

Prediction Method of Sunshine Duration Hours by Computer Simulation

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ABSTRACT

In Korea, apartments account for over 50 percent of the housing types. Residential spaces soaring higher and growing denser accompany the violation of the right to have sunshine duration hours and invite disputes among adjacent buildings. According to the court's ruling, the sunshine duration measurement of a residential area is based on the winter solstice. Sunshine duration should be over two hours from 9 a.m. to 3 p.m., or at least four hours from 8 a.m. to 4 p.m. One of the ways to measure sunshine duration is to measure sunshine duration on the site in question. However, the court does not accept that because sunshine duration measurement is possible only once a year using that method. The court measures sunshine duration hours using a 3-dimensional computer simulation and makes an evaluation for court case data. Accordingly, this essay suggests how to simulate the sunshine duration of an apartment using Autodesk VIZ program and attempts to verify the validity of the simulation results in comparison with the result of the sunshine duration measurement of an apartment.

Keywords: sunshine duration, sunshine access right, VIZ, apartment housing

1. INTRODUCTION

1.1 Overview and Purpose

Sunshine in a living environment is one of the most important factors that affect our health. A residential space without sunshine can hardly ensure a pleasant living environment. In large cities in Korea, many existing low-story residential buildings are being reconstructed into high-rise apartments in order to enhance the living environment and the efficient use of land.

In Korea, disputes as such are settled based on the winter solstice. The measurement of sunshine duration hours of a building accompanies many difficulties due to time and weather constraints;

accordingly, computer simulation is used for the settlement of most of the disputes and the Supreme Court also relies on a similar method. Computer simulation is highly efficient in that it can be done regardless of the construction schedule of a building and can evaluate sunshine duration by tracing the sun's path during the winter solstice. However, the criterion for simulation related to disputes over sunshine duration has not been established, which results in varying outcomes depending upon the performance of simulation programs and the way the programs are used. In this respect, it is imperative to establish a criterion for the computer simulation programs and the

methods of using them and conduct research on the validity of simulation programs.

This study attempts to suggest a methodology for the evaluation of sunshine duration through a 3 dimensional simulation program by assessing the sunshine duration hours of the PL2 apartment complex in Samseong-Dong in Gangnam-gu, Seoul, with the program and comparing it with the actual sunshine duration hours of the apartment.

1.2 Methodology

① In this study, I examined buildings around the PL2 apartment complex(“the subject apartment”) in Samseong-dong and collected various data including drawings by visiting the management office, on-site office, and architecture office for reference. Also, I briefly introduced the simulation program for the evaluation of sunshine duration hours, Autodesk VIZ 2008.

② I created a three dimensional model of the SR apartment complex south of the PL2 apartment complex (“the new apartment”) and explained simulation methods.

③ I evaluated sunshine duration before and after the construction of the SR apartment complex and also sunshine by the sun's shadow.

④ I compared the sunshine of the apartment complex and that in computer simulation at the same time to verify its validity.

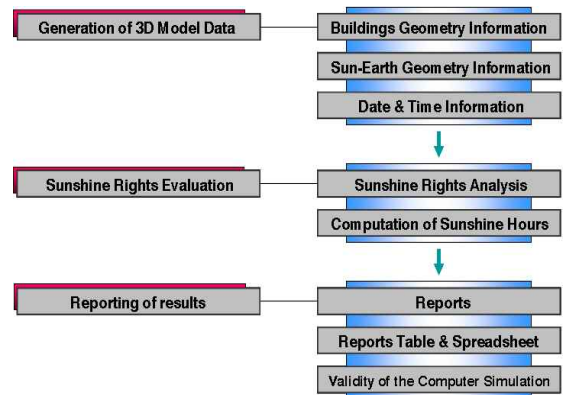


Figure 1: Sunshine Access Rights Analysis

2. OVERVIEW OF THE APARTMENT COMPLEX

2.1 Selection of an Apartment Complex for the Evaluation of Sunshine Access

For this study, I chose the PL2 apartment complex in Seoul as some residents of the apartment complex are expected to suffer from a lack of sunshine due to the construction of the SR apartment complex. Among 136 households in one building, I chose 7 households as the victims and measured the sunshine of their apartments. The PL2 apartment complex consists of 8- to 12-story buildings and the SR apartment complex 6- to 15-story buildings.



Figure 2: Site Plan



Figure 3: Apartments Isometric

2.2. Analysis

I compared the architectural drawings of the two apartment complexes with the help of the Gangnam District Office. The ground level of the PL2 apartment complex is 19.1m and that of the building no. 101 of the SR apartment complex, 19.6m. As the drawing of the building on 4 lots of land before the construction of the SR apartment

complex has already been destroyed, I used the land survey and the aerial photo map (Photo. 1) for the measurement of sunshine duration hours before the construction of the new apartment complex.



Photo 1: Aerial photo of the PL2 apartment complex before the construction of the SR apartment complex

2.2.1 Overview of the PL2 Apartment Complex

As seen in (Figure 4), the PL2 apartment complex consists of 136 apartments in one building. It is located to the north of the SR apartment complex with a 6-m road between them. The height of each floor on the 1st to 10th floors and 12th floor is 2.6m and that of the 11th floor 2.7m.



Figure 4: PL2 Apartment Building

2.2.2 Overview of the SR Apartment Complex

Located on the southeast of the PL2 apartment complex, the SR apartment complex consists of four, 6 to 15-story buildings covering an area of 8,730 m² of the building site. Among the four buildings including building nos. 101 to 104, the building 101 is expected to affect the PL2 apartment complex in terms of sunshine access (Fig. 5).

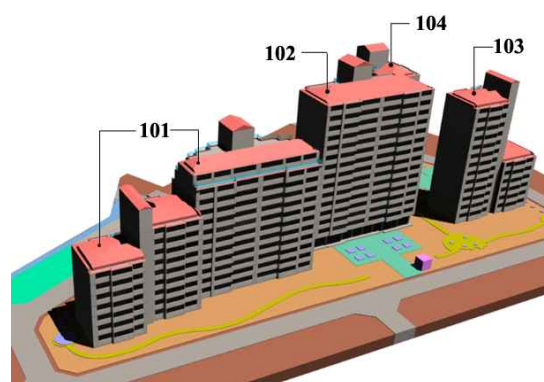


Figure 5: SR Apartment Buildings

2.2.3 Multi-Family Houses and Shopping Center before the Construction of the SR Apartment

The SR apartment complex was newly constructed on the lot that had been occupied by a 2 to 3-story shopping center and multi-family houses. (Fig. 6) shows the shopping center and the multi-family houses before they were demolished for the construction of the SR apartment.

I produced a three-dimensional model of the dismantled buildings based on the borderlines on the survey and confirmed the number of floors of each building as seen on the survey, which shows the three buildings of the 3-story Hyundai Villa with 36 households, one building of the 3-story Hanyang Town with 18 households, and 2 buildings consisting of the 3-story Shinhayang multi-family houses with 30 households, and a 2-story shopping center.



Figure 6: SR Apartment Site

2.3 Criteria on Amount of Sunshine Access

In Korea, the maximum height of an architectural building for sunshine access is specified by article 53 and article 86 of architecture law. The law stipulates that any two apartment buildings should have a certain distance between them in order to ensure a certain number of hours of sunshine based on the winter solstice with the shortest daylight hours. It accepts two or longer hours of sunshine access based on the winter solstice as adequate to meet the distance criteria. However, the regulation is applied only to the buildings on the same lot and, in case of buildings on adjacent lots, regulates the height of the buildings or distances from other buildings without regulating sunshine duration hours.

The High Court decision on case no. 94 Na 11806 on March 29, 1996 serves as a good example for the tolerable limits of sunshine intrusion. The High Court ruled that multi-family housing like apartments in Seoul and Incheon areas should be tolerable if a building has at least 2 consecutive hours of sunshine access during the 6-hour period from 9 a.m. to 3 p.m. based on the winter solstice or at least 4 hours in total during the 8-hour period from 8 a.m. to 4 p.m. and that shorter hours of sunshine access than those specified above are not tolerable.

3. METHODOLOGY FOR SUNSHINE ACCESS EVALUATION

3.1 Selection of a Sunshine Access simulation program

An accurate analysis of sunshine duration hours and view requires analysis techniques for quantitative evaluation. Recently, sunshine measurement software are commonly being used these days.

In this study, I analyzed the sunshine duration hours of each apartment using the computer simulation program Autodesk VIZ 2008. I made the sun shadow plan of each apartment in question by entering the measurement data and the shape of the lot and the building and analyzed the time when

shadows are cast by compiling the data. Also, I used the program VIEW, which I developed for the calculation of the size of the shadows of the building.

The VIEW program is designed to calculate the number of pixels of certain colors of the image given and express them as a ratio. It uses the Bitmap function of Visual Basic 6.0 and expresses the size ratio by sorting out the white dots on the monitor screen.

3.2 Evaluation of Sunshine Access on the PL2 Apartment

3.2.1 Input of Building data

I entered the three-dimensional data on the building in question using AutoCAD based on the drawings and determined the height of the buildings based on the ground level of each lot. I referred to the digital map of the building lot number created by the National Geographic Information Institute of the Ministry of Construction and Transportation in order to determine the direction and location of the apartment lot.

Table 1: Autodesk VIZ input data

Setting		Input Data		
Object Type		Daylight		
Daylight		Sunlight : IES Sun, Skylight : IES Sky		
Location		Latitude : 37.30°, Longitude : -127.03°		
Time		GMT +9 Japan, Korea, 12. 22. 08:00~16:00		
Render Scene	Common	Process	Initial Quality	85%
			Refine Iterations	3
Environment and Effects	Environment	Logarithmic Exposure Control Parameters	Brightness	75.0
			Contrast	50.0
			Mid Tones	2.0
			Exterior daylight	Active

I separated the layer of each apartment building for simulation on Autodesk VIZ and created a Virtual Side of Sunshine on the balcony for the calculation of the size of the sun's shadow cast on the PL2 apartment complex. I also created the structure of the roof and rooftop of the SR apartment complex for the accuracy of the sun shadow on the PL2 apartment

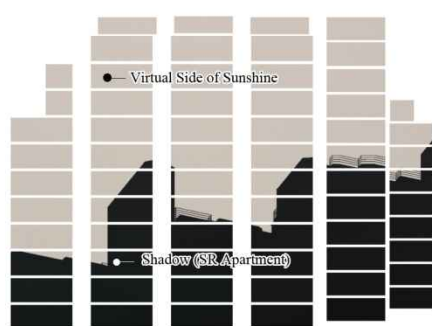


Figure 7: Virtual Side of Sunshine

3.2.2 Daylight Input Data

I linked the model created with AutoCAD to Autodesk VIZ by using the file link manager function and installed IES SUN in the model for sunshine measurement. I entered latitude and longitude to determine the exact location and recorded the simulation time based on the winter solstice as in (see Table 1).

4. SUNSHINE ACCESS EVALUATION OF THE PL2 APARTMENT COMPLEX

4.1 Overview of Sunshine Access Evaluation

For this study, I made a sunshine chart for each apartment complex by measuring sunshine access every 10 minutes from 8 a.m. to 4 p.m. based on the winter solstice. For the sunshine access in between, I considered it the same as that simulated 10 minutes ago. (For instance, sunshine access between 8 a.m. and 8:10 a.m. is the same as that at 8 a.m.)

I calculated the area of possible sunshine access through the window on the balcony in percentage (%; percentage of sunshine below) and analyzed daylight hours based on the percentage of sunshine already calculated. As the balcony of the PL2 apartment complex faces south, I assumed the whole area of the balcony as a window. Also, I assumed that over 50 percent of the sunshine area of the balcony means that the balcony can receive sunshine during the time being analyzed and less than 50 percent means that the window does not receive sunshine.

For consecutive sunshine access evaluations from 9 a.m. to 3 p.m., I analyzed only when the sunshine access was over 50 percent. In addition, I assumed that changes in sunshine between two consecutive points of time were consecutive line and sunshine changes evenly when sunshine is 70 percent at 10 a.m. and 50 percent ten minutes later.

I analyzed the sunshine access of the possible victims-apartments (no. 102, no. 201, no. 202, no. 301, no. 302, no. 401, no. 501) of the PL2 apartment complex and evaluated sunshine received through the living room window of each apartment complex that is thought to be affected by the construction of the SR apartment. (Figure 8) shows the apartments chosen for sunshine access analyses.

		1205	1204	1203	1202	
		1105	1104	1103	1102	
1006	1005	1004	1003	1002		
906	905	904	903	902	901	
806	805	804	803	802	801	
706	705	704	703	702	701	
606	605	604	603	602	601	
506	505	504	503	502	501	
406	405	404	403	402	401	
306	305	304	303	302	301	
206	205	204	203	202	201	
106	105	104	103	102	101	

Figure 8: PL2 Apartment Evaluation Households

4.2 Analysis of Sunshine Access Evaluation

(Table 2) below shows the analysis of the possible sunshine duration hours each apartment complex can receive on its own. The percentage of sunshine access was 88.6 percent on average with a total sunshine duration of 5 hours and 30 minutes on average, and consecutive sunshine duration of 4 hours 30 minutes on average.

Table 2: Sunshine duration hours at PL2 Apartment

Household Number	Accumulative sunshine duration	Consecutive sunshine duration	Sunshine rights satisfaction
201	5h	4h	Yes
301	5h	4h	Yes
401	5h	4h	Yes
501	5h	4h	Yes
102	6h 10m	5h 10m	Yes
202	6h 10m	5h 10m	Yes
302	6h 10m	5h 10m	Yes

I examined the possibility of the PL1 apartment complex to affect the sunshine of the PL2 apartment complex through computer simulation. As a result, the PL1 apartment complex does not affect the sunshine access of the PL2 apartment complex. In other words, the PL1 apartment complex partially affects the PL2 apartment complex at certain points of time, but an analysis shows that the PL2 apartment complex does not receive sunshine regardless of external influence.

(Table 3) shows the sunshine duration hours of the PL2 apartment complex without external influence and the multi-family houses under consideration. As a result, the 7 apartments satisfy the requirements of the total of 4 hours of sunshine and over 2 hours of consecutive sunshine duration hours during the winter solstice.

Table 3: Sunshine duration hours of the PL2 apartment complex before the construction of the SR apartment complex

Household Number	Accumulative sunshine duration	Consecutive sunshine duration	Sunshine rights satisfaction
201	4h 20m	4h	Yes
301	4h 50m	4h	Yes
401	5h	4h	Yes
501	5h	4h	Yes
102	4h 40m	4h 30m	Yes
202	5h 30m	5h 10m	Yes
302	6h	5h 10m	Yes

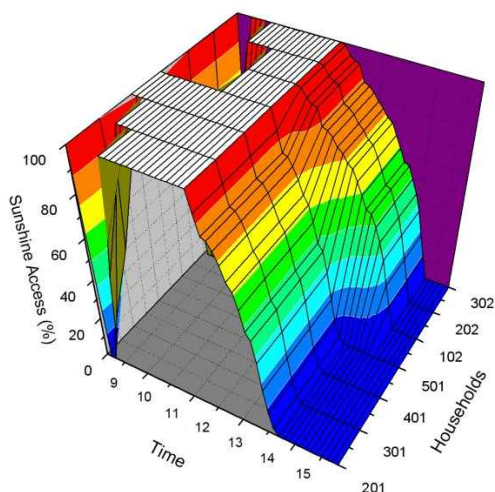


Figure 9: Sunshine duration hours of the PL2 apartment complex before the construction of the SR apartment

The graph in (Figure 9) shows the sunshine access evaluation of the seven households under the influence of the PL2 apartment complex and the multi-family houses before the construction of the SR apartment complex. According to the graph, sunshine access was 88.6 percent in average, with a total sunshine access period of 5 hours and 2 minutes, and the consecutive sunshine access period of 4 hours and 24 minutes.

As seen in (Table 4), all 7 households in question did not meet the requirements of 4 hours duration of total sunshine and 2 hours duration of consecutive sunshine.

Table 4: Sunshine duration hours of the PL2 apartment complex after the construction of the SR apartment complex

Household Number	Accumulative sunshine duration	Consecutive sunshine duration	Sunshine rights satisfaction
201	1h 20m	1h 20m	No
301	1h 20m	1h 20m	No
401	1h 20m	1h 20m	No
501	1h 50m	1h 50m	No
102	1h 30m	1h 30m	No
202	1h 40m	1h 30m	No
302	2h 40m	1h 40m	No

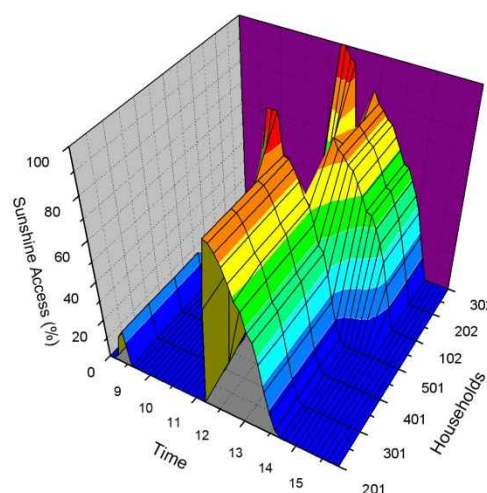


Figure 10: Sunshine duration (%) of the PL2 apartment complex after the construction of the SR apartment

The graph in (Figure 10) shows the percentage of sunshine access of the 7 households in the PL2 apartment complex after the construction of the SR apartment

complex. The percentage of sunshine access is 20.3 percent on average and consecutive sunshine duration of 1 hour 39 minutes on average, an average decrease of 68.3 percent after the construction of the SR apartment complex. Total sunshine duration hours decreased by 3 hours and 23 minutes and the consecutive sunshine duration hours decreased by 2 hours and 45 minutes on average.

Among the seven households of the PL2 apartment complex, No. 302 apartment, which had the longest sunshine duration with 6 hours, had an average of 30.5 percent of sunshine, 2 hours 40 minutes of total sunshine duration, and 1 hour 40 minutes of consecutive sunshine duration on average. When compared with the apartment before the construction of the SR apartment complex, No. 302 apartment had 41.2 percent less percentage of sunshine, 3 hours and 20 minutes less in total sunshine duration, and 2 hours 30 minutes less in consecutive sunshine duration. In other words, the construction of the SR apartment complex caused a shortage of total sunshine duration and consecutive sunshine duration of the 7 households of the PL2 apartment complex. (Table 5) shows a comparison of sunshine duration hours of the 7 households before and after the construction of the SR apartment complex.

Table 5: Sunshine duration hours of the PL2 apartment complex after the construction of the SR apartment complex

Household Number	Before Construction		After Construction		Reduced Hours of Sunshine Access	
	Accumulative sunshine duration	Consecutive sunshine duration	Accumulative sunshine duration	Consecutive sunshine duration	Accumulative sunshine duration	Consecutive sunshine duration
201	4h 20m	4h	1h 20m	1h 20m	3h	2h 40m
301	4h 50m	4h	1h 20m	1h 20m	3h 30m	2h 40m
401	5h	4h	1h 20m	1h 20m	3h 40m	2h 40m
501	5h	4h	1h 50m	1h 50m	3h 10m	2h 10m
102	4h 40m	4h 30m	1h 30m	1h 30m	3h 10m	3h
202	5h 30m	5h 10m	1h 40m	1h 30m	3h 50m	3h 30m
302	6h	5h 10m	2h 40m	1h 40m	3h 20m	3h 30m

Table 6: The influence of the SR apartment complex on the PL2 apartment in the total duration of the sun's shadow (%)

Household Number	Total duration of the sun's shadow after the construction of the SR apartment complex	Duration of the sun's shadow before the construction of the SR apartment complex	Duration of the sun's shadow with the SR apartment	The percentages of SR Apartment (new buildings)'s role in the hours of shadow made (%)
201	6h 40m	3h 40m	3h	45.0
301	6h 40m	3h 10m	3h 30m	52.5
401	6h 40m	3h	3h 40m	55.0
501	6h 10m	3h	3h 10m	51.4
102	6h 30m	3h 20m	3h 10m	48.7
202	6h 20m	2h 30m	3h 50m	60.5
302	5h 20m	2h	3h 20m	60.5

5. VALIDITY OF COMPUTER SIMULATION

For the verification of the validity of the computer simulation, I compared the pictures of the sun's shadow of the apartments and those of simulated images.



a) Photo

b) VIZ Image



c) Photo

d) VIZ Image

Figure 11: PL2 Apartment – Shadow
(a, b : 17 Oct. 2007 13:45)
(c, d : 17 Oct. 2007 14:24)

When latitude and longitude are entered, the setup option of IES Sun in the menu Daylight Parameters of the Autodesk VIZ program shows the location of the sun by calculating solar altitude and azimuth. Any valid program should be able to show the sun's shadow identical to that in actual photos.

(Figure 11, a) is the photo taken at 1:45 p.m. on October 17 and (Figure 11, c) 2:24p.m. on the same day at the PL2 apartment complex for the verification of the validity of simulated sunshine evaluation.

(Figure 11, b) and (Figure 11, d) are the simulated sun's shadow at the same time when the photos were taken. It is difficult to identify the shadow on the balcony without a window, but a virtual side of sunshine allows to clearly identify shadow.

A comparison of the pictures and the simulated images shows that they all have identical shadow in the same location.

6. CONCLUSION

In this study, I attempted to suggest how to evaluate sunshine of apartments using computer simulation and utilized it as a preliminary source for sunshine evaluation in the future. Below is a brief summary of the conclusion of this study.

1) A construction of a 3-dimensional model requires a drawing and a survey with information on the ground level. The study shows that the AutoCAD is capable of producing an exact model for 3-dimensional simulation.

2) The study proves that the Daylight function of the Autodesk VIZ program is highly reliable in terms of accuracy. It can identify the location and calculate altitude and azimuth with latitude and longitude. It also can visualize the sun's shadow before or after the construction of a building, showing sunshine intrusion in each time period.

3) The simulated image using the Autodesk VIZ program can show the sun's shadow cast on a building accurately, but the programs cannot convert the images into

numerical data. Accordingly, the accurate calculation of the area of the sun's shadow requires a different program with that capacity. In this study, I developed the VIEW program in order to calculate the shadow area of the images and the area with a possible view. The program helped reduce errors that manual calculation is prone to cause and thus save time.

4) I compared the actual photos and the simulated images to determine whether they are identical in terms of the location of the sun's shadow. I also simulated the images of the sun's shadow at the same time when the photos were taken. As a result, the photos and the simulated images were identical in terms of the location of the sun's shadow.

5) This study proves the validity of all the programs including Autodesk VIZ and VIEW for sunshine access evaluation for any building and the sunshine access evaluation of the PL2 apartment complex using these programs confirms their accuracy.

This study attempts to suggest computer-based sunshine access evaluation. As it takes a lot of time to accurately simulate a building using a 3-dimensional model, it is suggested that a methodology to evaluate sunshine be formulated to save time required for simulation.

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