Chapter 7:

UNDERSTANDING SHADOWS

Shadow Templates

Understanding shadows is an important but sometimes overlooked principle of nature. Often shadows appear as part of an artists' concept of a proposed development, not to demonstrate its impact on surrounding land uses, but to enhance the visual drama of the particular building. By educating both the professional person and the average citizen, development proposals can be scrutinized more carefully.

In a society that is increasingly capturing solar heat through passive house designs, access to the sun's rays is not a question to be considered lightly. Indeed, to a home designed with passive solar applications, shadowing from adjacent structures is a serious subject of basic economics.

Prediction of shadows can be achieved with the use of the "Shadow Templates" . The shadow template set is the simplest tool available for determining the size and direction of shadows cast by any natural or man-made object. With no sectional drawing required, the set can be used for:

1. The design and evaluation of development proposals, plans, landscape and architectural designs, and even interior layouts. Shadow templates make possible the quick determination of shadows from the nearest hour after sunrise to the nearest hour before sunset on the 21st day of every month.

   Formula: Shadow length = Height x Coefficient

2. A determination of the height of the object, if the length of the shadow is stipulated. Thus, we can arrive at the permissible height of adjacent structures, trees, the height and size of an overhang, sunscreen, and also arrive at the desirable size and shape of windows, skylights and other openings and architectural features.

   Formula: Height = Shadow Length / Coefficient

There are twelve separate templates. They work most easily if they are photocopied onto a transparency sheet. The templates were developed by the Region of Hamilton Wentworth for the City of Hamilton. However, they are applicable for Kitchener as well as any other city on the globe that is located between 42^{o}N and 44^{o}N Latitude. Referring to the enclosed map, the reader can obtain a better understanding of metropolitan areas that are located at a similar latitude to Kitchener.

There are twelve mylar templates, one for each month. The templates were designed for (and are accurate only for) the 21st day of each month. The altitudes and azimuths correspond to the sun angles as described on the Ecochart- Each template has a "cross-hairs point" with compass directions of north, east, south, and west. Concentric circles radiate out, and timelines are provided in one hour internals from sunrise to sunset. At the base of the template is a box that should be used when dealing with terrain that has an average slope in the range of 1% to 5%.

The reader should specifically note that all times are expressed in SOLAR TIME. Solar time is universal, and does not indicate any form of local time (that appears on your watch). The conversion of solar time to local time is somewhat complex, and changes from day to day. It is far simpler for the practitioner to describe all resulting shadows as occurring on the basis of solar time. The full extent of the resulting shadows will still occur on that day, however it will occur at the specified solar time, rather than local time.

Constructing Shadow Diagrams

Accurate shadow diagrams can be constructed using the following procedure.

Step 1: Determine and Plot True North

Precise diagrams depend upon fixing the line of True North on your site plan or construction drawing. A quick way of doing so is by obtaining a survey plan of the subject property. Typically, a survey plan will show property boundaries, the location of existing structures, easements, distances, and the direction of north. North on a survey plan represents True North (unless otherwise specified). Use this direction to construct your shadow lines. In the absence of a survey plan, you can obtain from the Planning and Development Department of most cities a "Grid Sheet" for your respective area of the city, for a nominal fee. The grid sheet will show your property and all surrounding registered lots, public streets and lanes, as well as registered agreements. The left and right borders of the grid sheet represent True North. With a set of triangles, or parallel rules, transfer the vertical edge through your lot. Measure the angle of intersect with any one of your property boundaries. You can now transfer that measured angle to your construction drawing.

Step 2: Select the Desired Template

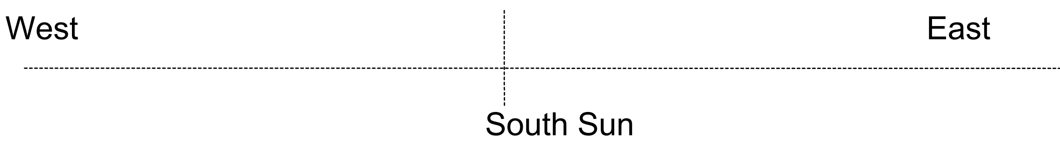
Select the template or templates that are most relevant to the plot that you need to construct. If you are making an annual assessment, it is best to begin with a series of 4 plots, June 21 and December 21, for the highest and lowest sun angles, and March 21 and September 21, for the median angles.

Step 3: Overlay the Centre of the Template on One Corner of the Proposed Structure

Be precise! The North-South line on your site plan should be totally in line with the 12:00 line of the Template. The East/West line on the template should also correspond exactly with the east-west line on your site plan.

Step 4: Transfer the required Timelines from the Template to the Site Plan

Mark the outside points of the timelines at the edge of the transparency onto your plan. Note the N,S,E,W coordinates and label each timeline for its time of day. Remove the transparency. Connect up the points with the chosen corner of the building to complete the transfer of the shadow timelines onto your drawing.



Step 5: Determine shadow length for each timeline

This is accomplished by multiplying the height of the object by the respective timeline coefficient. The coefficients are located on the timelines. Using January 21st, the following time lines would produce the following shadow lengths, for an object 20 feet in height.

Step 6: Plot these lengths (to scale) on your site plan.

TIME	COEFFICIENT	HEIGHT (m)	SHADOW LENGTH(m)
8:00	9.058	6.0	54.348
9:00	3.839	6.0	23.034
10:00	2.578	6.0	15.468
11:00	2.097	6.0	12.582
12:00	1.962	6.0	11.772
13:00	2.097	6.0	12.582
14:00	2.578	6.0	15.468
15:00	3.839	6.0	23.034
16:00	9.058	6.0	54.348

Now that you have the basic principles mastered, try the following exercises.

EXERCISE I:

Find the shadow of a 3 metre pole at 9:00, 10:00, 11:00, 12:00, 13:00, 14:00 and 15:00 hours.

DATE: December 21st
LOCATION: Kitchener
SLOPE: Flat (0%)

Step 1
Mark location of pole on site plan, and determine True North. North axis through centre of object (3 metre pole).

Step 2
Select proper template.

Ste 3
Overlay template on site plan so that the cross in the circle of the template exactly matches the centre of the object. Make sure that the 12:00 timeline covers the drawn True North axis.

Step 4
Mark on the site plan the ends of the desired timelines, and remove template. Construct timelines.

Step 5
Multiply the height of the object (3 metres) by the respective coefficient for each timeline, as shown below:

TIME	COEFFICIENT	HEIGHT (m)	SHADOW LENGTH(m) =Coefficient x Height
8:00	n/a	3.0	
9:00	4.829	3.0	14.487
10:00	3.078	3.0	9.234
11:00	2.463	3.0	7.389
12:00	2.289	3.0	6.867
13:00	2.463	3.0	7.389
14:00	3.078	3.0	9.234
15:00	4.829	3.0	14.487
16:00	n/a	3.0	

Step 6
Scale each length on site plan. Join the ends of each shadow line, and observe the arc that is formed by shadow moving progressively from the west to east.

EXERCISE 2:

Find the shadow of a 3 metre pole at 6:00, 9:00, 10:00, 11:00, 12:00, 13:00, 14:00, 15:00 and 18:00 hours.

DATE: June 21st
LOCATION: Kitchener
SLOPE: 5% North

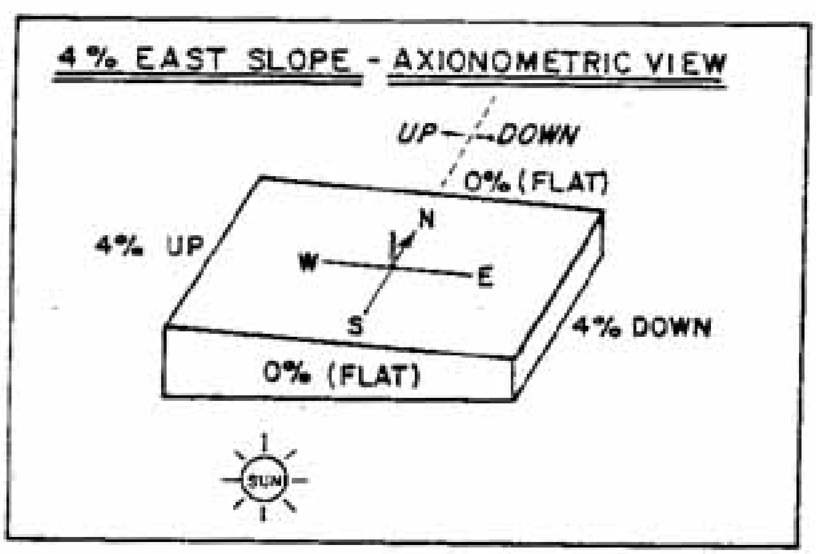
<u>Step 1</u>
Mark location of pole on site plan, and determine True North. True North axis through the centre of the object.

<u>Step 2</u>
Select proper template.

<u>Step 3</u>
Overlay template on site plan so that the cross in the circle of the template exactly matches the centre of the object. Make sure the 12:00 timeline covers the drawn True North axis.

<u>Step 4</u>
Mark on the site plan the ends of the desired timelines.

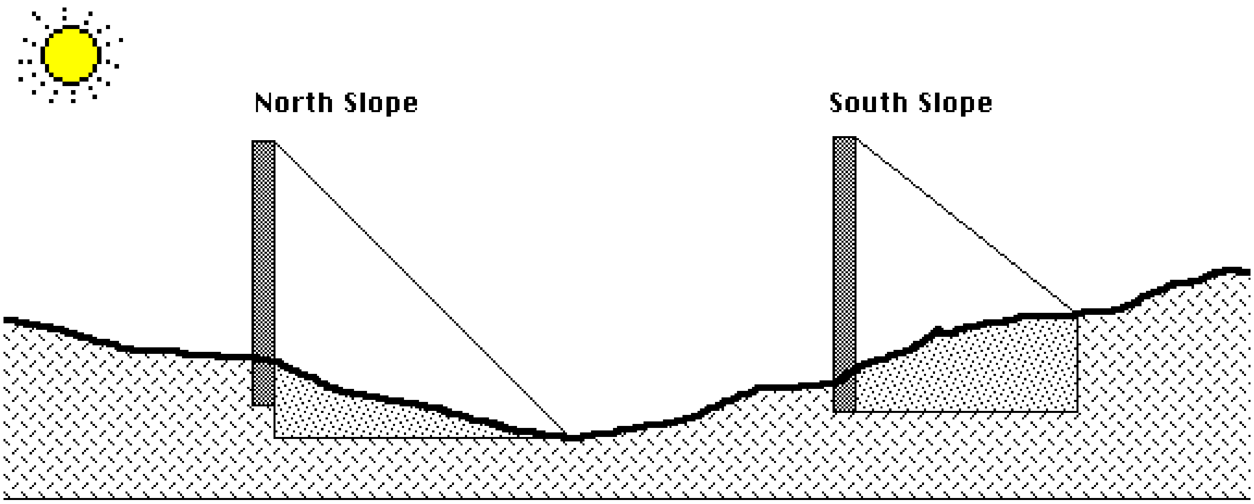
<u>Step 5</u>
Determine slope for each timeline. This step requires some explanation. The example states degree of slope (5%), and direction of slope (North). In terms of direction a simple question needs to be answered:



Q: Does the terrain slope **up** or **down** from the object that is casting a shadow? (Refer to the following sketch).

A: A "north" slope slopes **down**.

South sun



- North slope slopes DOWN or away from the object.
- North slopes generally lengthen shadows.
- South slope slopes UP or toward the object.
- South slopes generally shorten shadows.

(Conversely, a "south" slope slopes up.) The template has five concentric rings. At the 12:00 Noon timeline, note that where the rings cross the timeline the following notations appear: 1%, 2%, 3%, 4%, 5% (from the inside to the outside). Therefore, when dealing with a 5% slope you would use the outermost ring.

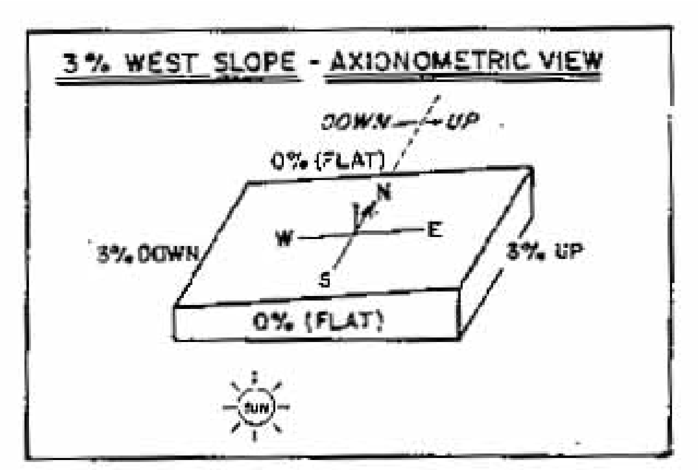
On this outer ring, note that along the arc from 12:00 down to the East/West line there is a series of large dots. Every other dot has a percentage figure. These dots divide the 90 degrees of arc into five equal portions. Observe the other rings, and you'll see that the 4% slope ring is divided into four equal parts; the 3% slope ring is divided in three equal parts, etc.

When calculating shadows on slopes, each timeline's coefficient needs to be considered individually. Referring to the sketch below, and the June 21st template, we know that the 12:00 timeline will have 5% Slope-Down. Referring to the table in the lower part of the template, the length coefficient is 0.363.

The 8:00, and 16:00 timelines on the other hand will have 0% slope. Refer back to the sketch, and notice that the East/West line cuts perpendicularly across the slope. Therefore, both these timelines would have no slope. Observe the template where these lines cross the 5% (outer) ring. At that point a value of O% appears, and therefore the coefficient on the timeline would be used (1.308).

The balance of the dots are used to interpolate the amount of slope for timelines. Observe the 11:00, and 13:00 timelines. Along these lines, the amount of slope is in the order of 3% (Down). The coefficients from the table would be 0.432.

Observe the 6:00 and 18:00 timelines. They are located on the south side of the East-West line. In these cases, the slope of the lines is in the order of 1% but they are "up" rather than "down". Of course the reason for this is obvious, in that the sun is situated on the northern side of the East/West axis. (Refer to the above axonometric figure). The coefficients would be 3.399 in both cases.



Step 6

Multiply the height of the object (3 metres) by the respective coefficient.

TIME	SLOPE (%)	COEFFICIENT	HEIGHT	SHADOW LENGTH =coefficient x height
6:00	1% (up)	3.399	3.0	10.197
9:00	4% (down)	0.927	3.0	2.781
10:00	2% (down)	0.620	3.0	1.86
11:00	3% (down)	0.432	3.0	1.296
12:00	5% (down)	0.363	3.0	1.089
13:00	3% (down)	0.432	3.0	1.296
14:00	2% (down)	0.620	3.0	1.86
15:00	4% (down)	0.927	3.0	2.781
18:00	1% (up)	3.399	3.0	10.197

Step 7
Plot lengths and connect shadows.

Other Kinds of Slopes

The templates can be manipulated to accommodate any direction of slope. It is helpful to draw a small axonometric diagram to give you the correct overview of the situation.