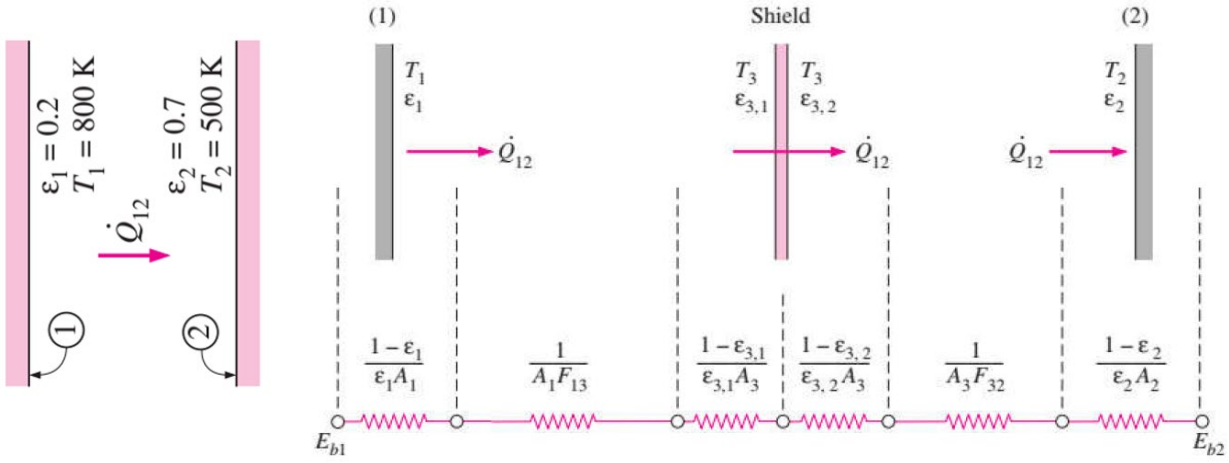
Task 1

Considering the same example you solved in the previous assignment (radiative heat transfer between two parallel plates), how many shields with epsilon = 0.1 should you add in order to have the new heat transfer rate to be 1% of the case without shields?



ANSWER

Without shield, $\boldsymbol{\varepsilon_1 = 0.2}$ ***and*** $\boldsymbol{\varepsilon_2 = 0.7}$,

$$\dot{Q}_{12} = \frac{E_{b1} - E_{b2}}{\frac{1-\varepsilon_1}{A\varepsilon_1} + \frac{1}{AF_{12}} + \frac{1-\varepsilon_2}{A\varepsilon_2}} = \frac{A\sigma(T_1^4 - T_2^4)}{\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1}$$

With N shield $\boldsymbol{\varepsilon_3 = 0.1}$

$$\dot{Q}_{12Nshields} = \frac{E_{b1} - E_{b2}}{\frac{1-\varepsilon_1}{A\varepsilon_1} + \frac{1}{AF_{13}} + \frac{1-\varepsilon_3}{A\varepsilon_3} + N \times \left(\frac{1-\varepsilon_3}{A\varepsilon_3} + \frac{1}{AF_{33}} + \frac{1-\varepsilon_3}{A\varepsilon_3}\right) + \frac{1-\varepsilon_3}{A\varepsilon_3} + \frac{1}{AF_{32}} + \frac{1-\varepsilon_2}{A\varepsilon_2}}$$

$$= \frac{A\sigma(T_1^4 - T_2^4)}{\left(\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_3} - 1\right) + N\left(\frac{1}{\varepsilon_3} + \frac{1}{\varepsilon_3} - 1\right) + \left(\frac{1}{\varepsilon_3} + \frac{1}{\varepsilon_2} - 1\right)}$$

$$= \frac{A\sigma(T_1^4 - T_2^4)}{\left(\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1\right) + (N+1)\left(\frac{1}{\varepsilon_3} + \frac{1}{\varepsilon_3} - 1\right)}$$

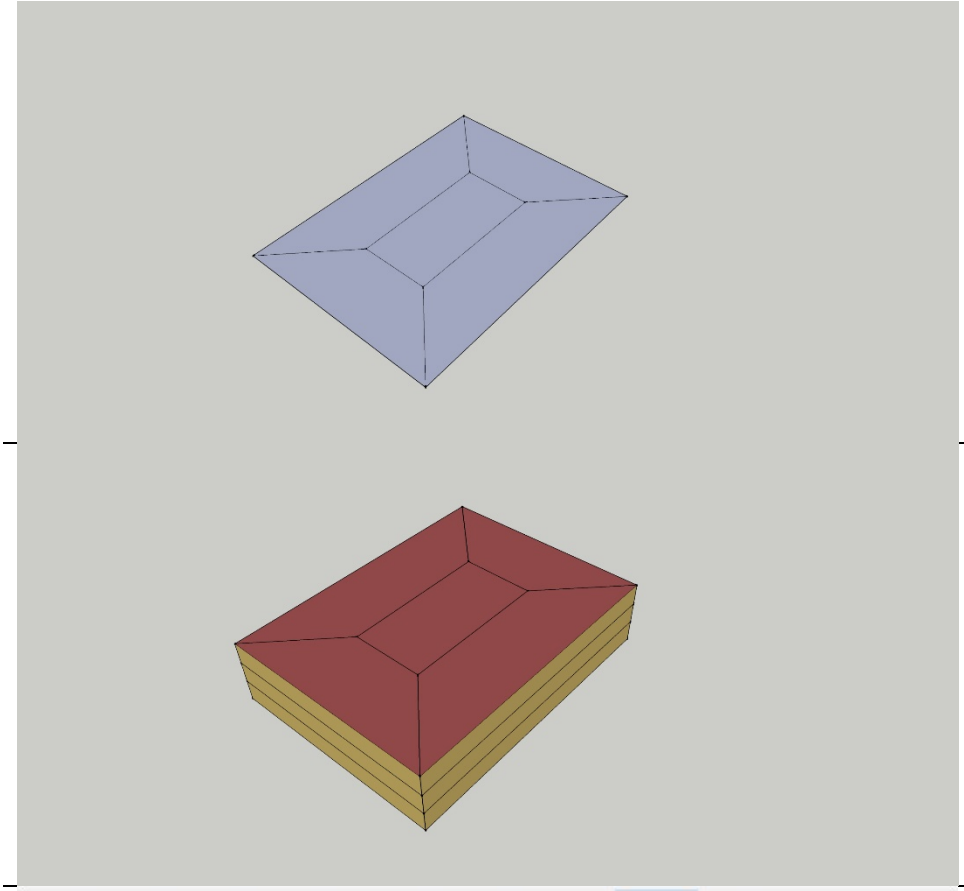
$$\frac{\dot{Q}_{12Nshields}}{\dot{Q}_{12}} = \frac{\left(\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1\right) + (N+1)\left(\frac{1}{\varepsilon_3} + \frac{1}{\varepsilon_3} - 1\right)}{\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1} = \mathbf{1} + (\boldsymbol{N}+\mathbf{1})\frac{\frac{1}{\varepsilon_3} + \frac{1}{\varepsilon_3} - 1}{\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1} = 100$$

$$\Leftrightarrow \boldsymbol{N} = 99 \times \frac{\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1}{\frac{1}{\varepsilon_3} + \frac{1}{\varepsilon_3} - 1} - 1 = 99 \times \frac{\frac{1}{0.2} + \frac{1}{0.7} - 1}{\frac{1}{0.1} + \frac{1}{0.1} - 1} - 1 \approx 27.3$$

Conclusion: 27 shields can be added.

Task 2

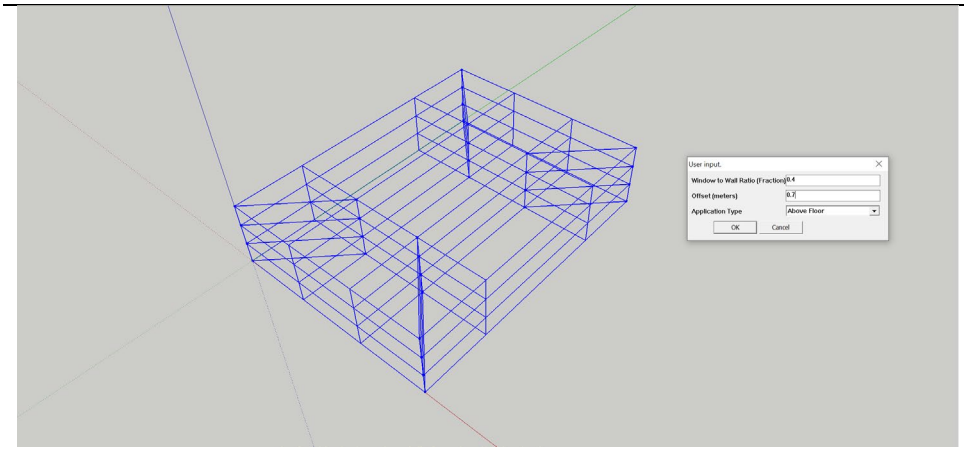
You should create a pdf file with screenshots of all the steps we went through (clearly from your own file) and explain briefly the reason behind the use of each step (in your own words!)



Draw Floor Plan Diagram by Sketchup

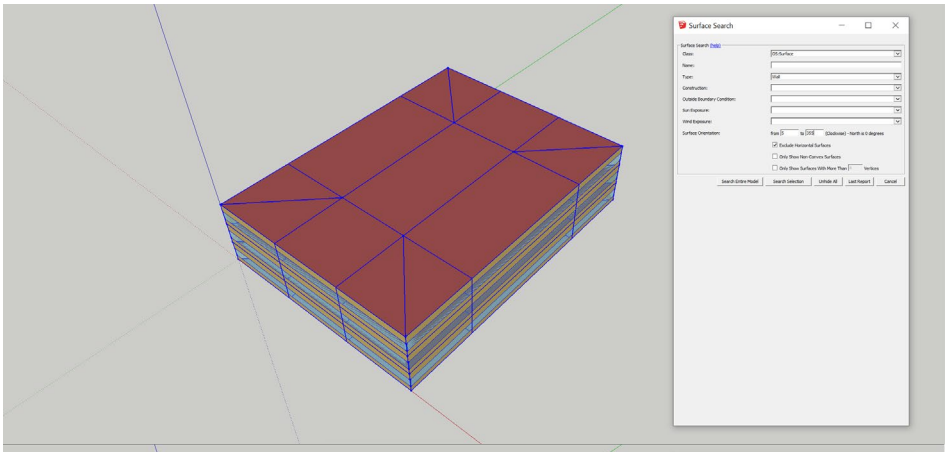
Open Studio Command:
Create Space from Diagram
> To quickly create the building. Every element is automatically given a function (wall, floor and roof).

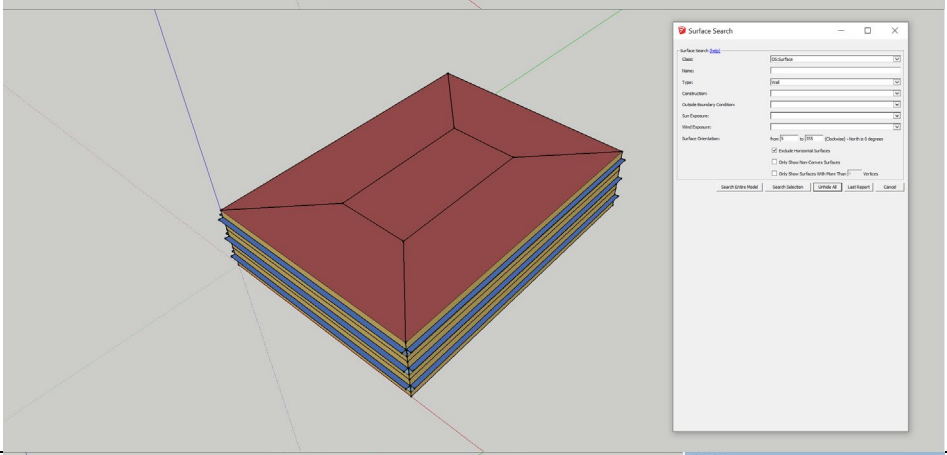
Open Studio Command:
Surface Matching
> To give definition of indoor/outdoor elements



Extension \ Open Studio User Script \ Set \ Alter or Add Model Element \ Window to Wall Ratio
> To add window (for calculation of heat transfer through wall)

It is not necessary to exactly model the architectural geometry because the result will be the same.

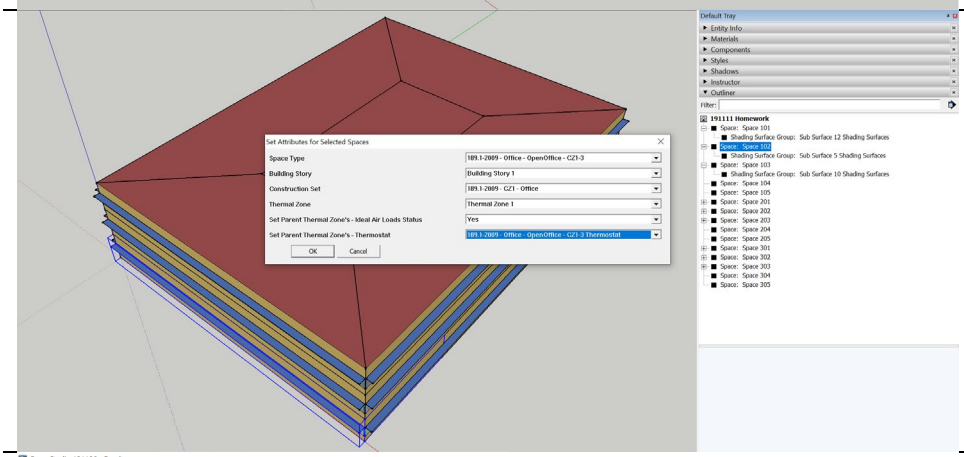




Open Studio Command:
Search Surfaces

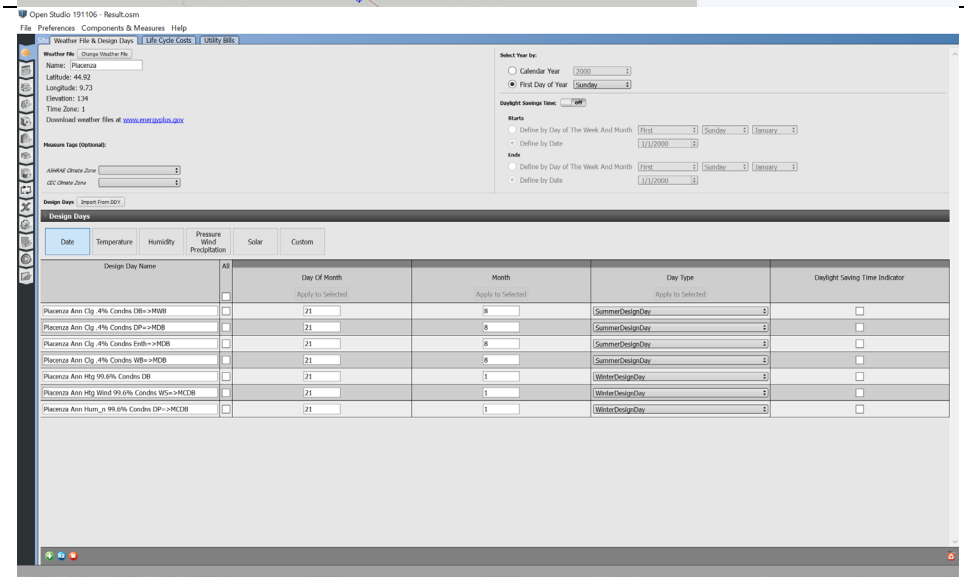
Extension \ Open Studio User Script \ Set \ Alter or Add Model Element \ Add Overhang by projection factor

> to add sun shading overhang on the selected exterior wall (in this case all walls except ones in the Northern side)



Assign Attributes to all the spaces

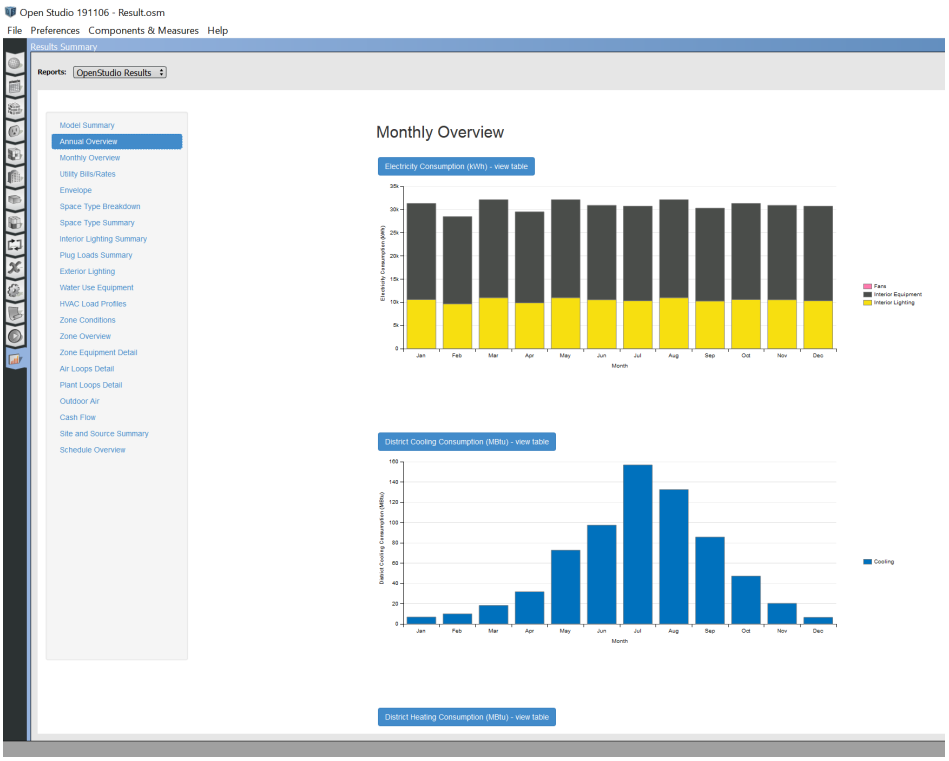
> to define the function (so that number of people, equipment, etc of the space is registered)



Open OpenStudio and import weather data.

Now we have all:
- Building geometry and material of the components
- Space function
- Climate data

We can click “Run” for calculation the building energy performance



Finally, we can read the result (including Open Studio Result and Energy Plus Result)