Experimental evidence of effective single sided natural ventilation beyond 20ft or 2.5 floor to ceiling heights in open plan office spaces

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KEYWORDS

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SUMMARY

Most natural ventilation (NV) systems used in non-residential buildings are single sided (SS). These systems are easy to integrate in the building layout, since, unlike in cross-ventilation (CV), these systems do not require access to two facades or a central stack. Current knowledge about SS NV flow penetration away from the façade can be found in building regulations and design rules of thumb. Examples of these rules include California's Title 24 20ft rule [1], that limits the use of natural ventilation to office areas that are less than 20 ft (6 m) away from a façade with operable windows, and the CIBSE recommendations of maximum room depth of up to 2.5 room floor to ceiling heights [**Error! Bookmark not defined.**] (2.5H) for SS NV systems. As expected, CV flows are subjected to similar limitations that set larger room depth limits (in fact the maximum distances between opposing room facades): 12m [1] or up to 5H [**Error! Bookmark not defined.**].

In the case of SS systems these ad hoc rules can have a large negative impact in the adoption of NV. In a building design or refurbishment project, whenever the room depth exceeds these limits, designers must at list resort to mechanical ventilation and, in many cases, end up opting for a traditional HVAC system for the whole space. Apparently, the limits used in current design guidelines and building regulations have not been validated by research and may be overly conservative. Existing experimental [2,3] and numerical [4] investigations of fresh air penetration depth in SS systems indicates that these limits may be overly conservative. In all existing studies the average penetration depth, defined as the point beyond which the mean age of air exceeds the age of air at the exhaust, exceeds 3H. These studies are limited by the use of low internal gains and fully open rudimentary windows (or no windows at all).

The experimental study presented in this paper tries to fill the existing knowledge gap on the effectiveness of single sided natural ventilation beyond 20ft or 2.5 floor to ceiling heights in open plan office spaces. The study used three rooms shown in figures 1 and 2, with SS ventilation and different internal dimensions and depths that varied between 3.5 and 5.7H. In all of these spaces the internal CO_2 concentrations, air and surface temperatures were measured in 2-3 hour periods with standard occupation (7-12m^2 per occupant) and internal gains (25-30W/m^2). The results confirm that the current regulation limitations are overly conservative. Adequate ventilation effectiveness can be achieved in room depths of 4H or even more in the case of displacement ventilation NV systems.

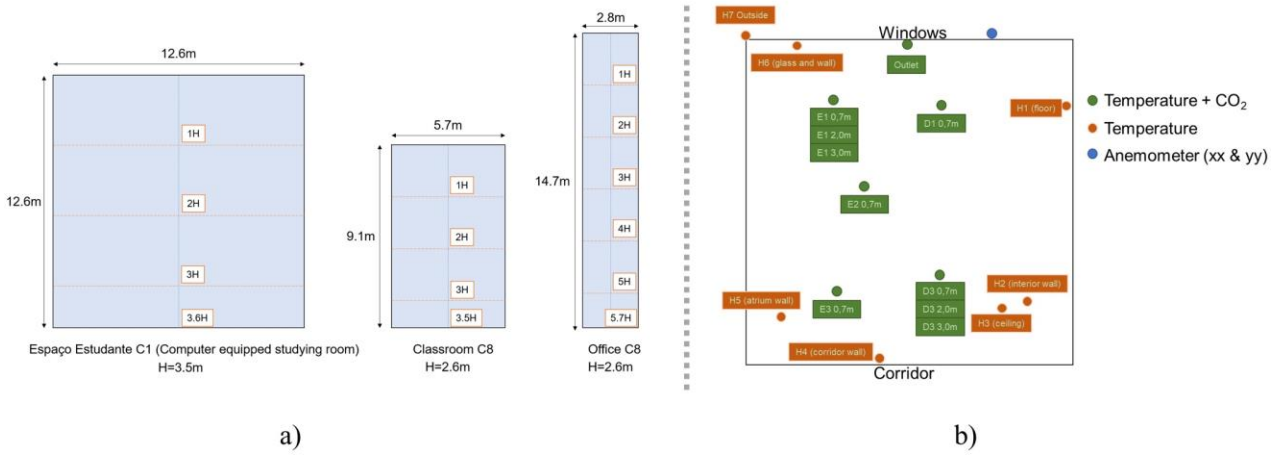

Figure 1: a) room floorplans with depth shown in floor to ceiling heights, b) schematics of the measurement setup used in room C1.

Figure 2: interior views of the three rooms during the measurements a) open space C8, b) open plan office C8, c) long office C8

References

[1] California Building Standards Commission (2013). California Building Standards Code, *California Code of Regulations*, Title 24.

[2] White MK, Walker RR. The efficiency of single-sided and cross ventilation in office spaces. DOCUMENT-AIR INFILTRATION CENTRE AIC PROC 1996 (pp. 487-496).

[3] Walker RR, White MK. Single-sided natural ventilation—How deep an office? Building Services Engineering Research and Technology. 1992 Nov 1;13(4):231-6.

[4] Guohui Gan, Effective depth of fresh air distribution in rooms with single-sided natural ventilation, Energy and Buildings, Volume 31, Issue 1, January 2000, Pages 65-73, ISSN 0378-7788, http://dx.doi.org/10.1016/S0378-7788(99)00006-7.