Kikayon 1.6.0

Grasshopper code for street shade calculations in Rhino 8

What does the code allow to calculate?

Kikayon is a **Grasshopper** code that enables the users to perform a parametric examination of the effect street design has on its shading conditions. Under hot climatic conditions, exposure to solar radiation in the summer causes a significant increase in the heat load felt by road users. Therefore, quantifying the degree of shading and its availability makes it possible to predict in a reliable and consistent manner the extent to which a street's design has a negative or positive effect on the climatic conditions prevailing in it and the heat loads its users are exposed to. The code also allows the examination of different shading modes by quantitatively evaluating their effect on improving the shading conditions on the street.

The code uses two different shading indices, calculated for the following parts of the street:

1. **Right of way:** the entire area of the street segment, which includes the two sidewalks, the road between them and possibly a central boulevard.
2. **Road:** The total area allocated for the passage of cars and vehicles. If a pedestrian boulevard is planned in the centre of the street, the area of the road includes the two driveways that delimit the boulevard on both sides.
3. **Sidewalk 1:** One of the two sidewalks. This area does not include the private open space between the front plot line and the front building line.
4. **Sidewalk 2:** The other of the two sidewalks. This area does not include the private open space between the front plot line and the front building line.
5. A central **walking boulevard** (optional).

The quantitative indices calculated by the code are the following:

1. **Shade Index (SI):** This index represents for a given unit area the ratio of the cumulative amount of global solar radiation that was blocked before reaching ground level to the

global solar radiation that would have reached the ground without shading. The index ranges from 0 to 1: the closer the value is to 1, the higher the daily shading level. By default, the Shade Index is calculated for August 6 between 8:00 and 17:00 DST. However, similar values can be calculated for other dates (see the "General Settings" section below on how to change the date and times of calculation).

2. **Shade Availability Index (SAI):** This metric indicates the relative amount of time during the reference period in which at least 50 percent of the area of a sidewalk or walkway is shaded. For example, if more than 50 percent of the sidewalk area is in the shade for 4 hours out of a 10-hour period, the Shade Availability Index will be 0.4. The index ranges from 0 to 1. By default, The SAI is calculated for August 6 between 8:00 and 17:00 DST. **The recommended minimum SAI value is 0.5**, which can be described as "acceptable shading". SAI value of 0.7 and above indicates very good shading, and values of 0.9 or above – excellent shading.
3. **Number of Trees:** The total number of trees planned on the street, without distinguishing between the types of trees.
4. **Tree Density per unit area (Trees per Dunam):** The number of trees per 1000 square meters of right-of-way area. The recommended value is 10 trees per dunam, as long as the physical conditions allow.
5. **Tree Canopy Cover ratio:** The ratio between the total area of tree crown vertical projections on the street and the total area of the street (the total right-of-way).

Installation

To run the code, you must first install the **Ladybug Tools** 1.8 plugin for **Grasshopper** by following the instructions below. **[Ladybug Tools]** is a plugin that includes a large number of computational functions relating to climate, buildings, energy, and lighting, and it is open for free use.

An up-to-date installation file of the plugin is available for download from the **food4Rhino** website which performs as a repository of **Grasshopper** plugins. To download Ladybug Tools, you first need to register on the **food4Rhino** website, then go to the **Ladybug Tools** download page. Download the latest version of the plugin (currently, 1.8).

Ladybug Tools 1.8.0 2024-03-23	A stable release of the Ladybug Tools (LBT) plugin for Grasshopper! Plugin includes Ladybug, Honeybee, and Dragonfly. It can be installed alongside Legacy without issues.	Grasshopper for Rhino 6 for Win Grasshopper for Rhino 7 for Win Grasshopper for Rhino 8 for Win Grasshopper for Rhino 6 Mac Grasshopper for Rhino 7 Mac Grasshopper for Rhino 8 Mac

After downloading the installation files, access the following webpage and follow the installation instructions of Ladybug Tools.

Please note: Besides installing the plugin, you also need to install the **Radiance** computation engine (without it, the radiation calculations in the **Kikayon** code will not work). **Radiance** installation instructions are included in the **Ladybug Tools** installation instructions under Optional Steps. The version of the **Radiance** engine that is compatible with **Ladybug Tools 1.8** is **Radiance 5.4a**. Its installation files can be downloaded from here. For **Windows** users, it is recommended that you download and run the installation file Radiance_b268408a_Windows.exe.

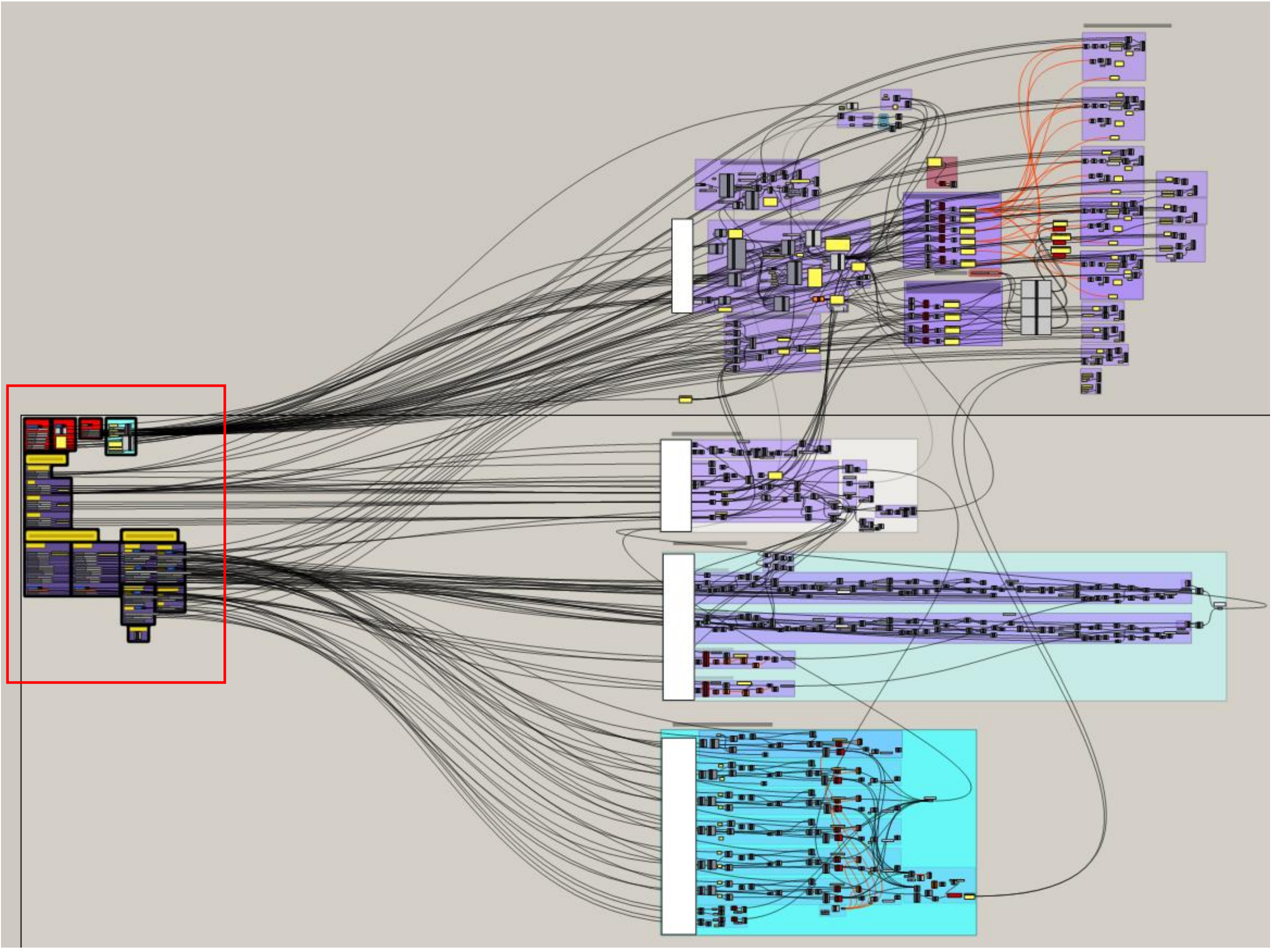
After installing **Radiance**, you should also set up a folder where the output files of the computation engine will be saved. The new folder should be saved at C:\ladybug\SkyMatrixNEW.

After the installation is complete, you must run the following files to start using **Kikayon**:

1. Open the Shade_Analysis_2.0.3dm file in **Rhino**.
2. Open the file Kikayon_1.6.gh in **Grasshopper** and start working with the shade calculation code.

User Interface

The code contains two distinct areas: on the left are the input components to be entered, and on the right are the set of calculations that are performed based on these inputs. **To make sure that the code is running properly, don't change anything in the components on the right side of the code layout**. The input elements that can be modified by the user are surrounded by a red rectangular in the following figure:



The recommended course of action is as follows:

1. Before running the code, we recommend that you save the **Rhino** and **Grasshopper** files under different names to keep the original files intact.
2. Determining the general characteristics of the street (length, width, orientation, sidewalk dimensions).
3. Determining building geometry on both sides of the street.
4. Running an initial radiation calculation to check the quality of shading received from the buildings.
5. Adding shading devices to the street – trees and/or awnings fixed to the walls of the buildings.
6. Running another radiation calculation to estimate the effect of the shading medium.

7. Updating the dimensions of the street and/or buildings and/or shading means and running additional radiation calculations for each configuration.

8. Comparing the results of the various design scenarios to determine the final design or design options.

The dimensions in the **Kikayon** code are in **meters** unless otherwise specified. You should make sure that your **Rhino** units are also set to meters.

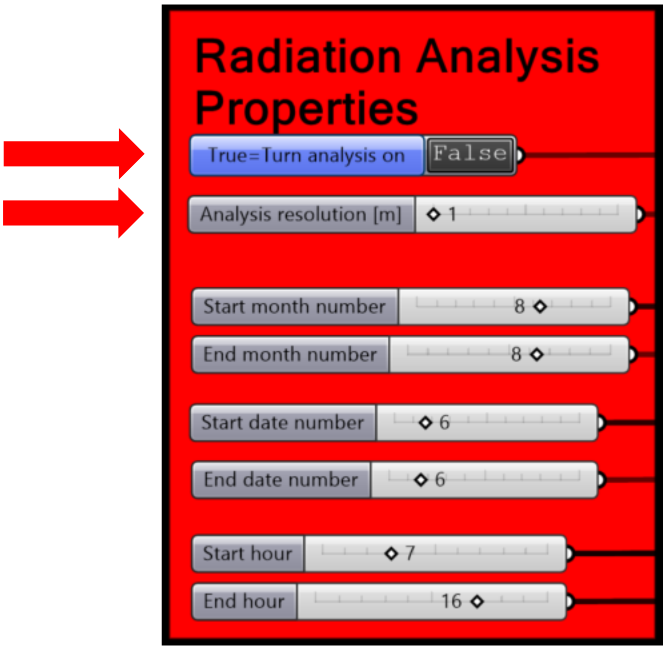
Input Components: General Settings

The top row of the input elements contains the general settings of the calculation and the output display. Below are detailed explanations of each component group in this part of the code.

Radiation Analysis Properties

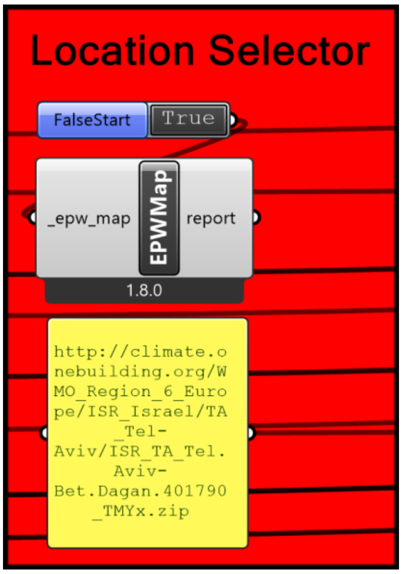
In this group, it is recommended to change only the top two components. The top component is a toggle button to run the radiation calculation. Clicking on this component will change the toggle state to True and start the calculation. You should run the calculation only after you have completed all street settings. The second component (Analysis resolution) is the component that determines the calculation resolution. The lower the number entered, the longer the calculation. A resolution of 1, for example, means that a separate radiation calculation is performed for each 1x1-meter area unit of the right-of-way in the modelled street. Since the resolution is spatial, it should be noted that doubling the calculation resolution is expected to extend the calculation time by four times. The recommended calculation resolution for initial calculations is 4, and for more advanced calculations, when it makes sense to examine the effect of adding different shading elements, the recommended resolution is 2 or 1.

The six additional sliders in this group of components allow control over the timing of the shading calculation. **It is recommended that you do not change the settings in any of these sliders.** The default is to calculate the cumulative effect of shade on August 6 between 7:00 and 16:00 (in fact, this is 8:00 to 17:00 DST), which corresponds to the height of summer. In southern hemisphere locations, it is therefore advisable to change the date to February 6 without changing the time span.



Location Selector

This group lets the user define the calculation location by finding a corresponding standard weather file. By clicking the toggle, an online global map will open on the computer's default browser. Click your preferred location on the map, and then click **Copy** to copy the web address of that location's weather file. Then, paste the copied address to the text panel right below the **EPWMap** component. By default, the calculation is based on a standard weather file from Tel Aviv, and the address leading to it appears in the text panel.



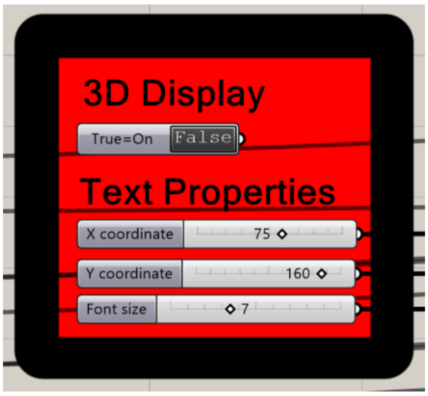
Display settings

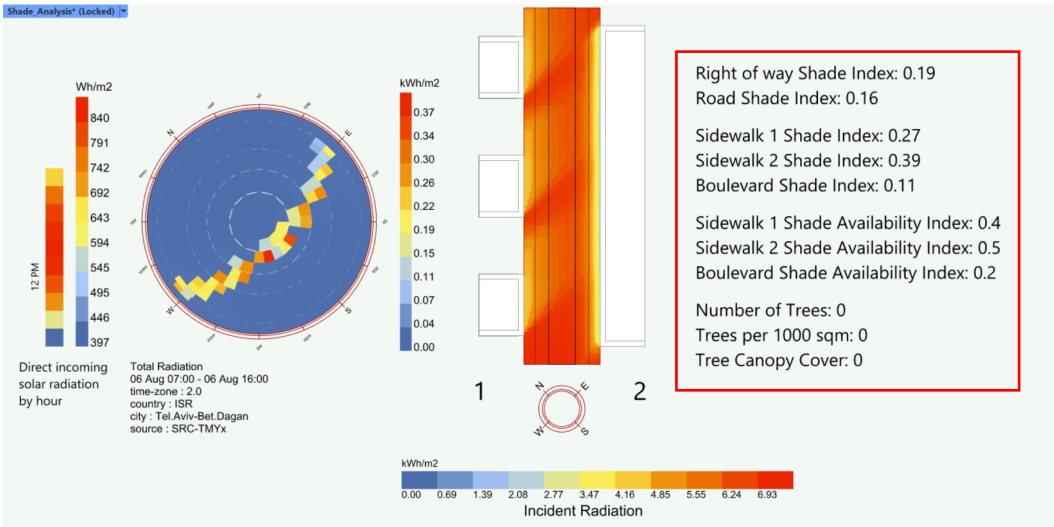
3D Display

The toggle button below **3D Display** controls how the trees in the model are displayed. In False mode, the trees are displayed in the model only as contours of their crowns. We recommended using it as the default display option for producing screenshots of different design scenarios. These screenshots should be taken when the **Rhino** Shade_Analysis viewport is the active viewport (this viewport is embedded in the Shade_Analysis_2.0.3dm file). Changing the toggle mode to True will turn on the 3D view of the trees. This mode is recommended for producing perspective screenshots or for a three-dimensional impression of the street design.

Text Properties

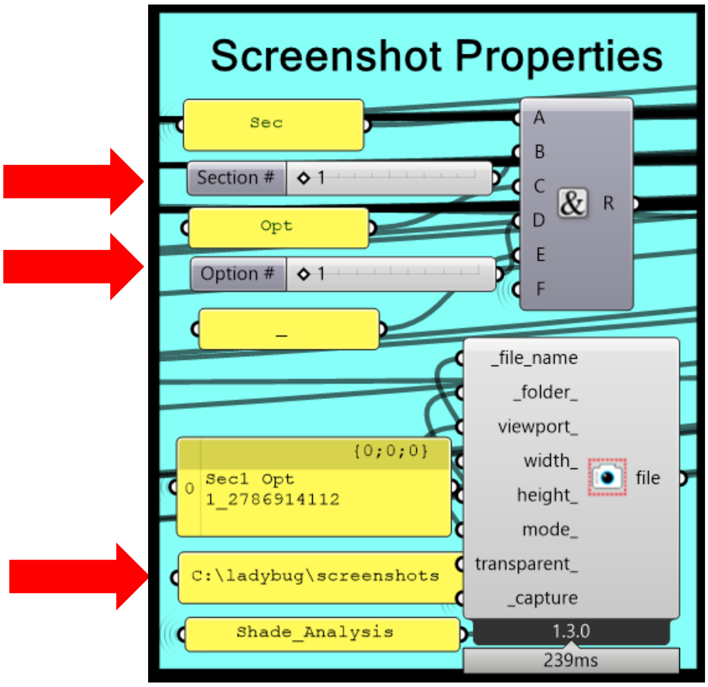
The three sliders control the position of the text in the right part of the default view: the relative position of the text on the **Rhino** screen and the size of the font displayed. **It is recommended that you do not change any of these values.**





Screenshot Properties

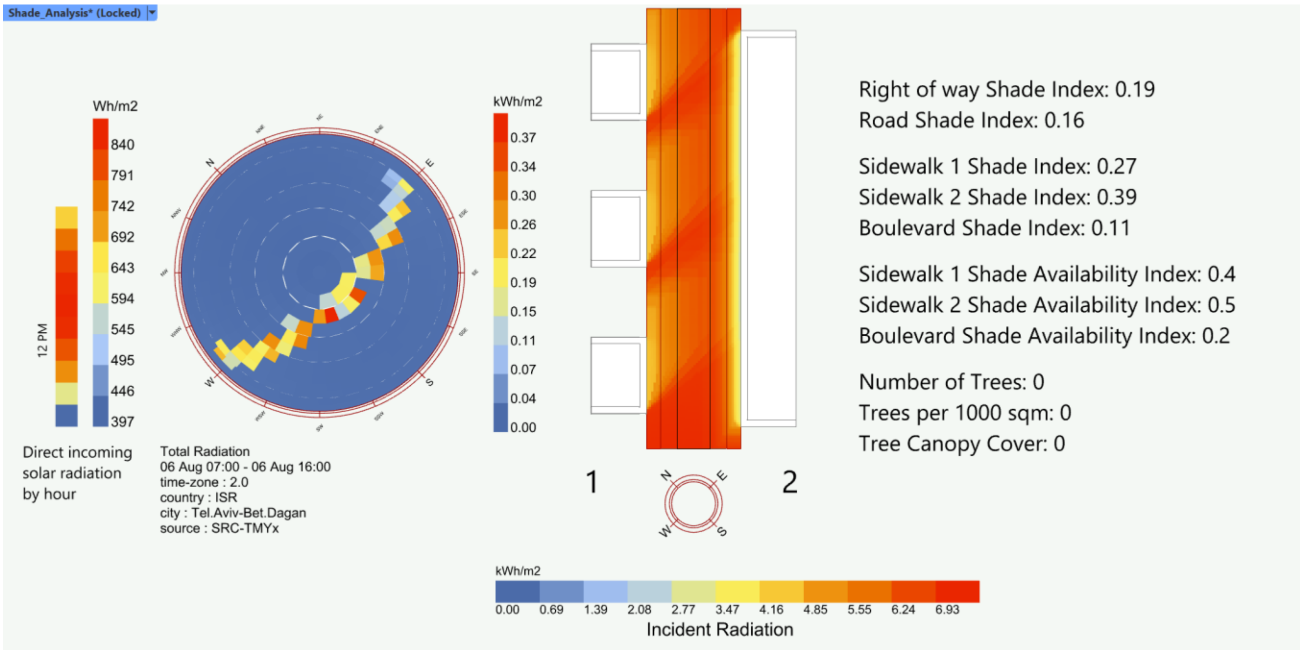
With each calculation of a new design state, the code automatically generates a png file that records the design, the shading map it creates, and the several metrics that describe the level of shading and the use of trees. In this group of components, it is recommended to change only the number of the modelled street section (slider Section #) and the number of the planning option being examined for that street section (slider Option #). The files are saved by default in C:\ladybug\screenshots folder on the computer where the code is run, and you should make sure it exists before running the calculations. You can change the save location by changing the contents of the corresponding text panel.



Input Components: Street Dimensions

In this part of the code, entries relating to the design of the physical dimensions and orientation of the street ("right of way"), including the separation between the car lanes and the sidewalks, must be determined. It should be noted that to maintain uniformity, the left side of the street is marked with the number 1, and the right side is marked with the number 2. In the default view, the street is displayed as a vertical longitudinal surface when viewed from above. Changing the orientation of the street does not change how the street is displayed in the main viewport in

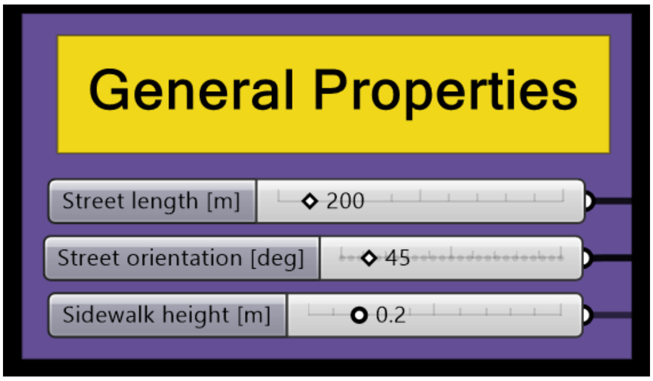
Rhino, and the different orientation is graphically represented by the rotation of the compass that appears at the bottom of the screen.



General Properties

In this section, three values must be defined:

1. Street length [m]. It is recommended not to exceed a 200-meter-long street segment to keep calculation time low.
2. Street orientation [deg]. An orientation of 0 degrees means that side number 1 is in the west and side number 2 is in the east. A 90-degree orientation means that side number 1 is in the north and side number 2 is in the south.
3. Sidewalk height [m]. It is recommended not to change this value since it has no real effect on the shading calculations and is intended for display only.

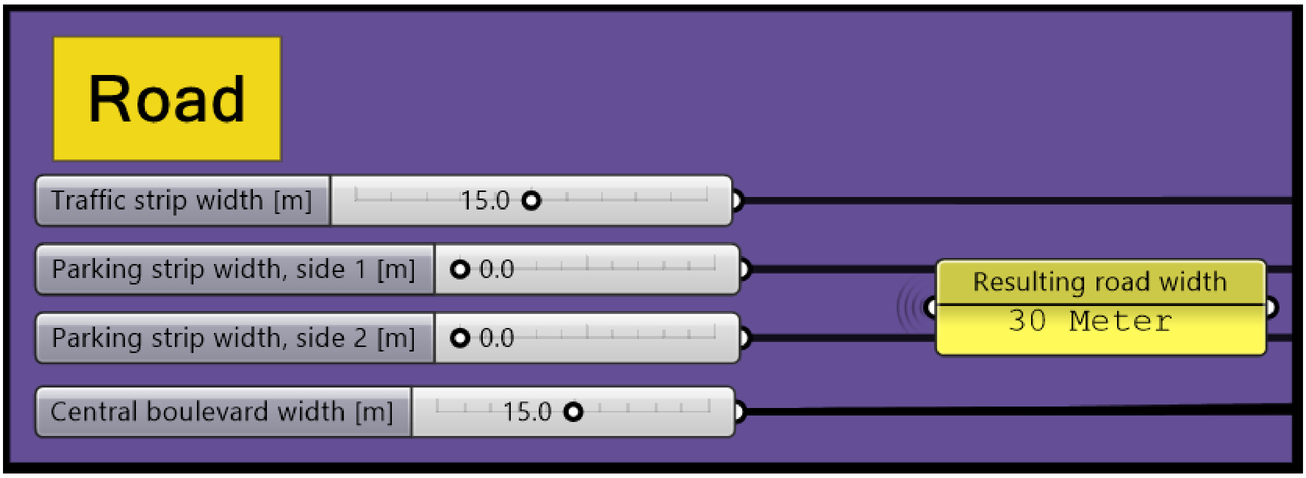


Road

In this section, the width of the road is defined using different functional strips, as follows:

1. Traffic strip.
2. Parking strip on side 1. If there is no parking strip, the value in the slider should be 0.
3. Parking strip on side 2. If there is no parking strip, the value in the slider should be 0.
4. Central boulevard. If there is no central walking boulevard, the value in the slider should be 0.

After entering these values, the width of the road is calculated as the sum of the widths of each strip. The value appears in the text panel to the right of the sliders.

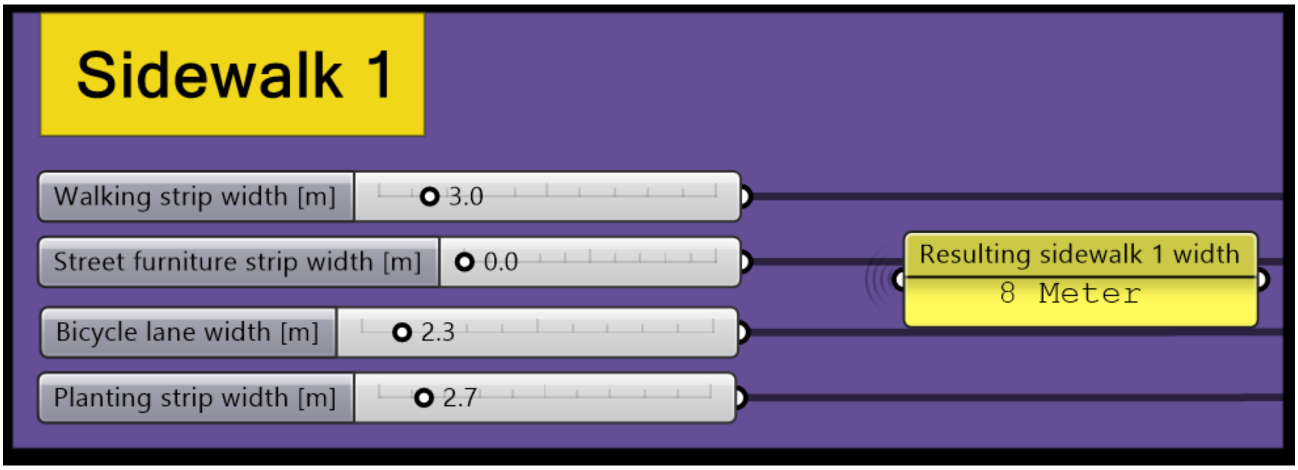


Sidewalk 1

In this section, the dimensions of the sidewalk on side 1 (left) are defined as a total width of a number of strips of different uses, as follows:

1. Walking strip.
2. Street furniture strip. If there is no such strip, the value in the slider should be 0.
3. Bicycle lane. If there is no bicycle lane, the value in the slider should be 0.
4. Planting strip. If there is no planting strip, the value in the slider should be 0.

After you enter these values, the width of Sidewalk 1 is calculated as the sum of the widths of each strip. The total width value appears in the text panel to the right of the sliders. Similarly, the width of each strip should also be entered for Sidewalk 2.



Input Components: Building Dimensions and Locations

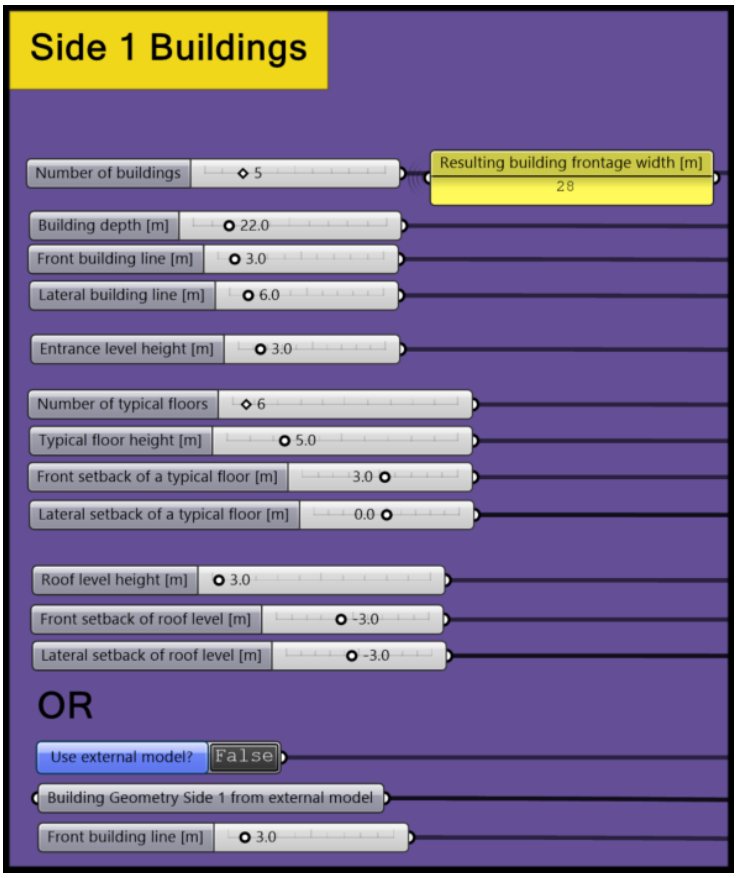
The modelling of the buildings on both sides of the street is based on the assumption that all the buildings along each side of the modelled street segment are identical and that each building has three distinct parts: an entrance level, several typical floors, and a roof floor or floors. For parametric modelling of the buildings, values must be entered for each building properties values on each side separately, as follows:

1. The number of buildings along the street. To the right of this slider is a text box showing the façade width of each building as a product of the data entered for the length of the street, the number of buildings, and the lateral spaces between them.
2. Building depth of the entrance level.
3. The front building line of the entrance level. The minimum building line is 0, representing a situation in which the building's façade at the entrance level directly faces the sidewalk, with no front yard between the sidewalk and the building.
4. Lateral building line of the entrance level. The lateral distance between each building and the building next to it equals twice the lateral building line.
5. Entrance level height.
6. Number of typical floors above the entrance level.
7. Typical floor height.
8. Front setback of a typical floor relative to the entrance level. A negative value means a

retreat of the typical floors from the front line of the building on the entrance level, while a positive value means a protrusion of the typical floor beyond the front building line of the entrance level. A positive value can be thus used to model a colonnade at the entrance level.

9. Lateral setback of a typical floor relative to the entrance level. A negative value means a retreat of the typical floors from the lateral building line of the entrance level, while a positive value means a protrusion of the typical floor beyond the lateral building line of the entrance level.
10. Roof level height.
11. Front setback of roof levels relative to the typical floors. A negative value means a retreat of the roof floors from the front building line of the typical floors, while a positive value means a protrusion of the roof floors beyond the front building line of the typical floors.
12. Lateral setback of roof levels relative to the typical floors. A negative value means a retreat of the roof levels from the typical floors' lateral building line, while a positive value means a protrusion of the roof floors beyond the lateral building line of the typical floors.

Alongside the option to generate a bottom-up building geometry based on these attributes, it is also possible to use an external 3D geometry that exists within the **Rhino** file on each side of the street and import it into the calculations of the **Grasshopper** code **instead of the** geometry generated by the parametric code. To do so, under the word OR, toggle the **Use external model?** Button to True, then right-click on the **Building Geometry Side 1/2 from external model** button below it. When the options pane opens, select **Set one BREP** from the drop-down list, then select the geometry of the buildings on the same side of the street from the open **Rhino** file. When you import multiple buildings to one of the street sides, you must add a thin surface 10 cm high right below all the buildings, and then join the buildings and the surface into a single 3D volume using **the Boolean Union command** in Rhino. This will ensure the buildings are inserted into the **Kikayon** model correctly. You can then determine the building line of the inserted buildings using the slider **Front building line [m]**. The file Shade_Analysis_2.0.3dm already contains sample linked 3D volumes, which will appear when you change the **Use external model?** toggle to True.



Input Elements: Shading Elements Design

This part of the code allows for the control of two main types of shading: shading by means of trees and shading by means of awnings that protrude beyond the building line. Trees can be placed along the sidewalks (up to two rows of trees per sidewalk) or in the center of the road/boulevard (up to two rows of trees). It is assumed that each row of trees is composed of trees of the same species and the same size, but it is possible to have separate control over the type and number of trees in each row of trees separately. The definition of the trees in each of the columns is done using the following components:

1. Tree type: Choose from a possible list of trees. Each tree has different settings for the height and diameter of the tree's crown (see below for how to change the settings for each tree type).
2. The location of the trunk is defined as a setback distance from the curb. The location of the trees on the central boulevard in the middle of the roads is determined in relation to the center line of the road.

3. The number of trees in each row of trees.

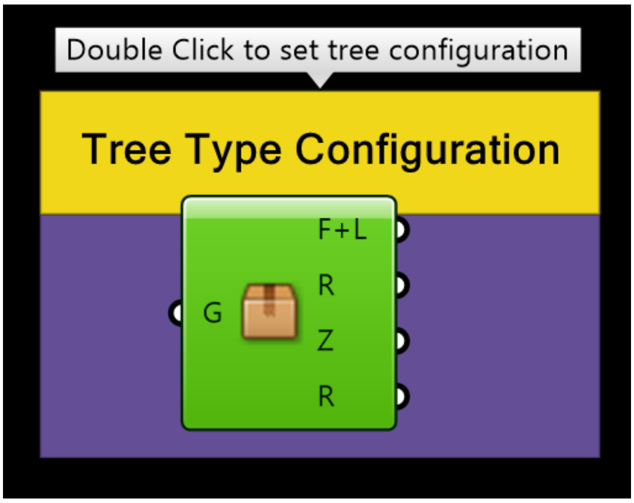
The fixed planting distance between trees in a row is calculated automatically and appears under the **Resulting distance between tree trunks [m]** component.

By default, trees are not included in the calculation model. To add a row of trees to the calculation, after defining its properties, change the toggle at the top of the tree settings to True. Another click on the toggle will remove the trees from the model. Note that the radiation calculations performed by the code treat the tree crown as an opaque volume that does not transmit light through it. In reality, crowns of healthy trees with a high leaf density will block more than 90 percent of the incoming solar radiation, but they will not be able to completely block solar radiation.

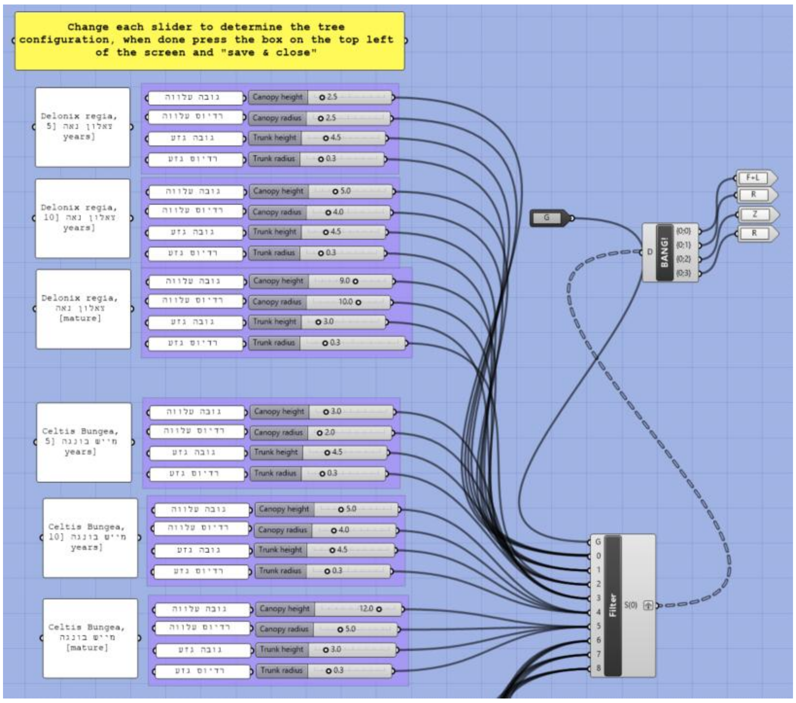
Horizontal awning is defined using two parameters: Height from the ground and Depth in relation to the façade of the entrance level.

Defining Typical Tree Type Characteristics

The code defines three types of trees (Delonix regia, Celtis bungea, and Fraxinus uhdei var obelisk), each in three stages of growth (after 5 and 10 years and in a state of full maturity). The physical dimensions of these trees are based on the work of agronomist Yaakov Eilon. However, you can define additional trees or change the geometric settings of new trees by double-clicking on the Tree Type Configuration component:

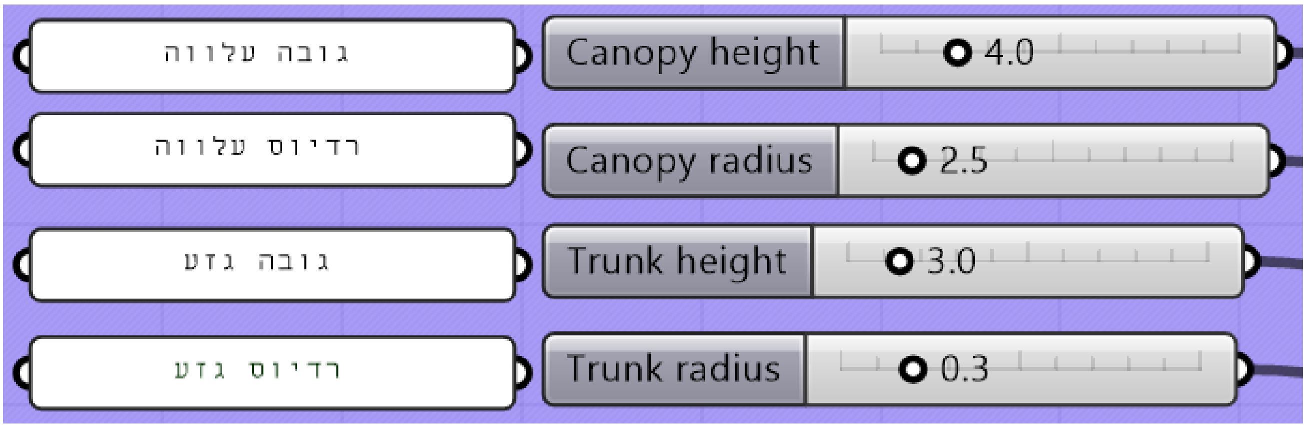


Double-clicking leads to the internal code, which looks like this:

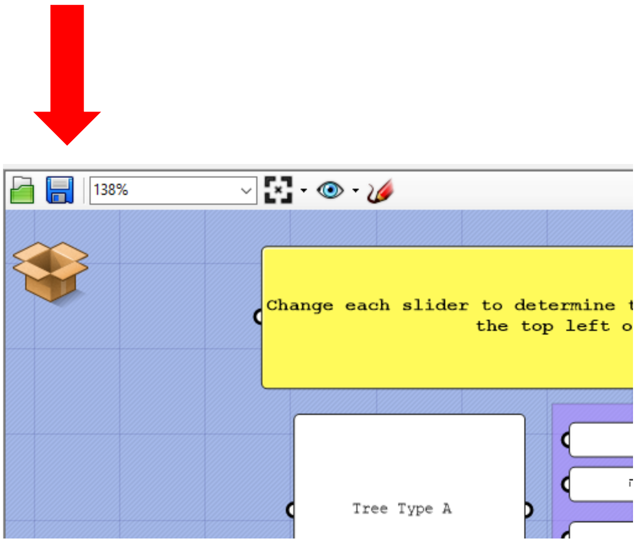


Tree geometry can be defined using four physical variables:

1. Crown height: The total height of the tree's crown, from the lower to the upper crown line.
2. Foliage radius (crown radius): The vertical projection radius of the tree crown.
3. Trunk height: The height between the ground level and the lower crown line.
4. Trunk radius: A horizontal cross-sectional radius of the trunk.



After updating the tree settings, click the floppy disk icon on the top left, below the **Grasshopper** toolbars, to save the new settings. This closes the Tree Type Configuration window, and the main calculation code reappears on the screen.



View Results

After entering the various parameters of the design and running the calculation, the results will appear in the default Shade_Analysis viewport in **Rhino**. The quantitative indices of the calculation will appear as text on the right side of the screen. In the center of the screen, a top view of the street will appear, with a color indication of the cumulative exposure of the ground level to solar radiation. The color legend of this display appears horizontally below the street plan. The radiation values are displayed in units of kilowatt-hours per square meter. As mentioned, in each calculation, a png screen image of the results display is automatically generated, allowing the different outcomes of different design scenarios to be documented.

To the left of the street plan is a circle representing the sky dome during the calculation period, including a representation of the sun's trajectory and intensity at the times relevant to the calculation. To the right of the circle representing the sky dome is a vertical color legend that allows the intensity of the incoming global radiation to be quantified in kilowatt-hours per square meter in each of the sectors of the sky shown in the circle. To the left of the sky dome, a legend shows the direct incoming solar radiation values by the hour for the same calculation period.