily sunshine durations" of all dwellings in the residential area referred to in Section 2.1 with the average daily sunshine durations of the year-round optimum direction.

3. Design Steps to Make the Best Use of the Sun When Designing a Sustainable Residential Area

With the background of the above sections, it is important to follow the steps listed below when planning a sustainable residential area based on solar use:

- Regarding the suitability of the orientation of the flat blocks, choosing a residential area that coincides as much as possible with the direction of the settlement where the sun is best utilized, the prevailing wind direction, the direction that provides natural ventilation, the dominant landscape direction and the slope direction (direction perpendicular to the slope).

- Designing the most used living areas of the residential blocks in such a way that they face the optimum sun direction of the latitude of the region or in the directions close to it.

- Determining the distances between the sun-facing blocks of flats to allow each floor to receive the midday sun in LHP.

- When the land is sloping; reworking the distances between houses, taking into account the decrease in the slope ratio.

- Determination of the directions of the most used volumes (living volumes) resulting from the positioning of all houses in the planning area.

- Calculation of annual average day long sunshine durations for each of the specified directions.

• The number of all residences with the most used volumes facing the same direction, multiplied by the annual average day long sunshine duration of that direction, to find the total annual day long average sunshine durations pertaining to that direction.

• Adding the total annual day long sunshine duration for each direction and dividing it by the total number of residences in the planning area.

• Evaluation of the annual average day long sunshine duration of the entire residential area by comparing it with the annual average day long sunshine duration of the optimum direction.

4. A Case Study

In this section, an exemplary application area, the site plan of which is shown in Figure 8 and the field cross-sections in Figures 9,10 is examined with regard to positioning for optimal solar yield. To do this, first the distances between the buildings and then the sunshine durations have been calculated and compared according to the required values.

Figure 8. An example application site plan (Tepe İnşaat Sanayi AŞ., 2019).

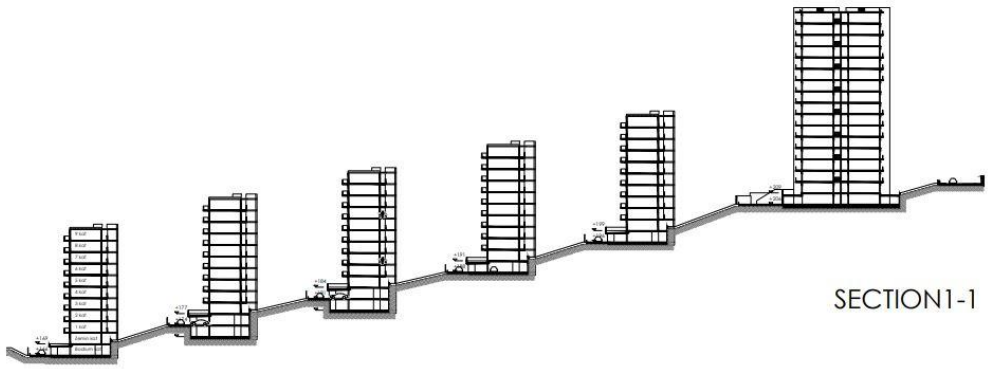

Figure 9. A sample application area cross-section (Tepe İnşaat Sanayi AŞ., 2019).

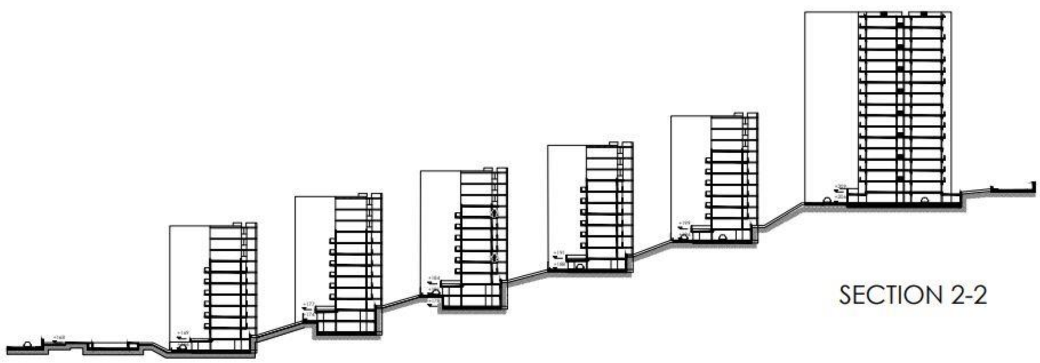

Figure 10. A sample application area cross-section (Tepe İnşaat Sanayi AŞ., 2019).

4.1. Calculation of distances Between Block Types According to Obstacle Building Height

According to the distances shown in the layout plan and the slopes shown in the section, the distances between the apartment blocks were calculated in terms of obstacle building height using the curve equation in Figure 5 and presented in Table 1.

Table 1. The distances between blocks (Constituted by authors).

BLOCK NO	DIRECTION OF THE HALL FACADES	NUMBERS OF BLOCKS	%LAND SLOPE	THE DISTANCES BETWEEN THE RESIDENTIAL BLOCKS*	MINIMUM CLEARANCE REQUIRED	RESULT (SUFFICIENCY FOR THE WINTER SUN OF DECEMBER 21)
1	SOUTHEAST	A1, B1	30	1,06h	1,25h	insufficient 1,06<1,25
		B1, C1	33	0,85h	1,20h	insufficient 0,85<1,20
		C1, D1	29	0,89h	1,26h	insufficient 0,80<1,26
		D1, E1	29	0,89h	1,26h	insufficient 0,89<1,26
		E1, F1	33	0,85h	1,20h	insufficient 0,85<1,20
		F1				Sufficient (no obstacle blocks)
2	SOUTH (10° EAST)	A2, B2	50	1,14h	h	sufficient 1,14>1
3	SOUTH	B2, C2	40	0,95h	1,11h	insufficient 0,95<1,11

		C2, D2	35	0,95h	1,17h	insufficient 0,95<1,17
		D2, E2	35	0,95h	1,17h	insufficient 0,95<1,17
		E2, F2	40	0,95h	1,11h	insufficient 0,95<1,11
		F2				Sufficient (no obstacle blocks)
4	SOUTHWEST	F3				Sufficient (no obstacle blocks)
5	NORTHWEST	A3				Sufficient (no obstacle blocks)
6	NORTH (10° WEST)	A4				Sufficient (no obstacle blocks)
* As a multiple of the height of the obstacle building						

The comparison of the deviations of the distance values between the buildings in the application area, calculated in terms of the obstacle building height, according to the variation curve in Figure 5 is shown in Figure 11.

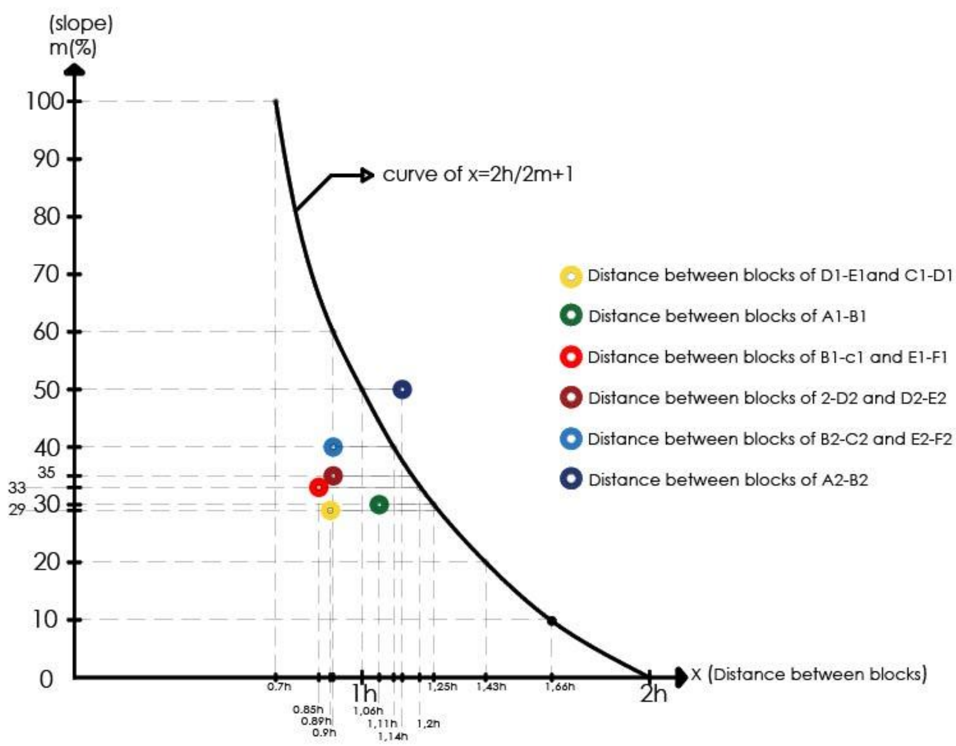

Figure 11. The comparison of the deviations of the distance values between the buildings in the application area, calculated in terms of the obstacle building height, according to the variation curve in Figure 5 (Drawn by authors).

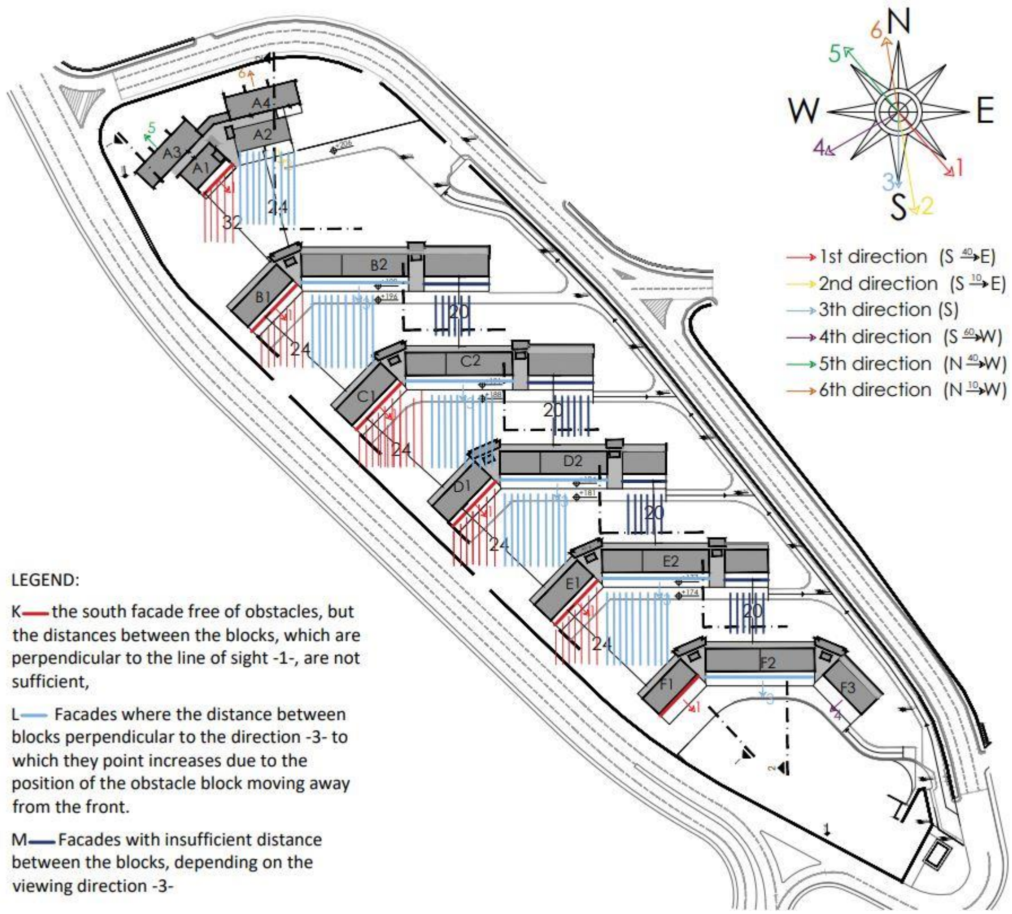

Figure 12. Obstacle Building- Distance Relationships According to the Direction of Facades of Blocks in the Direction of Slope (Drawn by authors).

When Table 1, Figure 11. and Figure 12 are evaluated together, the distances between buildings in the application area can be interpreted as follows:

- A1- The distances between B1, B1-C1, C1-D1, D1-E1 and E1-F1 blocks are slightly insufficient compared to the minimum distances determined by considering the slope to take advantage of the winter sun. However, the rays of the winter midday sun, which fall in the south-east slope direction of these blocks, are even more inclined than in the south direction. In this case, these available distances are even smaller than the minimum distances calculated with respect to the south direction. On the other hand, the sun rays coming to these blocks from the south are not blocked by the other blocks in front of them. For this reason, these blocks receive the sun's rays coming from the south unhindered, even though they are angled horizontally with their (K) façades. In this case, the effect of the inadequacy of the vertical distances between these blocks is reduced.

- While the distance between the blocks A2-B2 should be at least h as the height of the obstacle building, it is more and sufficient as 1.14 h.

- The distances between blocks B2-C1, C2-D1, D2-E1 and E2-F1 start from 0.95h and gradually increase. Therefore, these distances are sufficient to receive the winter sun for residences with an (L) facade, where the B2 block will be blocked by the C1 block, the C2 block by the D1 block, the D2 block by the E1 block and the E2 block by the F1 block.

- The current distances (0-95h) between blocks B2-C2, C2-D2, D2-E2 and E2-F2 are close to the required distances (1.11h and 1.17h), but less. Therefore, the rays of the midday sun on December 21 cannot reach the residences on the 1st and 2nd lower floors facing the (M) facades of these blocks, as seen in Figures 9 and 10.

- Since there is no structure blocking the F1, F2 and F3 blocks, these blocks can receive the sun's rays from all southern directions in summer and winter.

- There are no obstacle blocks in front of A3 and A4 blocks. However, since these blocks face north, they cannot receive the winter sun.

4.2. Sunshine Durations

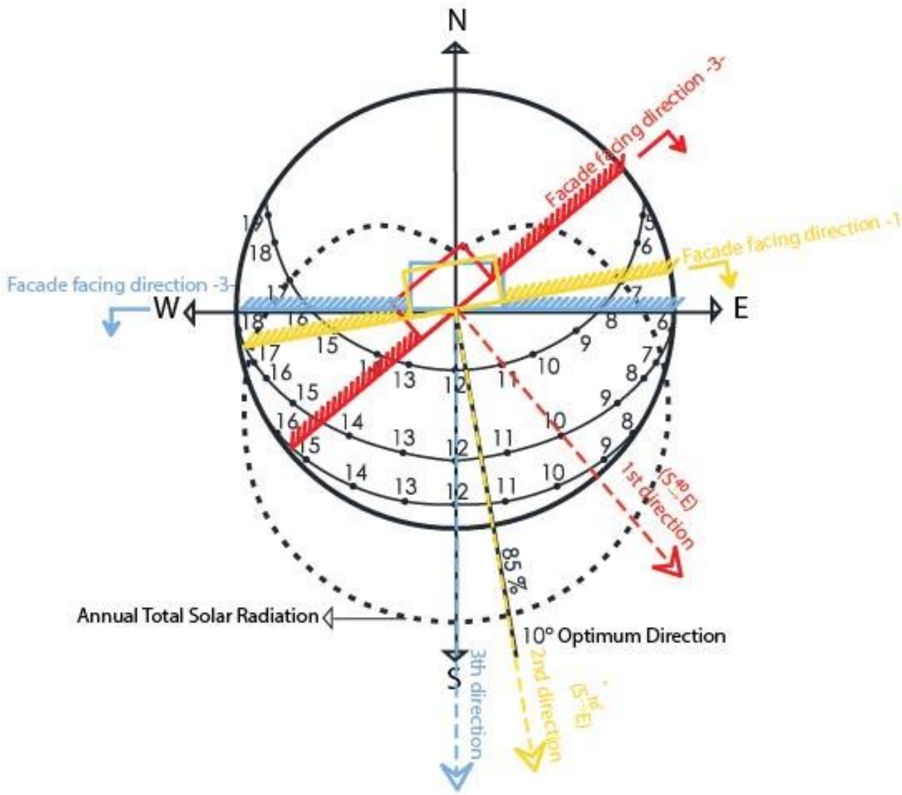

Figure. 13. Determination of the year-round average daily sunshine durations of the study area at 40 degrees north latitude according to the directions of 1, 2 and 3 that the block types' facades look, with the sun path diagram (Drawn by authors).

BLOCK NO	NUMBER OF RESIDENCES	THE DIRECTION OF RESIDENCE	DAILY SUNBATHING TIME DURING THE YEAR				AVERAGE DAILY SUN TIME OF TOTAL RESIDENCES	AVERAGE DAILY SUN TIME PER HOUSING
			DECEMBER 21 (WINTER)	JUNE 21 (SUMMER)	MARCH 21 SEPTEMBER 21 (ECINOX)	AVERAGE DAILY SUNBATHING TIME		

A1, B1, C1, D1, E1, F1	152	S 40° E (1st direction)	8 hours 10 minutes (7:30-15:40)	8 houres 50 minutes (4:30-13:10)	8 houres 30 minutes (06:00-14:30)	8 houres 30 minutes (24 h 90 m /3)	8 houres 30 minutes x152=~1292 houres	
A1, B1, C1, D1, E1 1th and 2nd flats	6	S 40° E ((1st direction)	0	8 houres 50 minutes	8 houres 30 minutes	5 houres 47 m (17 h 20 m) /3	5 houres 47 minutes x6=~35 h	
A2	48	S 10° E (2nd direction)	9 hours 7.30-16.30	8 houres 7.00-15.00	11 houres 6.00-17.00	9 houres 20 minutes (28 h /3)	9 houres 20 minutes x48=~448 houres	
B2, C2, D2, E2, F2	186	S (3th direction)	9 houres 7.30-16.30	8 houres 8.00-16.00	12 houres 6.00-18.00	9 houres 40 minutes (29 h /3)	9 houres 40 minutes x186=~1796 houres	3194/455
B2, C2, D2, E2 1. ve 2. flats	24	S (3th direction)	0	8 houres	12 houres	6 houres 40 minutes (20 h /3)	6 houres 40 minutes x34=~159 houres	
F3	16	S 60° W (4th direction)	6 houres 50 minutes 8.50-16.30	8 houres 20 minutes 11.10-19.30	7 houres 30 minutes 10.30-18.00	7 houres 30 minutes (22 h 40 m / 3)	7 houres 30 minutes x 16=120 houres	
A3	7	N 40° W (5th direction)	0	6 houres 13.30-19.30	3 houres 15.00-18.00	3 houres (9 h /3)	3 houres x7=21 houres	
A4	16	N 10° E (6th direction)	0	7 houres (4.30-7.00)+ (15.00-19.30	1 houres 17.00-18.00	2 houres 40 minutes (8 h / 3)	2 houres 40 minutes x 16 =~43 houres	
TOTAL	455	3194 hours						8 hours 36 minutes

Table 2. Sunbathing times of residences (Constituted by authors).

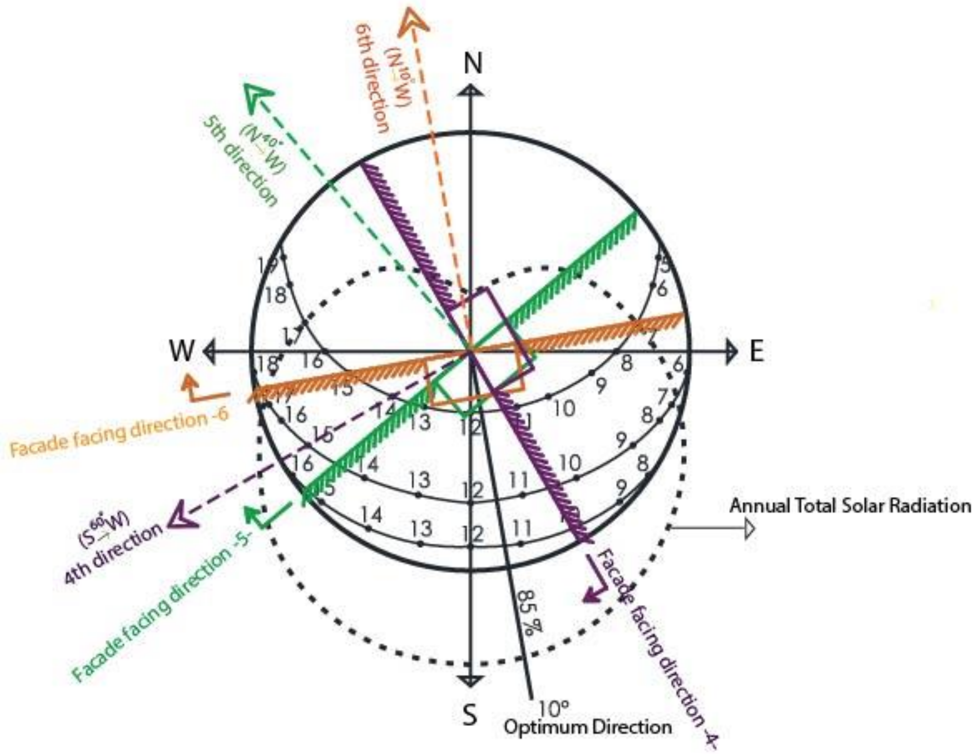

Figure 14. Determination of the year-round average daily sunshine durations of the sample study area at 40 degrees north latitude according to the directions 4,5 and 6 that the block types' facades look, with the sun path diagram (Drawn by authors).

The comparison of the total daily average year-round sunshine durations of all residences in the study area with the daily average year-round sunshine durations of the optimum direction in Table 2 is as follows:

At the 40th degree of latitude, the daily average year-round sunshine duration based on the optimal direction "10 degrees east from south" can be determined as 9 hours and 20 minutes, as can be seen from the sun mask. However, as can be seen from Table 2., the total daily average year-round sunshine durations of all residences in the study area during the year is determined as 8,6 hours, that is, 8 hours and 36 minutes. There is a shortage of approximately 40 minutes.

This value can be considered as very close to the sunshine duration of the optimal direction. In this context it can be said that the positioning of the dwellings in the study area is appropriate in terms of the average daily sunshine durations all year round.

4.3. Evaluation of the Field Study

The alignment of the selected hillside location of the residential area does not conflict with the optimal alignment of the maximum solar radiation in terms of maximum solar utilization, matching the angles of incidence of the sun, which offers long solar radiation times for a latitude of 40° north. For this reason, the directions of the residential volumes of most of the blocks of flats in the area are directed to the south. If the distances between the blocks were at least the formula 2h/2m+1, all the floors, including the ground floors, of the hillside apartment blocks in the area could receive the sun's rays of December 21 at 12:00. In this case, the average daily hours of sunshine for most dwellings in the area during the year would be equal to or very close to the times in the optimal direction. However, based on the following explanations, the average daily sunshine duration of the entire dwellings in the area does not differ significantly from the values that should be (approximately 9 hours):

-The distances between the blocks in question are smaller than the minimum distances that should be depending on the slope, but they are very narrow. Because of this, the M-facing apartments of the blocks facing the 3 directions can not only receive the first two layers of winter sun above ground, and the average daily sunshine duration is 5-6 hours. However, the number of apartments (30 apartments) on these floors is approximately 6% of the total number of apartments in the area.

- Due to the fact that the directions of the facades facing the residential volumes of the 2 types of blocks in the area face north, the apartments in these blocks have a very insufficient average daily sun exposure of 2-3 hours and they do not receive the winter sun at all. However, the number of these houses (24) accounts for 5% of the total number of houses.

-The 24 residences mentioned above, together with the 30 residences in the M-facing part of the blocks facing the 3rd direction, constitute 11% of the total number of residences as residences that do not receive the winter sun. Therefore, apart from the number of residences whose sunbathing times are insufficient and cannot receive the winter sun, the residences constitute 89% of the total number of residences and can receive the winter sun. The average daily sunshine duration of these residences during the year is about 8 - 9 hours, which is equal to or quite close to the sunshine duration of the optimum direction (9 hours and 20 minutes).

-Since the distances in front of the K facades of the blocks are not sufficient in the -1 direction, the apartments on the first two floors above the ground of these blocks cannot receive winter sun. However, since the southern directions of these blocks are unobstructable, they can sunbathe all year round even if they are not perpendicular to the facade. Therefore, it can be said that the average daily sunshine duration throughout the year can reach more than 5-6 hours, which is determined by the direction of the gaze.

- For the reasons explained above, the average daily sunshine duration of all dwellings in the study area during the year was calculated as 8 hours and 36 minutes, which is quite close to the required value of 9 hours and 20 minutes. Moreover, this number can be increased if one accepts that the average daily duration of the houses in the two floors above the ground of the blocks open to the south is more than 5-6 hours.

- As a result, it can be said that the housing arrangement in the study area is suitable for maximum passive use of the sun.

CONCLUSIONS:

The maximum use of the sun when planning a sustainable residential area depends primarily on the optimal assessment of the passive effect of the sun. This assessment requires a close connection to the distribution, location and orientation of the residential development in the residential area.

When designing residential areas to take advantage of the sun; "Sun duration", "distances between buildings" and "land slope" are the primary parameters to be evaluated. The harmony between these parameters ensures optimization in the maximum use of the sun.

With passive use of the sun, it is important that the angle of incidence of the sun on the building is not blocked. When positioning buildings in residential areas, orienting a building to the sun's angles is not sufficient unless the building is spaced from another building such that it does not obstruct the sun's rays. This distance, which is 2 times the height of the obstacle building, changes by decreasing according to the increase in the slope of the view of land in the direction of the sun. These change depending on the degree of inclination including the building distances -x-, the inclination of the property with sun orientation -m-;

It is given by the formula $x= 2h/2m+1$.

In a residential area, the slope of the plot is more advantageous than the plot without a slope, with maximum passive use of the sun, provided that the orientation is the optimal direction according to the sun diagram of the region's latitude or directions with suitable insolation times. Sloping lots allow shorter distances between buildings. However, the structural and application-related problems as well as the economic disadvantages caused by the gradient that would make it suitable for settlement must be taken into account.

In order to ensure maximum efficiency without passive use of the sun, when planning a house, the building spacing should be designed according to the angle of the sun, depending on the slope of the property, and the average daily sunshine duration of the entire house throughout the year. This time the opt. The closer the direction is to the daily mean value of the sunshine duration, the more positive it should be assumed.

The methods of storing solar energy such as solar collectors, trumpet wall and converting them into other electrical energy can be effective only by positioning the buildings in the residential areas according to the given parameters.

Compliance with Ethical Standard

Conflict of Interests: The authors declare that for this article they have no actual, potential or perceived conflict of interests.

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