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Effect of Sky View Factor and Wind Direction on Surface Temperatures in Urban Areas

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***Abstract*—Sky view factor (SVF) is an important parameter which is being used to define the urban density in urban areas. In this study we investigated the correlation between SVF and surface temparatures of building facades'. For this purpose we implemented an application study on some specific points which exist on Gazi Street in Elazig on east side of Turkey and some branch streets connected to Gazi which have a remarkable structural density. In the study first we calculated SVF values of 2 points on Gazi Street which is east-west oriented 4 points on branch streets connecting to Gazi. Then we measured surface temperatures of building façades for choosen points for the hours between 8:00 am-16:00 pm. Rayman 1.2 program and fisheye photos were used to calculate SVF values. Surface temperatures were measured by infrared thermography method. Calculated SVF values for the two points on Gazi Street are 0.561 and 0.574 while the SVF values for branch streets ranges from 0.287 to 0.574. Higher surface temperatures measured on the points on branch streets. The results are evaluated by the wind velocity and direction which are taken from Government Meteorological Office.**

***Keywords*—sky view factor, surface temperature, infrared thermography.**

I. Introduction

It has been an obligation to incorporate solar exposure of urban elements in their design process for architects and city planners. In recent years many researchers studied on different parameters to define urban elements' effect on microclima [1,2,3]. Sky view factor (SVF) which is a dimensionless parameter and an indicator for urban density has been get used to analyze the solar exposure of some urban elements. In this study we investigated the correlation between SVF and surface temperatures of building facades. For this purpose we implemented an application study on some specific points on Gazi Street and branch streets connecting to it in Elazığ in Turkey. Rayman 1.2 [4,5] program was utilized and fisheye photos were used to calculate SVF values. Surface temperatures were measured by infrared thermography. Figure 1 shows the workspace area.

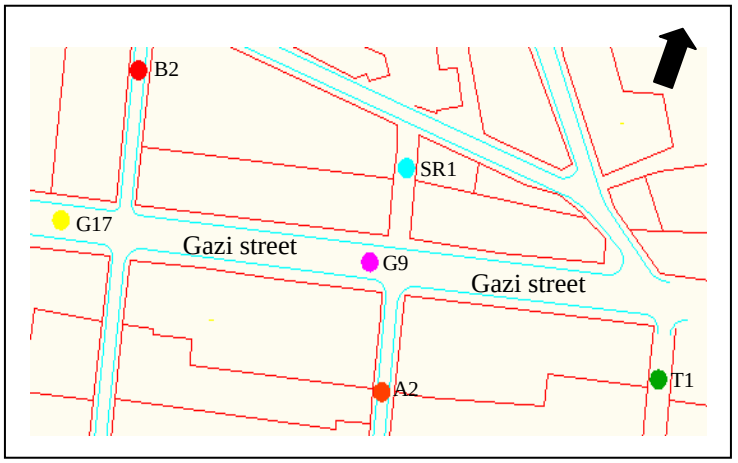

Figure 1. Workspace area

A. *Sky View Factor*

Sky view factor is a dimensionless parameter that predicts the amount of visible sky from a point on the earth. In other words, it is an angle between an observer and obstacles for sky in an urban area. It affects the solar exposure of urban surfaces due to street geometry and urban density [6]. Figure 2 compares SVF values of two different points that have different H/W ratios (aspect ratio-building height/street width) [7].

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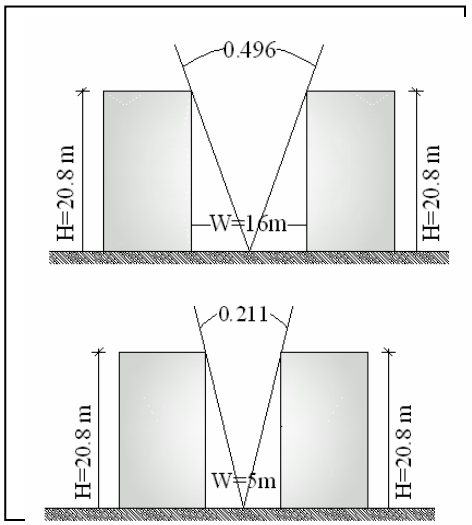

Fi W ratios.

II. Method

A. *Calculation of Sky View Factor by Rayman 1.2*

Different methods could be useful for the calculation of SVF. In this study RayMan model was utilized for calculation of SVF values using fisheye photos [8]. Fisheye photos and H/W ratios for each location are shown in Figure 3.

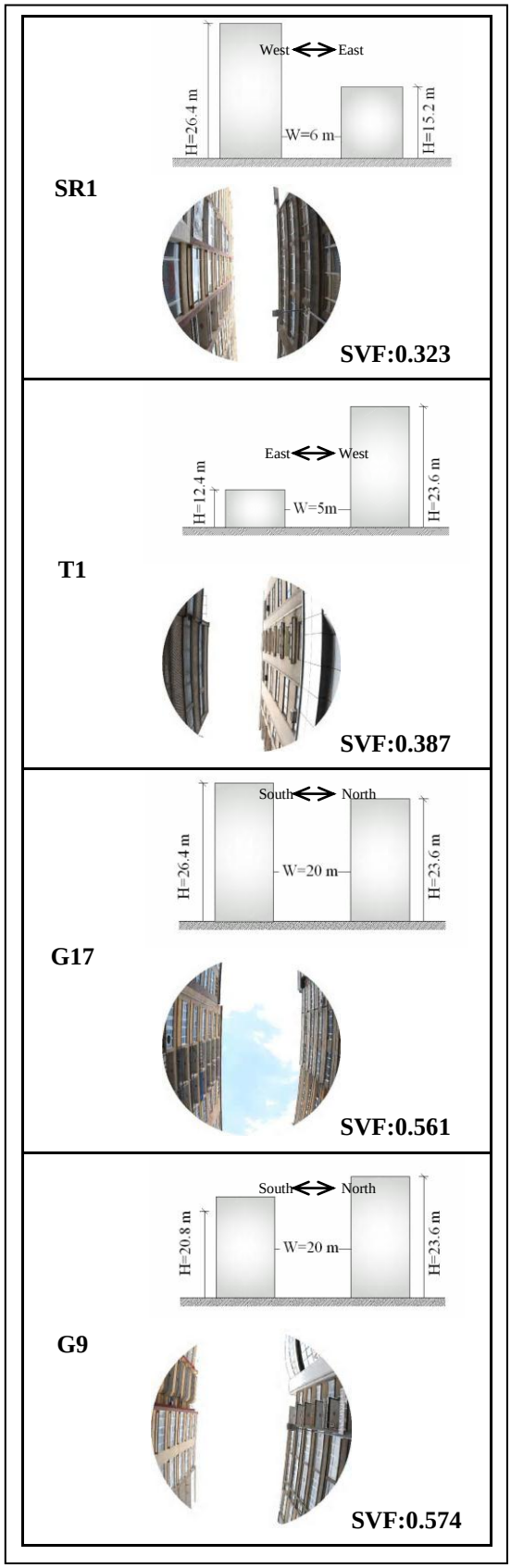

Figure 3. Fisheye photos and H/W ratios for each location

B. Surface Temperature Measurements

A thermal camera (Flir Thermacam) [9] was used to measure surface temperatures and measurements were made on 21th of March 2007. A point at 1.5 m height on each surface was measured for every hour. Results were evaluated by thermacam reporter and thermal photos for some points on 12.00 are listed in Figure 4. Thermophysical properties of building materials are neglected.

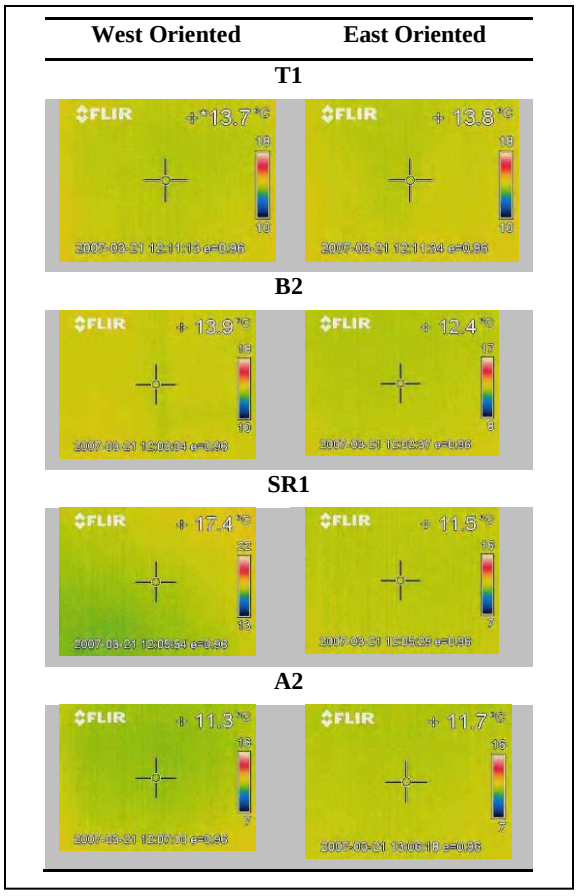

Figure 4. Thermal Photos for some points

C. Wind Velocity /Direction and Weather Data

Correlation between surface temperatures and SVF values was evaluated with the effect of wind velocity-direction and weather data taken from Government Meteorological Office for 21 th March 2007. Data for wind velocity/direction and air temperature are listed in Table 1

TABLE 1. DATA FOR WIND VELOCITY AND AIR TEMPERATURE

Time	Air Temperature (°C)	Wind Velocity(m/s)	Wind Direction
8.00	10.6	3.3	SSE
9.00	12	2.4	ESE
10.00	12.2	2.4	SSE
11.00	12.6	1	SSW
12.00	12.4	1.5	NE
13.00	13.2	1.7	SSW
14.00	13.6	1.2	WSW
15.00	13.4	2.3	NNW
16.00	12.4	2.3	NNW

III. Results

In this study we calculated the SVF values and measured surface temperatures of building facades which exist on chosen points for case study. Surface temperatures of building facades presented graphically correlated with wind speed and air temperature. Figure 5,6,7 and 8 presents the measurement results for the points located on branch streets which are east-west oriented. SVF values calculated for A2, B2, SR1 and T1 are 0.287, 0.331, 0.323 and 0.387 respectively. A common increasing attracts the attention on the west surfaces of facades' while the SVF values increases but T1. T1 case differs from others by height of it's west oriented façade. Cause of shadow effect of opposite wall, west oriented wall of T1 presents lower values. However there is a big amount of difference between west and east oriented facades of SR1. It is because of urban heat island effect (unability to let off the absorbed energy by the surface) on west oriented wall of SR1. Among all of the points located on branch streets, SR1 has the highest temperature values but does not have the highest SVF value. This could be a result of heat generation rate caused by heavy traffic line occurs on this street more than others.

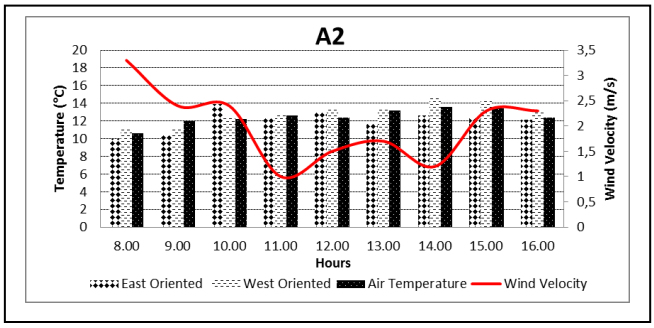

Figure 6. Measurement for the points located on B2

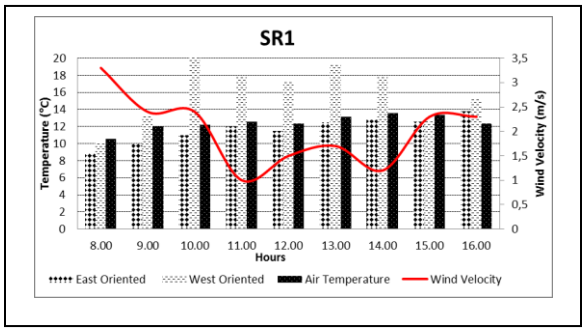

Figure 7. Measurement for the points located on SR1

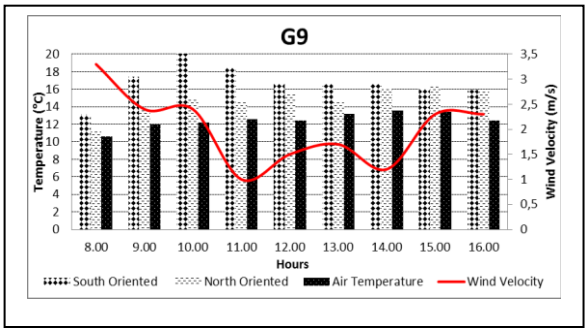

Figure 9. Measurement for the points located on G9

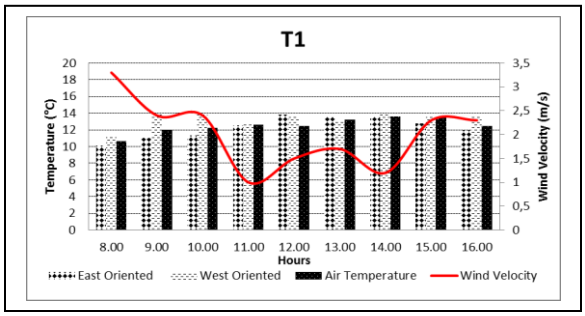

Figure 8. Measurement for the points located on T1

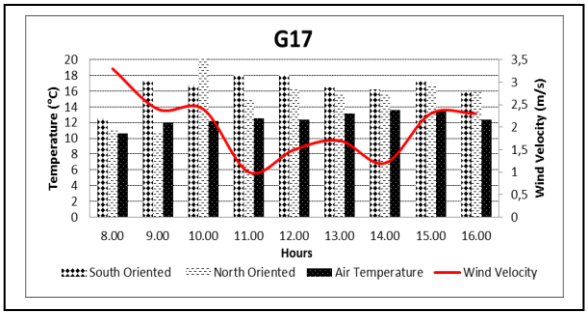

Figure10. Measurement for the points located on G17

Figure 9 and 10 presents the measurement results for the points located on Gazi Street, G9 and G17. SVF values for G9 and G17 are 0.561 and 0.574 respectively. Facades are north-south oriented and present highest temperature values among all studied points because of the highest SVF values. For G9 and G17 we have seen the big difference between air temperature and surface temperatures while they are almost at the same level for A2, B2 and T1. Beside the increasing amount of solar radiation exposed by facades, heavy traffic line of Gazi Street is another strong reason for this situation.

Surfaces are exposed to wind velocities between 1 and 3.3 m/s that are from different directions. Wind does not provide a cooling effect on facades directly. In some cases (at 15.00 and 12.00 for G17) when the surfaces are windward, any decrease didn't occur on surface temperatures by the increasing wind velocity. East-west oriented surfaces on branch streets were not influenced by wind effect also. Street geometry as a barrier and lower SVF values of branch streets prevent cooling effect of wind for branch streets approximately.

IV. CONCLUSION

As a result SVF is an important indicator about solar exposure of surfaces. While the SVF increases the solar exposure and temperatures of surfaces increases also. For some extraordinary cases like SR1 and T1, higher SVF values don't provide more solar exposure. For this reason SVF should be evaluated with shadow effect of surfaces to each other. Cooling effect of wind is not sensible on surface temperatures with respect to street geometry that does not let the air movement to reach inside of city structure. Data of air temperature could be useful to analyze the side factors that surfaces influenced by like heavy traffic, particles and air pollution.

Acknowledgment

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