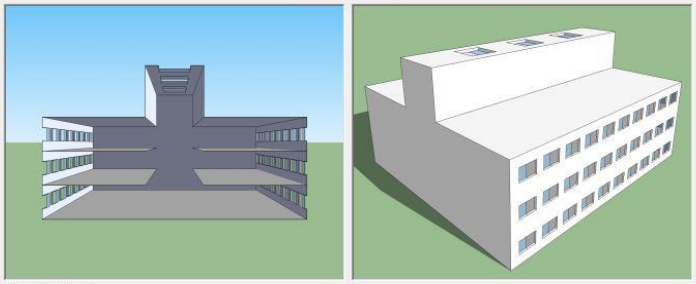
INPUTS: Central atrium; Jun

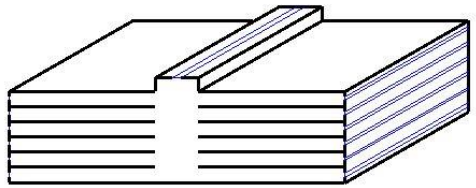
Simulation type
Transient (24 hour) Steady state (snapshot)

Building type
Central atrium



Internal heat loads
Heat source level: Educational 40 W/m^2
Occupancy schedule: From 9 hours to 24 hours
All zones but the atrium zones (if any) are assigned heat loads.
Off peak equipment load fraction: 0.2

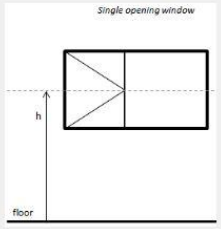
Terrain properties
Terrain type: Urban, industrial or forest area



Building dimensions

Number of floors:	6	
Floor length:	33	m
Floor (bay) width:	33.8	m
Floor-to-floor height:	3.5	m
Floor-to-ceiling height:	3	m
Chimney width:	10	m
Chimney height:	3	m

Side windows dimensions



In each floor, there is only one opening per window (see schematic)
In each floor, there are two openings separated vertically per window (see schematic). REQUIRED for single-sided ventilation

Window glazing area per floor per facade, fixed and operable (to calculate solar gains through windows):	7	m^2
Operable window area per floor (used to calculate air flowrate):	2	m^2
Height from floor to mid-opening (h):	1.75	m
Operable lower window area per floor per facade:	1	m^2
Height difference between upper and lower opening (Delta H in figure):	1	m

Roof opening dimensions
Roof operable area: 1 m^2
Note: CoolVent does not account for solar heat gains through the roof opening(s)

Internal opening dimensions
Internal opening area per floor: 20 m^2
Advanced internal opening options: Advanced...

Additional opening options
More window options and opening specifications: Advanced...

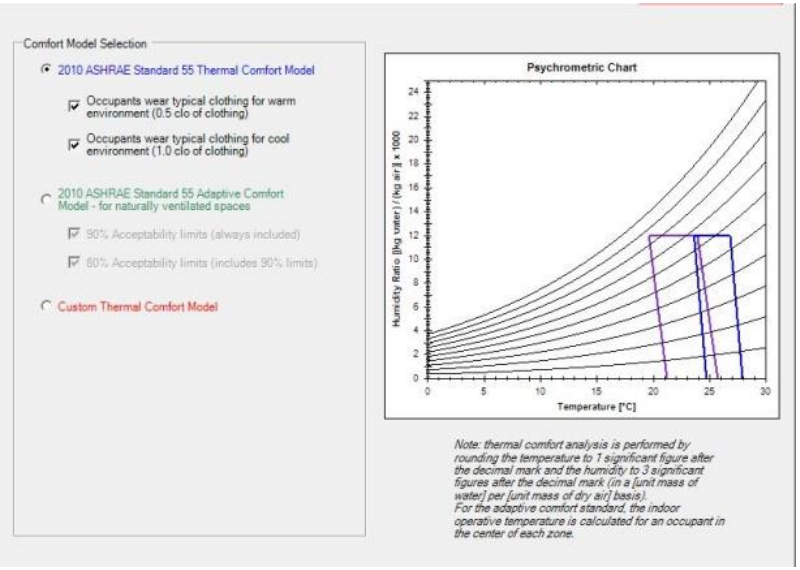
Thermal mass
Include slab thermal mass
Floor / roof slab thickness 5 cm
Exposed area 90 % of floor area
Floor slab material: Concrete
Floor type: Exposed
Ceiling type: Exposed

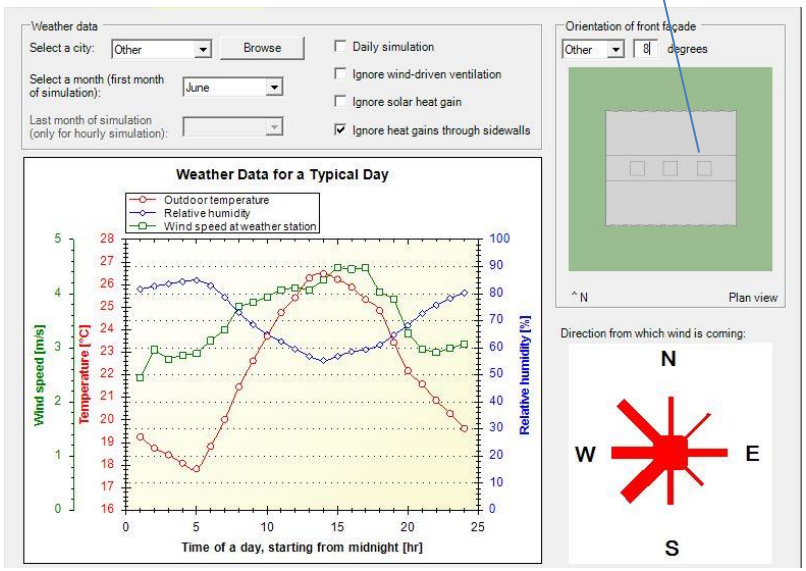
Night cooling
Use night cooling. Windows open at nighttime, when the air is cold enough to cool down the thermal mass. Windows close (down to 10%) during daytime to prevent hot outdoor air from entering the building. If the building has a fan, it will be used to assist night cooling.
Time controlled: close all windows at 7 hours, open windows at 19 hours
Temperature controlled: close windows in zones where temperature is lower than outdoor temperature; close windows otherwise

Window operation
Close windows when the outdoor air temperature drops below 16 °C
Close Window and turn on heating when any internal zone temperature drops below 18 °C

Hybrid ventilation mode
Use hybrid mechanical-natural ventilation
Turn on fan when any internal zone temperature is above 24 °C
or humidity ratio is above 0.012 (kg water) / (kg air) Windows will open even if using night cooling.
Close windows, turn off fan and turn on AC when any internal zone temperature is above 26 °C
or humidity ratio is above 0.012 (kg water) / (kg air)
Allow independent window and AC control in each zone
Define fan / AC operating characteristics: Specify fan / AC

INPUTS: Central atrium; Jun





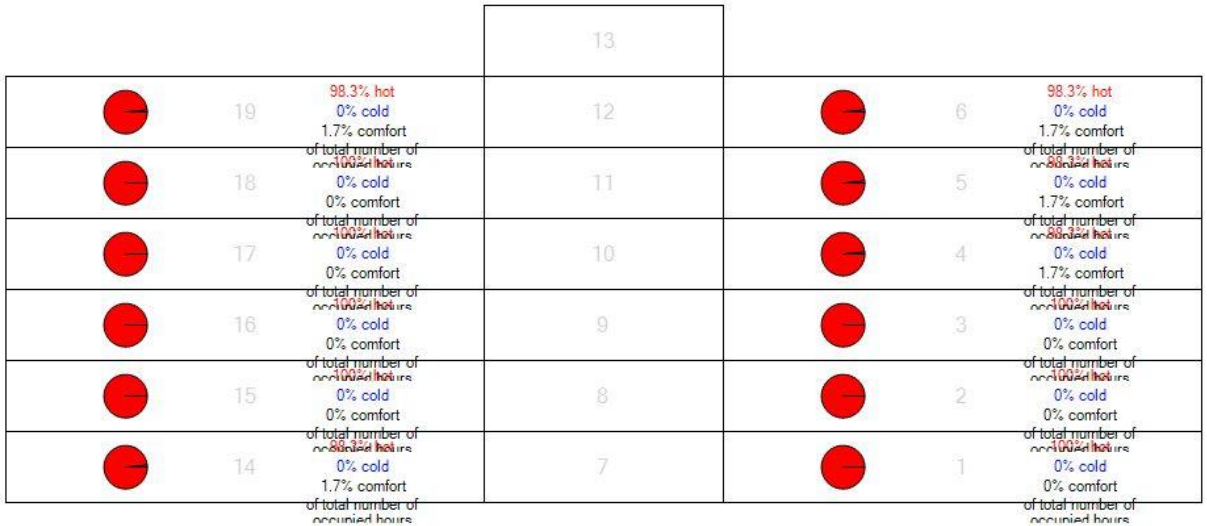
The above images show all the relative inputs for the simulation of the type 1: central atrium

REPORT: Central Atrium; Jun

CoolVent Thermal Comfort Results USA_PA_Philadelphia.Intl.AP.724080_TMY3

2010 ASHRAE Standard 55 Thermal Comfort Model

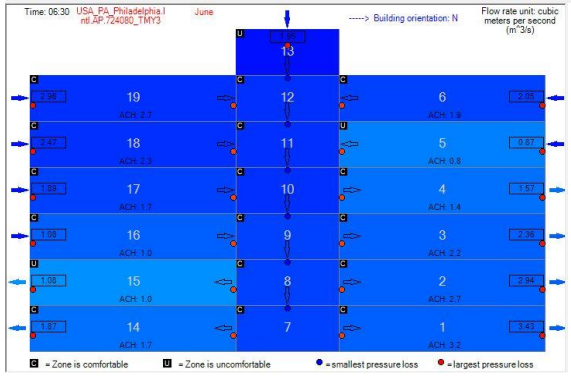
Temperature Pie Charts



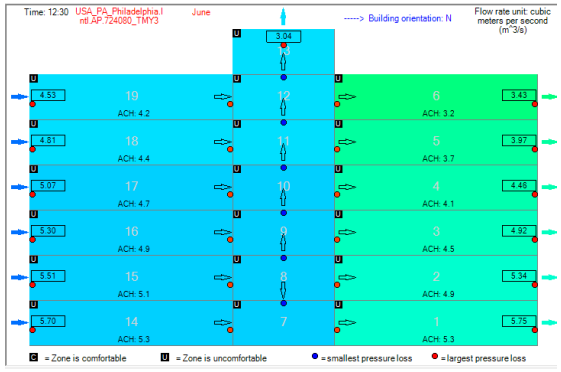
The pie charts represent temperature concerns for comfort in non-atrium zones of the building.

Red represents the percent of total occiped hours that a given zone is too hot.
Blue represents the percent of total occiped hours that a given zone is too cold.

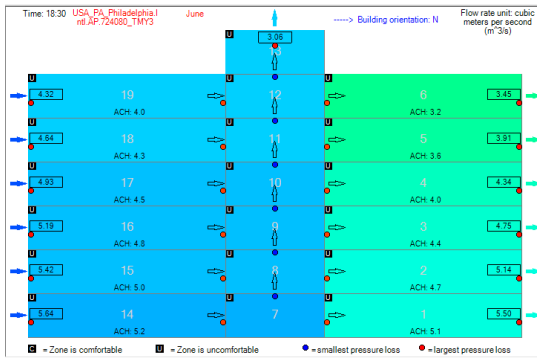
Humidity concerns are not addressed in the pie charts.



6:30



12:30



18:30

The report for the type 1: central atrium shows the building is too hot in June

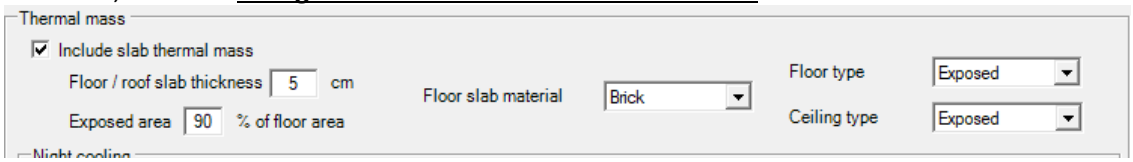
Specifically, the three images show the ventilation condition at 6:30 – 12:30-18:30. At 6:30, the building is almost comfortable; however at 12:30 or 18:30 the building is totally uncomfortable.

IMPROVEMENT TESTS: Central Atrium; Jun

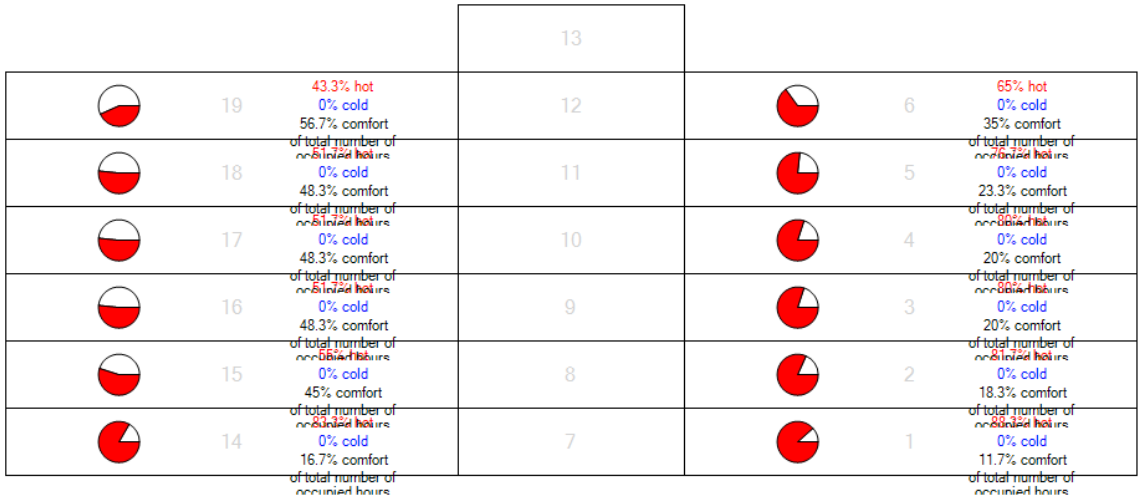
- Thus, the first strategy to improve the comfort condition is **<u>to include slab thermal mass</u>**

Then the comfort results improved around 20%-50%.

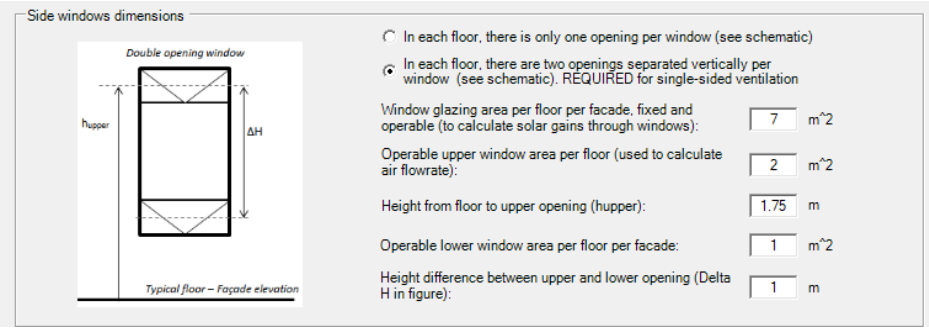
And then, I tried to **<u>change the material from concrete to brick</u>**



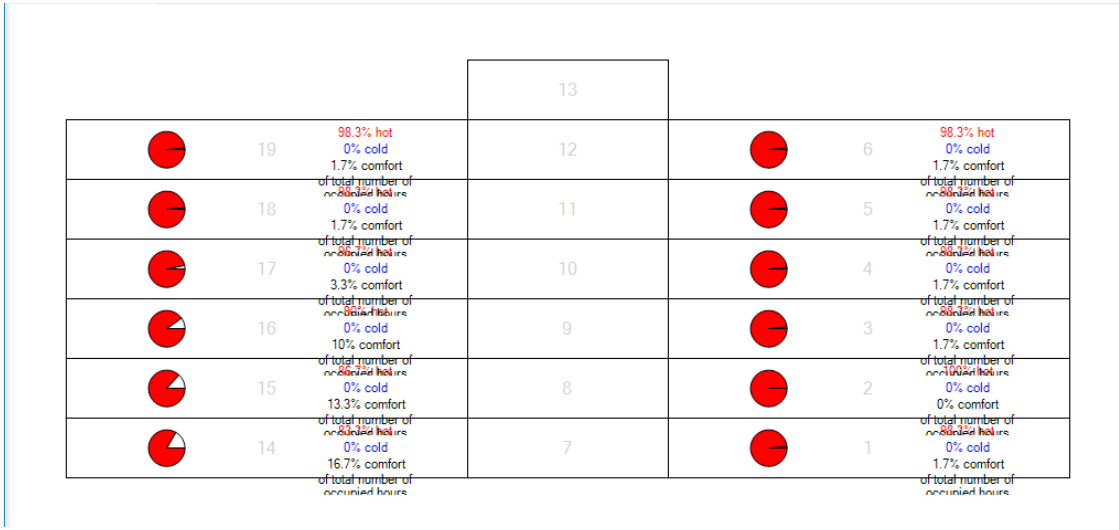
But the result does not change dramatically



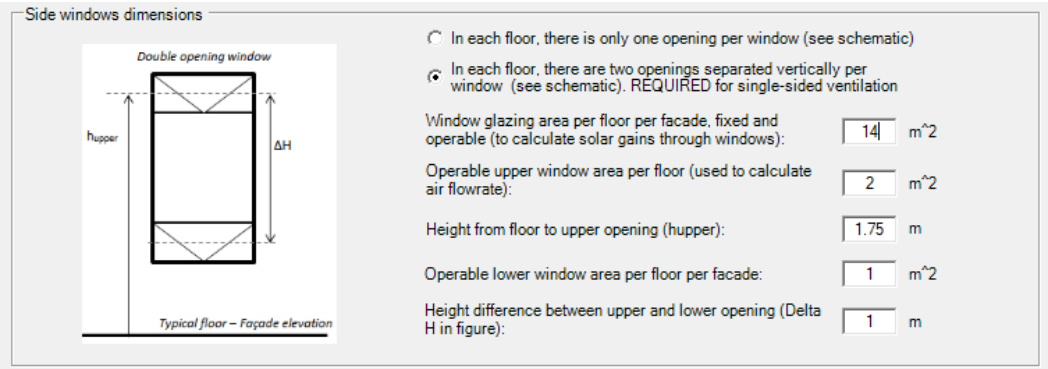
- The second strategy is to change **<u>the side windows type from only one opening per window to two openings</u>**



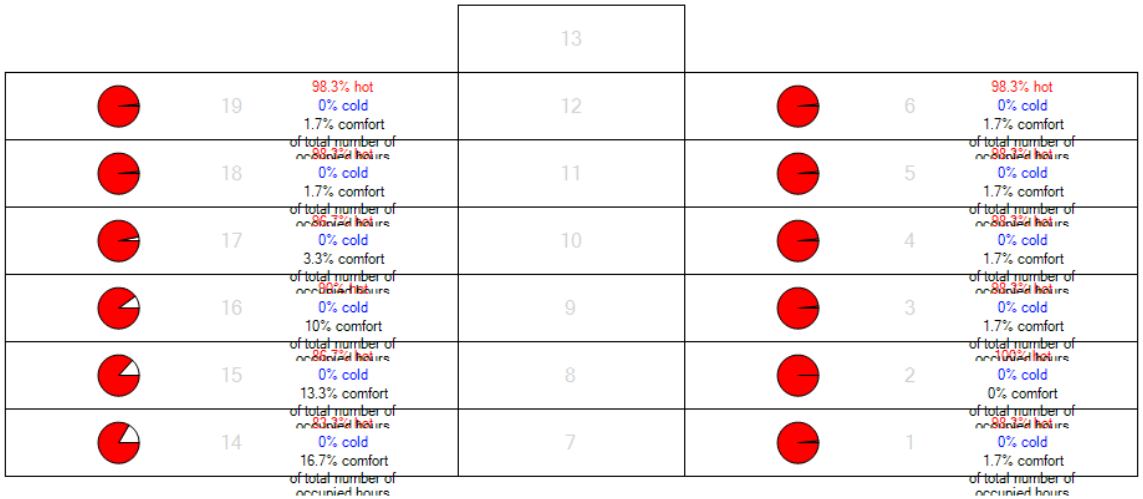
And then the comfort result improved around 2%-20%



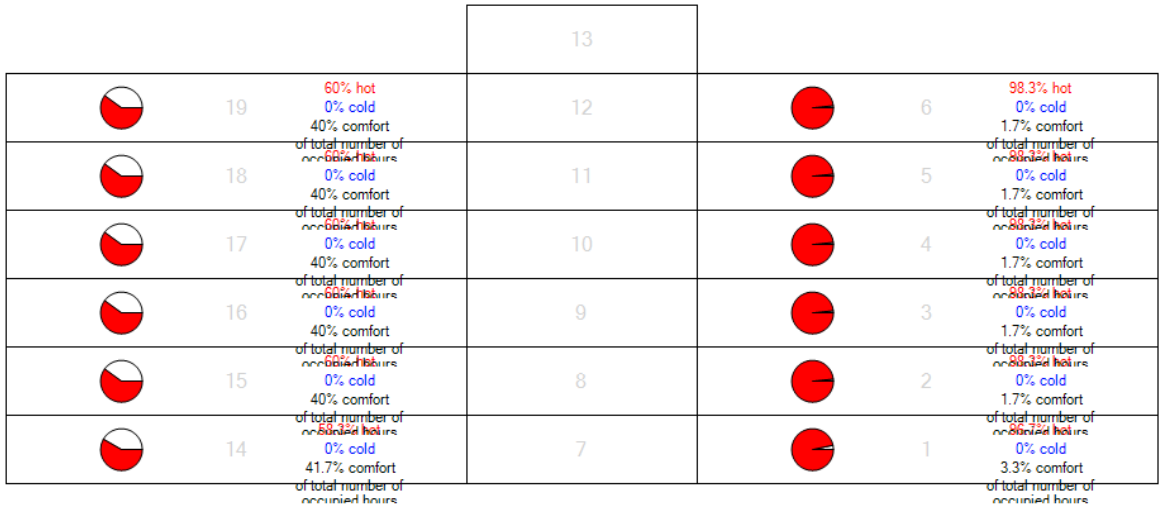
And then I tried **<u>to double the window glazing area</u>**



However, the result does not change a lot:



But when I tried **to double operable upper area per floor:**



The comfort result in 14-19 zones improved a lot, around 40%

IMPROVEMENT STRATEGY: Central Atrium; Jun

In conclusion,

I combined the different strategies which work efficiently: include slab thermal mass and use the window which has two openings separated vertically (and the operable area per floor is doubled)

The final result is showing as following :

IMPROVED REPORT: Central Atrium; Jun

CoolVent Thermal Comfort Results USA_PA_Philadelphia.Intl.AP.724080_TMY3

2010 ASHRAE Standard 55 Thermal Comfort Model

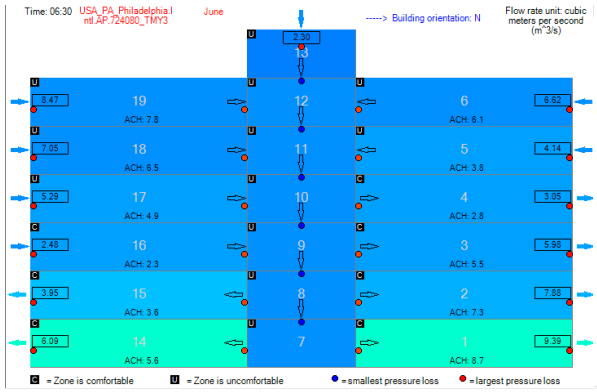
Temperature Pie Charts

		13			
	19	25% hot 0% cold 75% comfort of total number of occupied hours	12		6	45% hot 0% cold 55% comfort of total number of occupied hours
	18	35% hot 0% cold 65% comfort of total number of occupied hours	11		5	55% hot 0% cold 45% comfort of total number of occupied hours
	17	35% hot 0% cold 65% comfort of total number of occupied hours	10		4	55% hot 0% cold 45% comfort of total number of occupied hours
	16	35% hot 0% cold 65% comfort of total number of occupied hours	9		3	53.3% hot 0% cold 46.7% comfort of total number of occupied hours
	15	35% hot 0% cold 65% comfort of total number of occupied hours	8		2	53.3% hot 0% cold 46.7% comfort of total number of occupied hours
	14	43.3% hot 0% cold 56.7% comfort of total number of occupied hours	7		1	76.7% hot 0% cold 23.3% comfort of total number of occupied hours

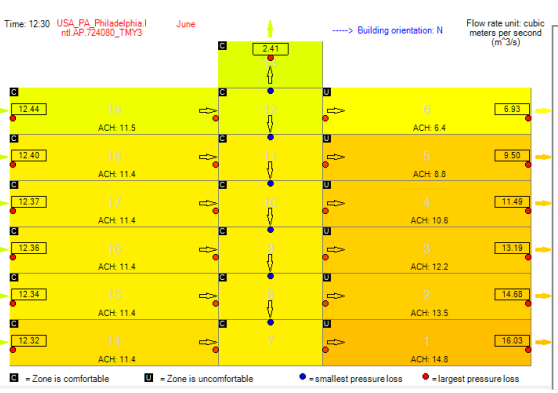
The pie charts represent temperature concerns for comfort in non-atrium zones of the building.

Red represents the percent of total occiped hours that a given zone is too hot.
Blue represents the percent of total occiped hours that a given zone is too cold.

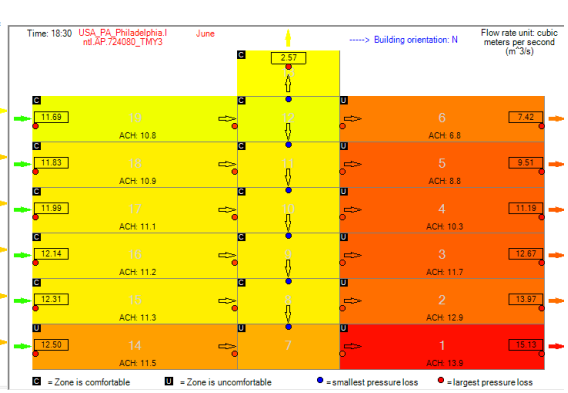
Humidity concerns are not addressed in the pie charts.



6:30



12:30

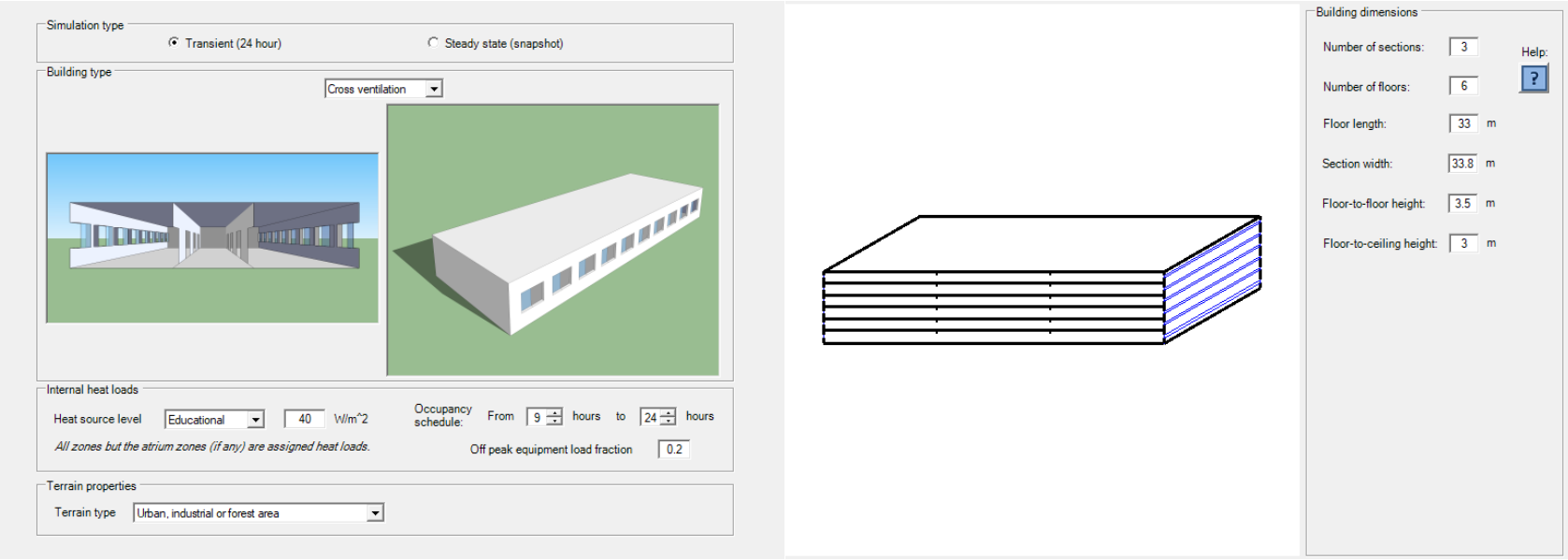


18:30

We can find from the new report that the comfort condition improved by 23% to 75%.

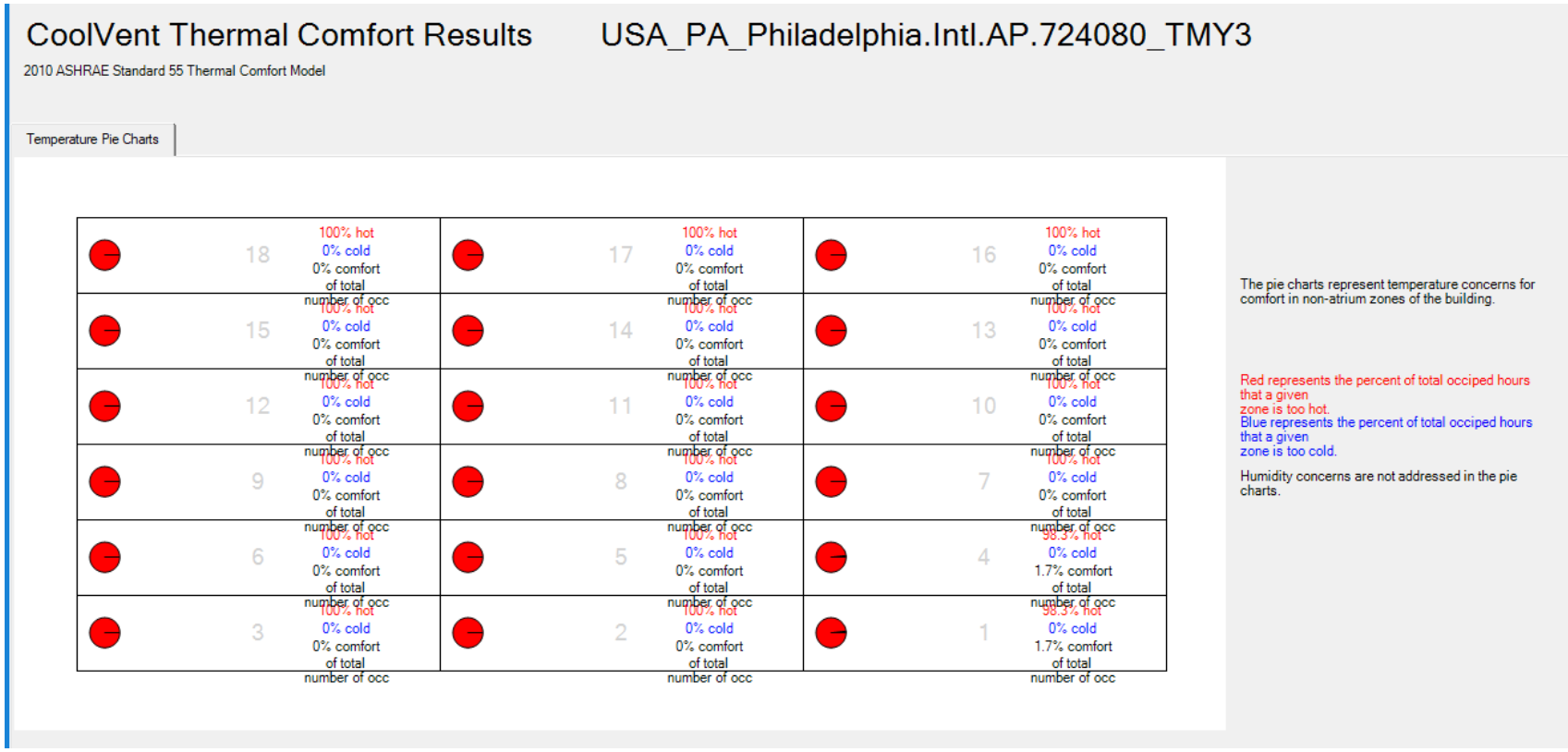
However, at 6:30 the comfort condition is poorer than the previous one. But at both 12:30 and 18:30, the comfort condition are improved a lot.

INPUTS: Cross ventilation; Jun



The Second type is cross ventilation. The other inputs are exactly the same as that of the first type(central atrium) which is shown in the page 1 and 2.

REPORT: Cross Ventilation; Jun

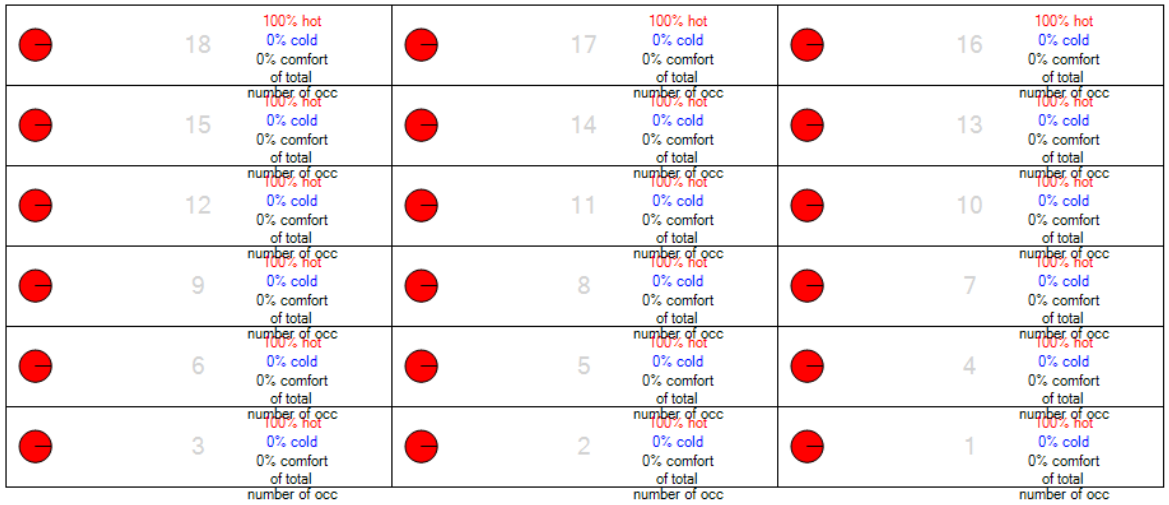


The comfort condition is too hot

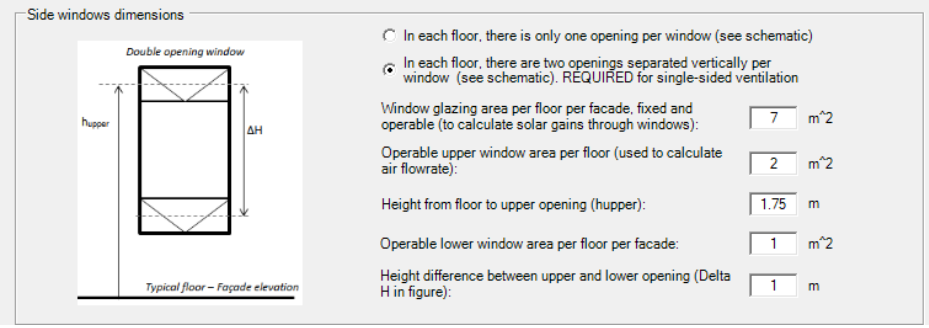
IMPROVEMENT TESTS: Cross Ventilation; Jun

- The first strategy to improve the comfort condition is **<u>to include slab thermal mass</u>**

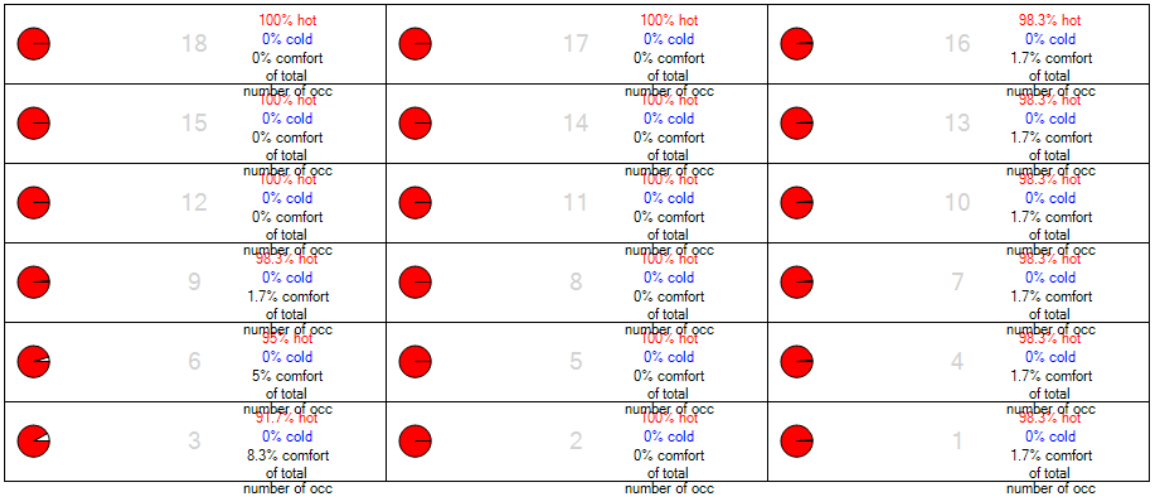
However the result does not change at all.



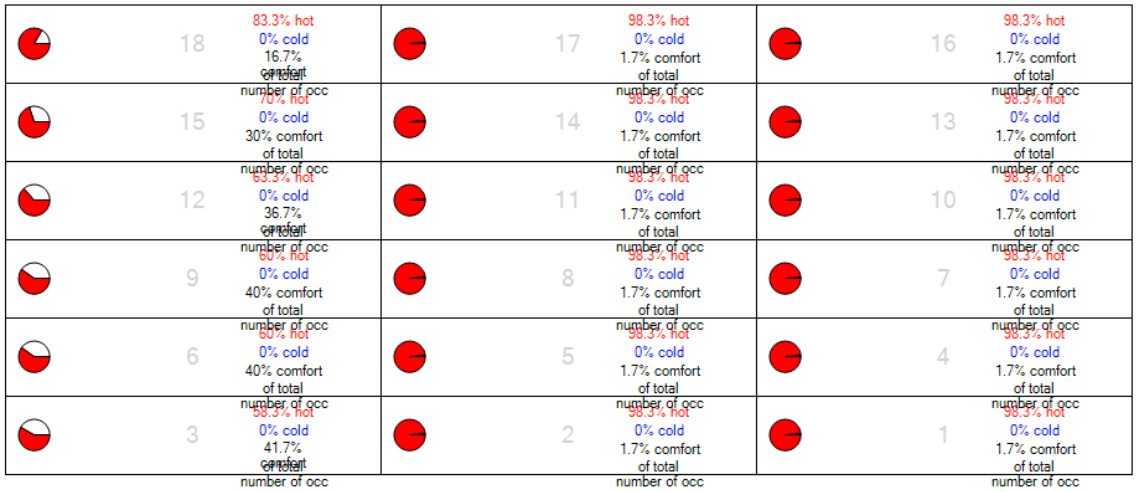
- The second strategy is to change **the side windows type from only one opening per window to two openings**



And then the comfort result improved around 2%-8%

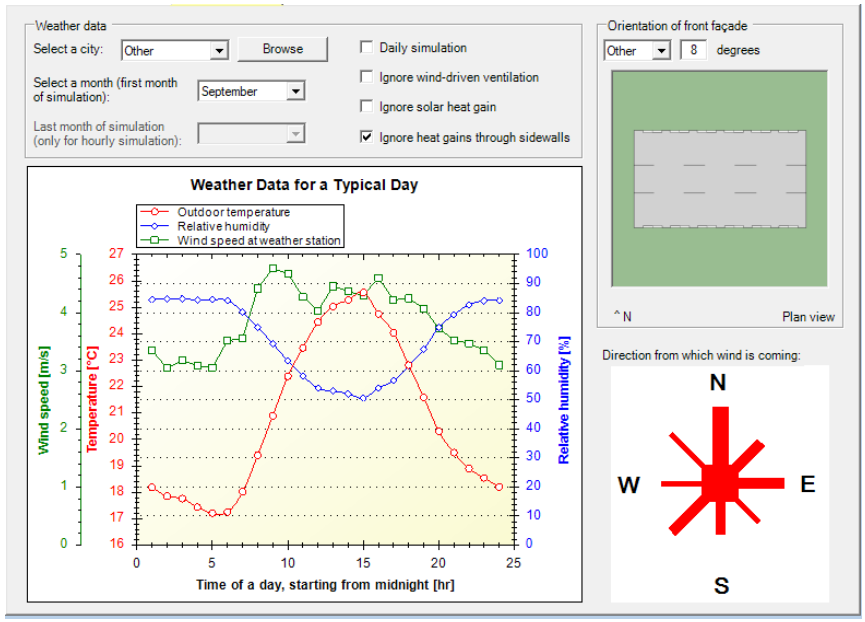


Then I tried **<u>to double operable upper area per floor:</u>**



The comfort result improved around 20%-40%, however, the change only happened in one side of the building.

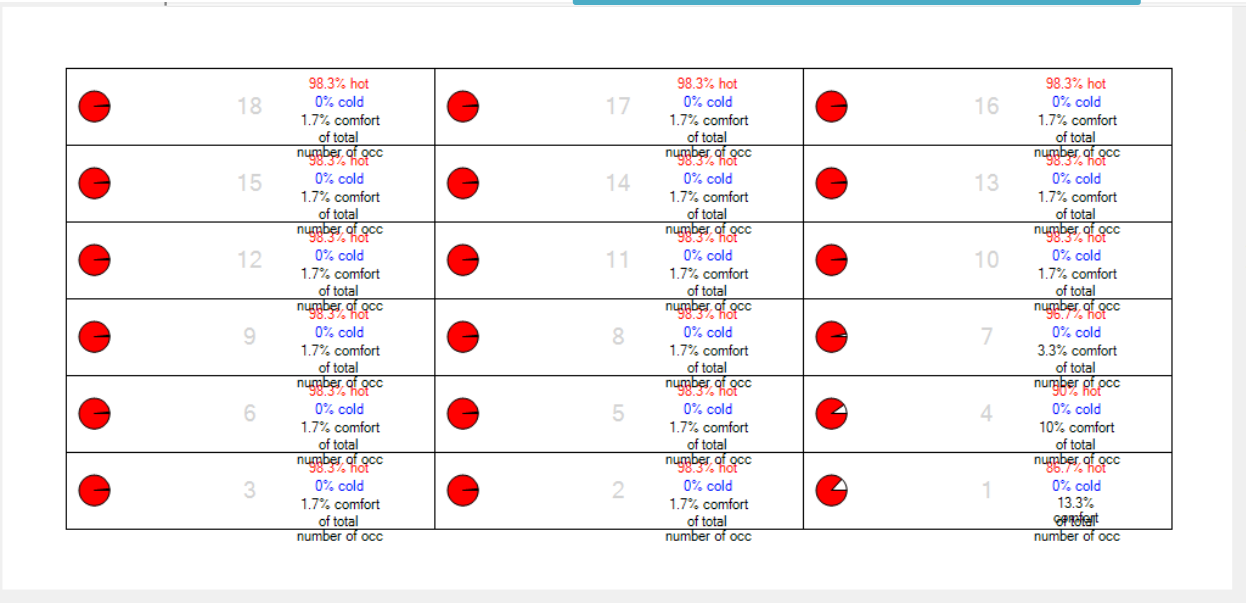
INPUTS: Cross ventilation; Sep



Then I tried the condition in September instead of June. The type is still cross ventilation and the other inputs are exactly the same as the inputs in page 1 and 2.

Then the comfort result is shown as following:

REPORT: Cross Ventilation; Sep



Compared with the result in June, the comfort result is a little bit better in zone 4 and 1 but it is still too hot in the other zones.

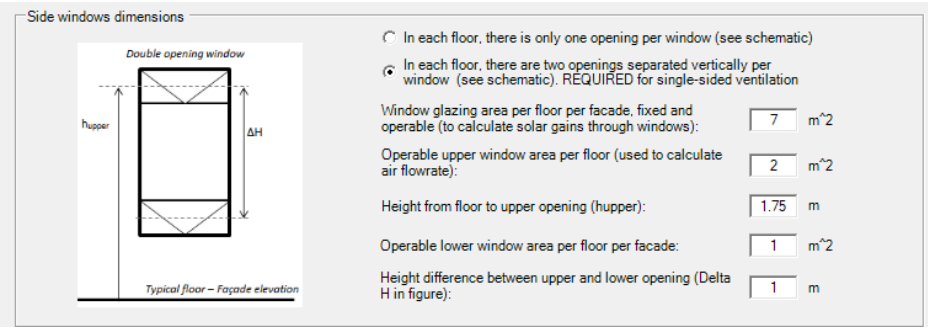
IMPROVEMENT TESTS: Cross Ventilation; Sep

- The first strategy to improve the comfort condition is **<u>to include slab thermal mass</u>**

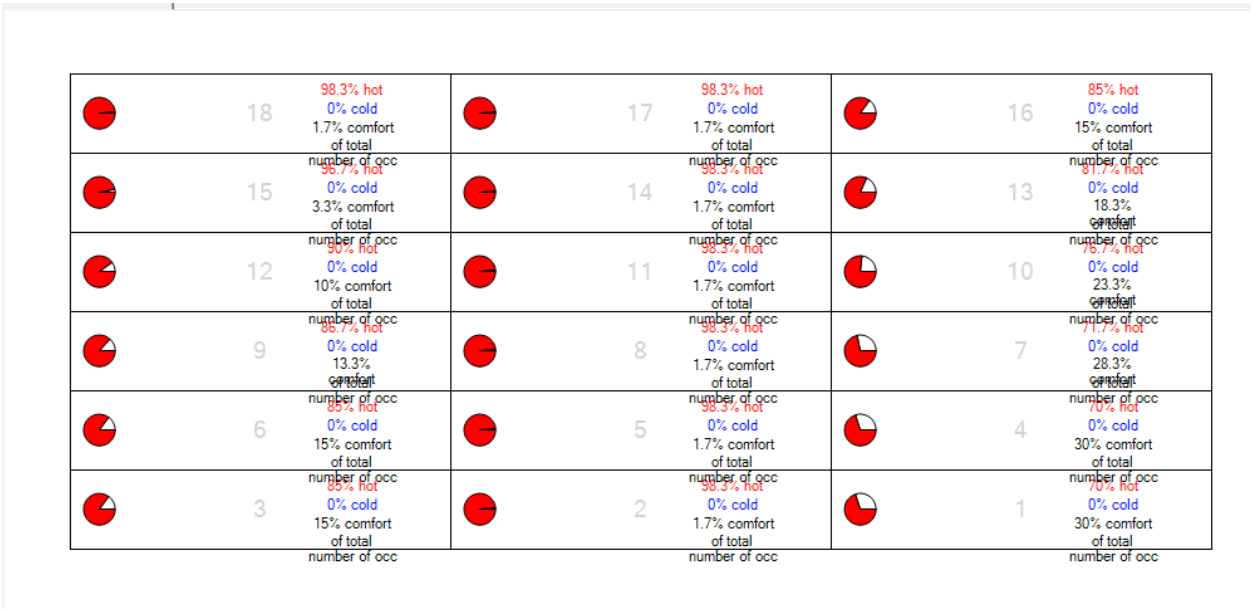
The result improved by around 5%-10%

18 100% hot 0% cold 0% comfort of total number of occ	17 100% hot 0% cold 0% comfort of total number of occ	16 98.3% hot 0% cold 1.7% comfort of total number of occ
15 100% hot 0% cold 0% comfort of total number of occ	14 100% hot 0% cold 0% comfort of total number of occ	13 93.3% hot 0% cold 6.7% comfort of total number of occ
12 100% hot 0% cold 0% comfort of total number of occ	11 100% hot 0% cold 0% comfort of total number of occ	10 88.3% hot 0% cold 11.7% of total number of occ
9 100% hot 0% cold 0% comfort of total number of occ	8 100% hot 0% cold 0% comfort of total number of occ	7 86.7% hot 0% cold 13.3% of total number of occ
6 100% hot 0% cold 0% comfort of total number of occ	5 100% hot 0% cold 0% comfort of total number of occ	4 85% hot 0% cold 15% comfort of total number of occ
3 100% hot 0% cold 0% comfort of total number of occ	2 100% hot 0% cold 0% comfort of total number of occ	1 90% hot 0% cold 10% comfort of total number of occ

- The second strategy is to change **<u>the side windows type from only one opening per window to two openings</u>**



The result improved by around 3%-15% in both sides of the building.



IMPROVEMENT STRATEGY: Cross Ventilation; Sep

I used the same strategies as before which work efficiently: include slab thermal mass and use the window which has two openings separated vertically (and the operable area per floor is doubled)

The final result is showing as following :

IMPROVED REPORT: Cross Ventilation; Sep

CoolVent Thermal Comfort Results USA_PA_Philadelphia.Intl.AP.724080_TMY3

2010 ASHRAE Standard 55 Thermal Comfort Model

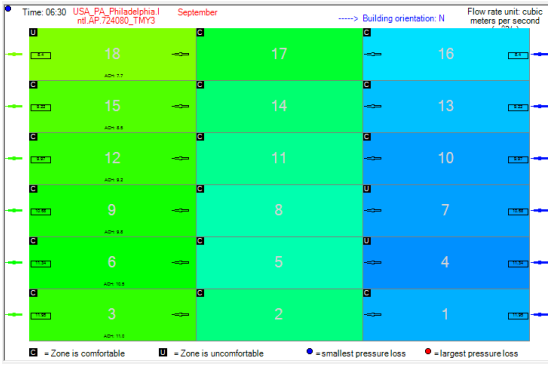
Temperature Pie Charts

18 — 86.7% hot, 0% cold, 13.3% comfort of total, number of occ	17 — 78.3% hot, 0% cold, 21.7% comfort of total, number of occ	16 — 55% hot, 0% cold, 45% comfort of total, number of occ
15 — 85% hot, 0% cold, 15% comfort of total, number of occ	14 — 78.3% hot, 0% cold, 21.7% comfort of total, number of occ	13 — 68.3% hot, 0% cold, 31.7% comfort of total, number of occ
12 — 81.7% hot, 0% cold, 18.3% comfort of total, number of occ	11 — 78.3% hot, 0% cold, 21.7% comfort of total, number of occ	10 — 66.7% hot, 0% cold, 33.3% comfort of total, number of occ
9 — 75% hot, 0% cold, 25% comfort of total, number of occ	8 — 78.3% hot, 0% cold, 21.7% comfort of total, number of occ	7 — 61.7% hot, 0% cold, 38.3% comfort of total, number of occ
6 — 73.3% hot, 0% cold, 26.7% comfort of total, number of occ	5 — 78.3% hot, 0% cold, 21.7% comfort of total, number of occ	4 — 58.3% hot, 0% cold, 41.7% comfort of total, number of occ
3 — 78.3% hot, 0% cold, 21.7% comfort of total, number of occ	2 — 78.3% hot, 0% cold, 21.7% comfort of total, number of occ	1 — 60% hot, 0% cold, 40% comfort of total, number of occ

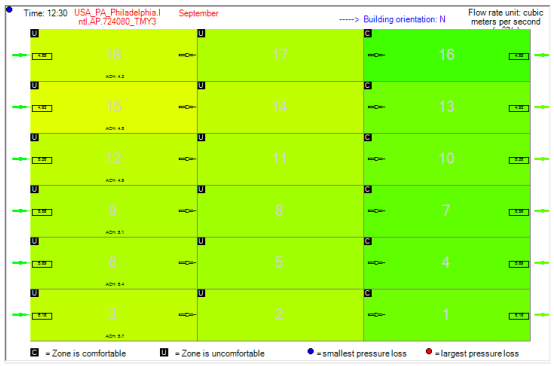
The pie charts represent temperature concerns for comfort in non-atrium zones of the building.

Red represents the percent of total occiped hours that a given zone is too hot.
Blue represents the percent of total occiped hours that a given zone is too cold.

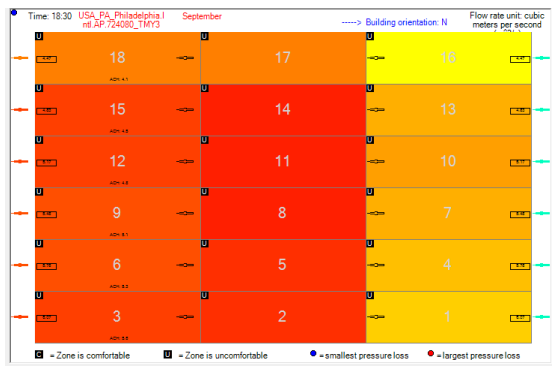
Humidity concerns are not addressed in the pie charts.



6:30



12:30



18:30

Although the comfort result has improved due to the ventilation strategies, it is still uncomfortable at 18:30 in the whole building.