Supplementary material for

Outdoor thermal comfort and summer PET range: A field study in tropical city Dhaka

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Calculation of urban geometry parameters in an asymmetric street canyon: H/W ratio and SVF

Calculation of H/W ratio

Since this study is mainly concerned with diversified street canyons, the following equation proposed by Ratti (2005) for asymmetric streets has been used in this study (Figure 1).

$$(H/W)_{Pi} = \frac{h_{i,1} + h_{i,2}}{2(w_{i,1} + w_{i,2})} \quad \textbf{(1)}$$

Here, $(H/W)P_i$ represents the value of the height-to-width ratio at point P_i , h_i represents the height of the obstructing buildings in two opposite directions, and w_i is the horizontal distance of those buildings from point P_i .

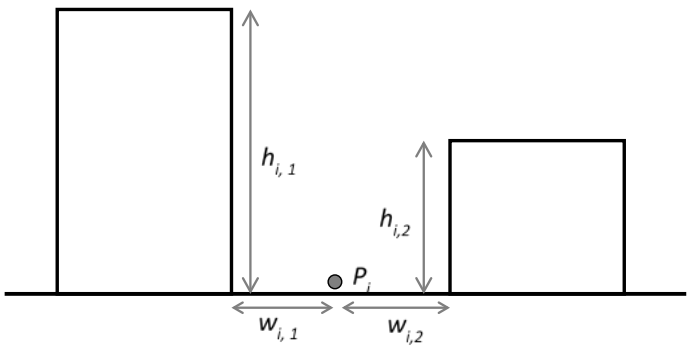

Figure 1. Calculation of H/W ratio in an asymmetric street canyon

H/ W ratio was calculated at every point where a change has occurred either in building heights or in street widths. Figure 2 shows the calculation of H/W ratio in TRA1NS canyon, where the H/W ratio of each single point was measured that was subjected to building height

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or street width change. As the points correspond to different lengths in a north-south direction, the building height at each point was multiplied by a corresponding street length to determine their (building height (*h*) x length weight (*l*)).

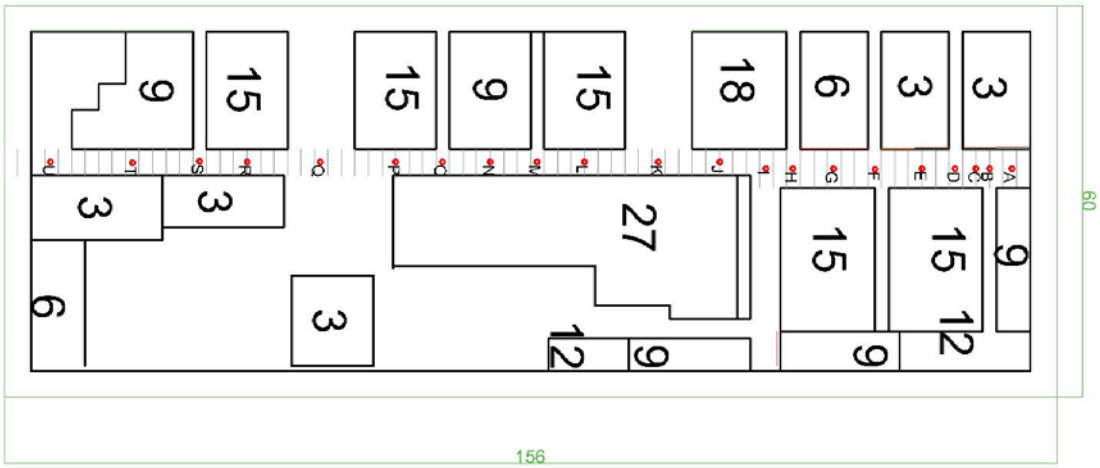

Figure 2. Calculation of H/W ratio in TRA1NS canyon

Table 1 shows the calculation of (h x l) for the point G. Thus, the average height (H) of the street was determined by adding (h x l) of each point divided by total street length (L) (2) and subsequently, average H/W ratio was determined by dividing H by street width (W) (3).

$$\text{Average Height for the whole street, } H = \frac{\sum(A_{h.l} + B_{h.l} + C_{h.l} + \cdots\ldots\ldots\ldots + U_{h.l})}{L} \quad \textbf{(2)}$$

$$\text{Average H/W Ratio} = \frac{H}{W} \quad \textbf{(3)}$$

Here, *(A, B, C,…..., U)* represents individual points in the street where a change in height or street width has occurred. *h* is the average building height at individual points and *l* is their corresponding street length. *L* is total street length, while *W* is street width.

The study has used three parameters regarding H/W ratio: firstly, H/W ratio of the actual point where microclimatic measurement was carried out during the field survey[4] (H/W ratio_MP); secondly, the average value of H/W ratio[5] (H/W ratio_AV) in the canyon; and

[4] H/W ratio_Measurement Point = H/W ratio_MP
[5] H/W ratio_Site Average = H/W ratio_AV

finally, the standard deviation of H/W ratio[6] (H/W ratio_STDEV) of all relevant points in the street canyon.

Table 1. Calculation of individual building height (h) x length weightage (l) for point G in Figure 2

Point	Average Height per point calculation	Street width	Height/ Width ratio per point	Length Weightage *(l)*	Height *(h)* x Length weightage *(l)*
G	(6+15)/2 = 10.5	4	2.63	5	52.5

Calculation of SVF

SVF was calculated in ENVI-met models using microclimate simulations. Using the site information, models were constructed in ENVI-met and SVF was calculated at a 1.5m height of the street canyon. Three types of SVF values are used in this study: SVF of the actual point where the microclimatic measurement was carried out during the field survey[7] (SVF_MP) and secondly, the average SVF[8] (SVF_AV) of the canyon; and finally, the standard deviation of SVF[9] (SVF_STDEV) values across every grid point (2m x 2m) in the street canyon. For example, in order to calculate the average SVF of the FRA2EW street canyon, the SVF of each 2m x 2m grid point inside the ABCD rectangle is taken into account (Figure 3). The fish-eye images presented in Figure 4 also give an idea of the SVF characters of the individual sites. SVF is calculated in ENVI-met using the following formula:

$$\sigma_{svf} = \frac{1}{360} \sum_{\pi=0}^{360} cos\ \omega \qquad \textbf{(4)}$$

Here, w is the maximum cut-off angle in the spatial direction π.

[6] Standard deviation of H/W ratio = H/W ratio_STDEV
[7] SVF_Measurement Point = SVF_MP
[8] SVF Site Average = SVF_AV
[9] Standard deviation of SVF = SVF_STDEV

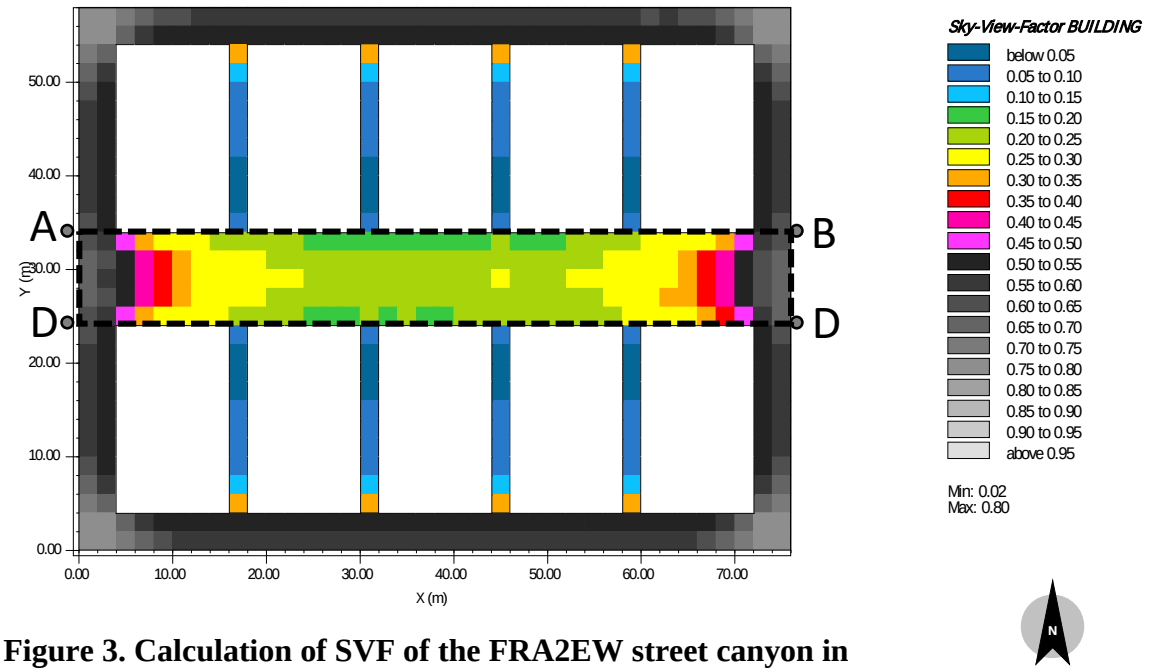

Figure 3. Calculation of SVF of the FRA2EW street canyon in ENVI-met model

Urban geometry matrices of the microclimatic sites are listed in Table 2.

Table 2. Urban geometry metrics of the microclimate sites

Site_abbreviated	H/W Ratio_AV	H/Wratio_MP	H/W ratio_STDEV	SVF_AV	SVF_MP	SVF_STDEV	S/V ratio	S(Plot)/V ratio	Form_factor
TRA1EW	2.9	4.2	1.399	0.231	0.135	0.155	0.245	0.256	8.7
TRA1NS	2.5	5.3	1.670	0.281	0.108	0.182	0.275	0.300	10.9
TRA2NS	2.5	1.9	1.114	0.249	0.143	0.118	0.357	0.380	11.6
FRA2EW	1.4	1.8	0.727	0.310	0.200	0.134	0.325	0.404	11.2
FRA2NS	1.0	1.3	0.537	0.345	0.241	0.103	0.305	0.355	11.4
FRA1EW	1.4	1.8	0.837	0.234	0.200	0.119	0.302	0.323	13.2
CAEW	2.1	3.5	1.030	0.198	0.124	0.102	0.132	0.145	10.1
ECA	0.1	0.1		0.699	0.548	0.131	0.613	0.755	15.5
Standard Deviation	0.935	1.688	0.425	0.161	0.143	0.027	0.137	0.177	2.021

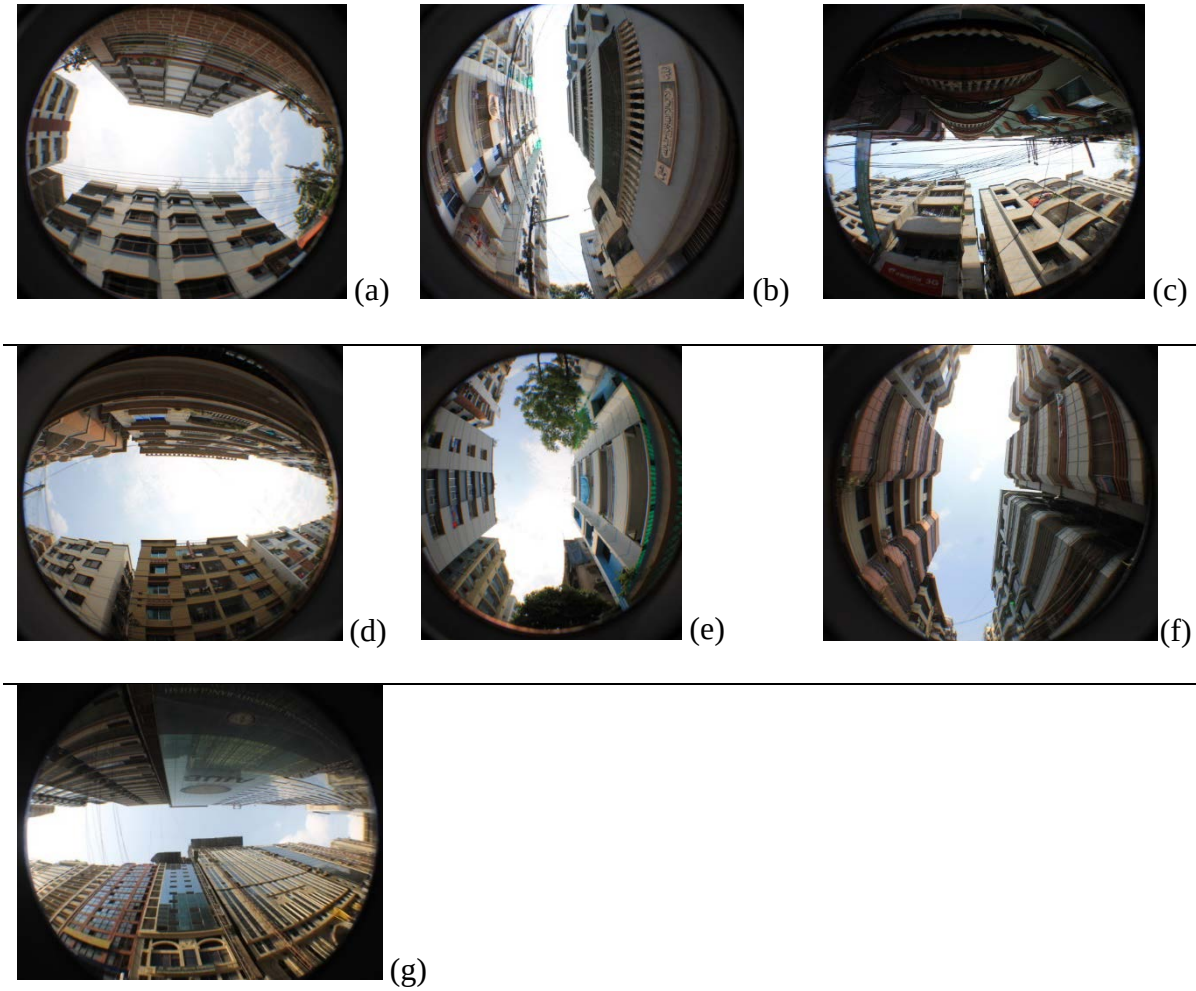

Figure 4. Fish-eye images in the case study areas depicting respective geometry characters: a)TRA1EW, b)TRA1NS, c)TRA2NS, d)FRA2EW, e)FRA2NS, f)FRA1EW, g)CAEW

Bibliography

Ratti, C. (2005). The lineage of the line: Space syntax parameters from the analysis of urban DEMs. *Environment and Planning B: Planning and Design*, *32*(4), 547–566. https://doi.org/10.1068/b31045