STRATEGIES FOR IMPROVING THERMAL PERFORMANCE AND VISUAL COMFORT IN OFFICE BUILDINGS OF CENTRAL CHILE

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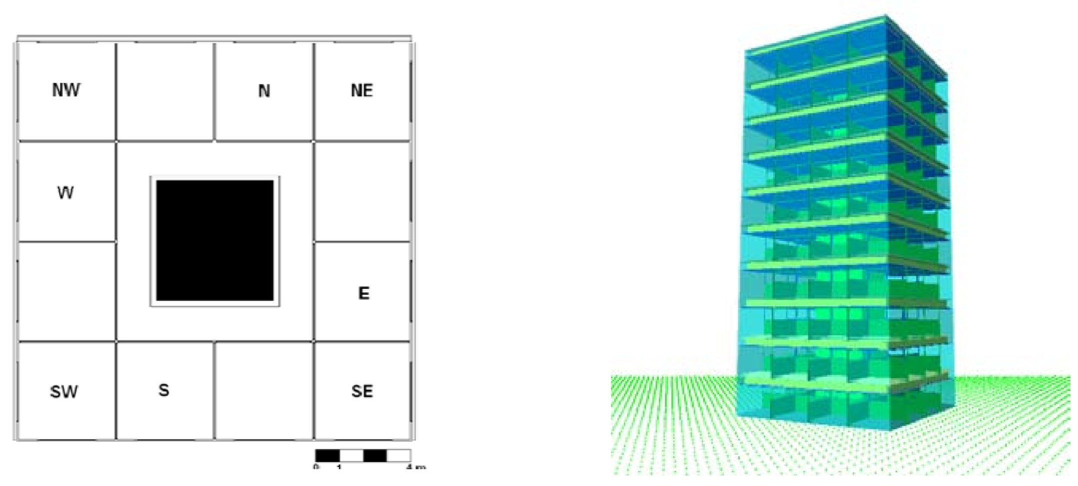
Introduction

Office buildings (OFB) in Santiago (33°S) and Valparaíso (33°S), Chile, show higher cooling than heating energy demand. Overheating or high cooling energy consumption and glare are recurrent problems in this type of buildings in these cities. In order to evaluate impact on thermal and lighting performance of OFB of these cities, a sensitivity study has been made. Variations on window façade area, type of glazing, orientation, solar protection, nocturnal ventilation and respective impact on energy and lighting performance has been considered. The methodology includes an evaluation of heating and cooling demand and variation of indoor temperature when no conditioning system is applied. For this purpose a dynamic simulation software was used (TAS). The effect on natural lighting was also analysed using Radiance software. This analysis was made using Daylight Autonomy (DA) and Useful Daylight Iluminance (UDI), considering different sky conditions. Climate of Santiago (located between the coastal and the Andes Cordillera) is Mediterranean, with a high solar radiation and high temperature oscillation between day and night. Mean max temperature is 29,7°C and mean min is 13°C for the warmest month of the year (Jan). Climate of Valparaíso show lower temperature oscillation with mean max of 20,8 °C and mean min of 13,5°C for January.

Methodology

A sensibility analysis is developed considering a square building with office rooms on all 4 orientations. This 9 story building has been specially proposed for this sensibility analysis. Figure 1 shows a plan (16X16m) of this building.



Specifications of the building are:
Walls: Reinforced concrete 150mm with external EPS 30mm. U=1,0 W/m2°C
Roof: Reinforced concrete 150mm with EPS 60mm. U=0,59W/m2°C (in Valparaíso) and with 80 mm of EPS in Santiago. U= 0,40 W/m2°C.

Table 2: Input parameters for sensibility analysis

Input parameters	Number of variables	Description of variables
Glazing ratio*	3	20% 50% 100%
Types of solar protection devices	3	Without solar protection Overhang in N orientation and blinds for E and W orientations Blinds in N, E and W orientations
Types of glazing	4	Single glazing, clear Single glazing, selective Double glazing, clear Double glazing, selective
Orientations	8	All orientations (N, NE, E, SE, S, SW, W, NW)

(*) Ratio of the glazed area with respect to the total area of the exposed envelope

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Table 2: Properties of different types of glazing.

	CS	SS	DGC	DGS
LT	0,90	0,60	0,82	0,54
ST	0,82	0,50	0,68	0,41
U (W/m2°C)	5,80	5,70	2,78	2,76

Simulations:

288 dynamic simulations (resulting from combination of different variables of Table 1), for estimating heating and cooling demand for different specifications of the building were made (using s TAS software). In some cases, internal temperature variation was studied (without conditioning): Night ventilation was also evaluated.

For Daylight analysis: dynamic metrics Usefull Daylight Illuminance (UDI) and Daylight Autonomy (DA) were used.

Results _ Thermal Analysis

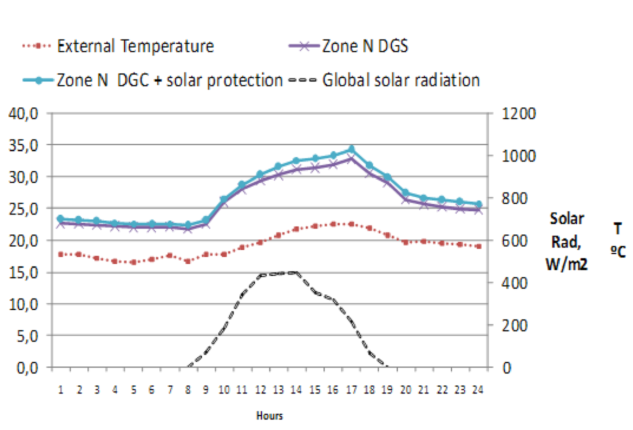


Figure 2: Temperature variation in Zones N of the building for a winter day in Valparaíso. 100% glazed facade Winter day.

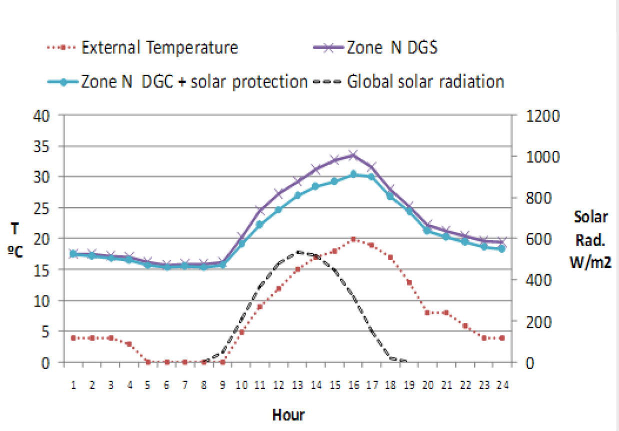


Figure 3: Temperature variation in Zones N of the widing for a winter day in Valparaíso. 100% glazed facade Winter day.

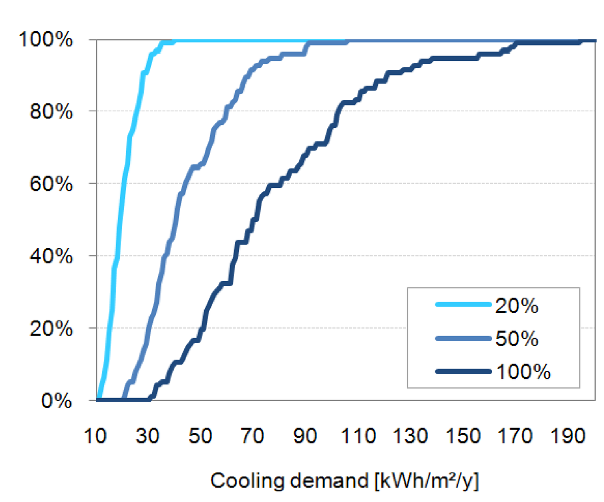


Figure 4: Cumulative frequency for cooling demand with respect to glazing ratio in the case of Valparaíso.

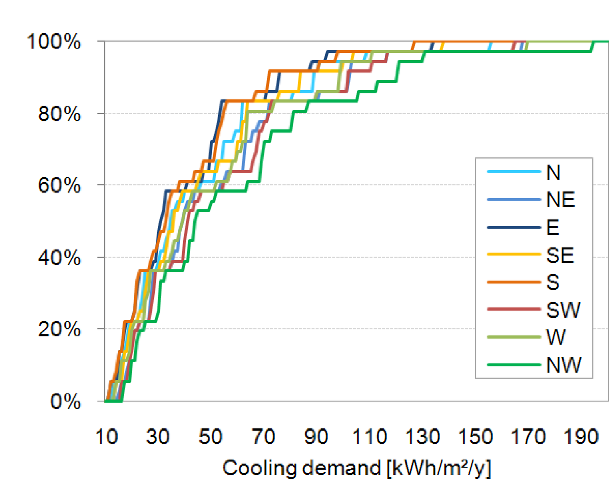


Figure 5: Cumulative frequency for cooling demand with respect to orientations ratio in the case of Valparaíso.

For a 100% glazed façade building, overheating is observed in Valparaíso (Figure 2) and Santiago (summer time). In Santiago, under clear sky conditions, overheating does exist in winter day (Figure 3).

Figure 4 shows as the high level of importance of glazing ratio, since the variability in cooling demand – as consequence of the input variability – is noticeable. Figure 5 shows low cooling demand variability with respect to orientation, (and lower for low cooling demand). Identical results are observed in the case of Santiago. It is clear that any design strategy proposed office developments in Valparaiso and Santiago, should prioritize the ratio of the glazed area with respect to the exposed façade.

Results _ Lighting Analysis

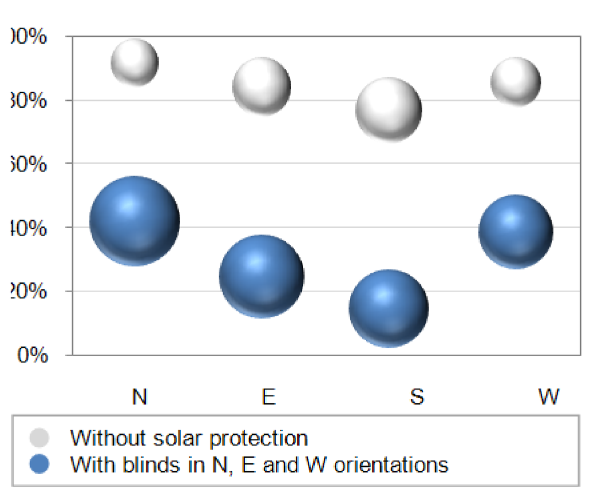


Figure 7: Bubble plots for UDI in the range over 2000 lux for different orientations in Santiago

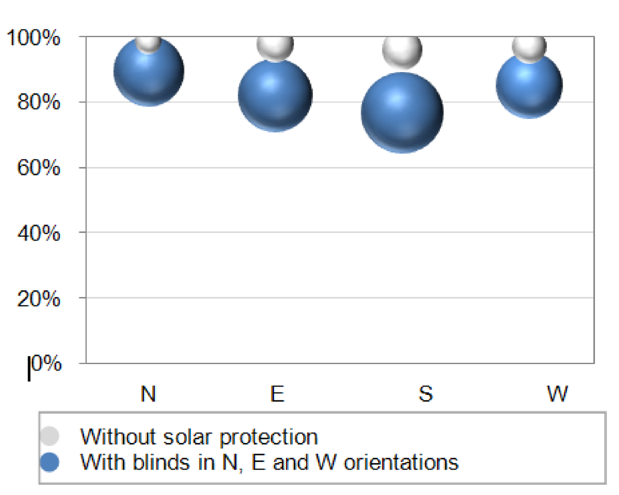
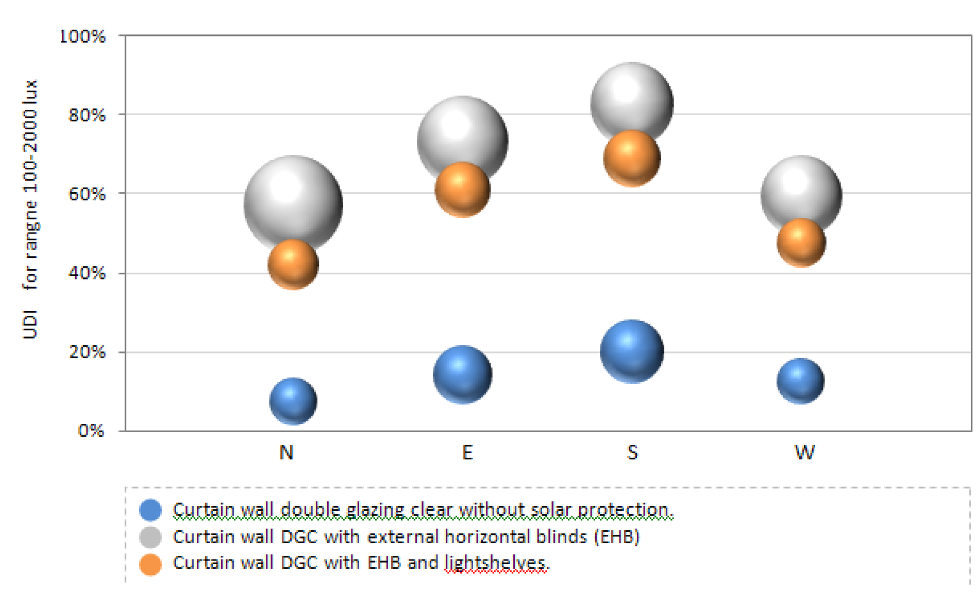


Figure 6: Bubble plots for daylight autonomy (DA) based on a required illuminance level of 500 lux in different orientations in Santiago.



High UDI (Useful daylight illuminance) values for over 2000 lux is observed in building without solar protection. Glare is highly possible to occur in different façade orientations. Lower UDI values are reached with solar protection, decreasing glare risk. (Figure 7). Values of Daylight Autonomy (DA) for 500 lux shows that it is possible to guarantee adequate illuminance level even when blinds are used (Figure 6). High standard deviation observed in UDI and DA (high size of blue bubbles) with solar protection, suggest use of lightshelves.

Use of external horizontal blinds (EHB) and lightshelves show high UDI values for 100-2000 lux, with lower deviation compared with case with EHB without lightshleves. Higher homogeneity light distribution is reached with lightshelves.

Conclusion

(1) Proposed methodology is very much effective to define design strategies for energy efficiency (EE) in office buildings (OFB). For EE, a simultaneous evaluation of thermal performance and lighting comfort is highly recommended.
(2) Glare and overheating is possible to be avoided with different design strategies applied to OFB in Central Chile
(3) Solar protection with the lower window to façade ratio is recommended for lighting and thermal comfort in OFB of Santiago and Valparaíso, cities with very different climates.
(4) Nocturnal ventilation is recommended for lowering cooling demand of OFB.
(5) Attention to type of glazing (clear, selective, double or single) should be taken into account according to different façade orientation of OFB
(6) Lightshelves and solar protection (external blinds) are recommended for getting lower illuminance dispersion in OFB in Central Chile.