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LIFE17 CCA/EN/000088

Application of Nature-Based Solutions for local adaptation of educational and social buildings to Climate Change

Deliverable: Help document for "Prototype Design".

06.b- Annex to document 06 (Calculation of minimum openings for night ventilation in summer - Badajoz)

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1. CALCULATION MODELS FOR SIZING OF VENTILATION OPENINGS

The models for sizing openings result in an estimation of the opening area required to obtain a general minimum air flow rate, or under certain conditions, which have to be specified. Their calculation is oriented to the establishment of the minimum area required to achieve the necessary conditions of healthiness. (1)

1.1. ASHRAE Model (1)

It allows obtaining the minimum necessary area of air inlet and outlet in order to maintain a certain flow rate.

The calculation can be made separately, either using the wind speed or using the value of the thermal difference between outside and inside.

It is used for rooms with simple or cross ventilation, considering these openings to be equal, although a correction coefficient could be applied if they are not.

It does not take into account window or terrain obstructions, although they could be considered in combination with other methods that modify wind speed, in the case of terrain.

1.2. Model CTE-HS3 (1)

It is applied for the sizing of intake, exhaust and air flow openings.

Its calculation is based on an estimate of the minimum ventilation flow rate required in a room.

It is oriented towards criteria for assessing the performance of a residential building, for forced ventilation systems (mechanical or hybrid).

2. ASHRAE MODEL

2.1. With the effects of wind

$$A=Q/EW$$

A = Free opening area (m^2) Q

= Design flow rate (m^3/s)

E = Effectiveness of the opening (0.5-0.6, perpendicular winds; 0.25-0.35 diagonal winds) W =

Wind velocity (m/s)

Q = 214.74 l/s = 0.21474 m^3 */s (Required flow in l/s x person).*

E = 0.25 *(the values of wind gusts in º, oscillate around 10º, predominantly coming from the North, therefore they are considered totally diagonal with respect to the facades studied).*

W = 1.4 m/s (mode value, i.e., the most repeated value, obtained from the average speed values of each of the days of the period from May 1,2019 to October 25, 2019.However, among the average values per day of wind speed, the maximum is 5.6 m/s and the minimum would be 0.3 m/s). Source:AEMET

$$\mathbf{A = 0.21474/(0.25 \cdot 1.4) = \underline{0.613\ m2}}$$

2.2. In absence of wind (temperature only)

$$A = \frac{Q}{1116\ \sqrt{h(Ti - To)}}$$

A = Free opening area (m^2) Q

= Design flow rate (l/s)

h = Height between inlet and outlet opening (m)

Ti = Indoor temperature (ºC)

To= Outside temperature (ºC)

Q = 214.74 l/s *(Required flow in l/s x person).*

h = 1 m *(Considering that it enters through the lower part of the window and exits under the classroom door or exits through the upper part of the window opposite).*

ΔT = 7 *(This takes into account the lowest temperature difference between outside and inside during the nights -from 0:00 to 7:00 h-, of the typical summer week studied in the report "05-Current State Simulation". If it were larger, the area would be smaller).*

$$\mathbf{A = 214,74\ /(116\sqrt{1(7)}) = \underline{0.699\ m2}}$$

Of the two calculation options above, the most unfavorable would be the one performed in the absence of wind, so the value of 0.70 m^2 could be taken as valid.

3. MODEL CTE-HS3*

* *Technical Building Code DB HS: Health and Safety. HS3: Indoor air quality*

Although the opening calculation model of the Technical Code is specifically for a mechanized ventilation system, a calculation estimate will be made to triangulate the solution offered by the previous model.

3.1. Calculation defined for a mechanical or hybrid ventilation system.

Ventilation openings (in cm)²

Intake openings	Max ($_{4 \cdot qv}$ or $_{4 \cdot qva}$)
Exhaust openings	Max ($_{4 \cdot qv}$ or $_{4 \cdot qve}$)
Passage openings	Max (**70 cm² or $_{4 \cdot qvp}$**)

$_{qv}$: minimum required ventilation flow rate of the room (takes into account the flow rate per m² . Source: ASHRAE).

$_{qva}$: ventilation flow rate corresponding to each room intake opening (according to ASHRAE). $_{qve}$: ventilation flow rate corresponding to each room exhaust opening (according to ASHRAE). $_{qvp}$: ventilation flow rate corresponding to each room pass-through opening.

Considering the same value of minimum flow rate (q) for all openings, the value obtained in case of mechanical or hybrid ventilation system would be:

$$A = 4 \cdot q = 4 \cdot 0{,}11977^{*} = 0{,}47908 \text{ m}^2$$

**In this case, according to Table 2, the minimum flow rate value is taken from the ASHRAE defined data.*

Of the three calculation options above, the most unfavorable would be the one performed in the absence of wind, by the ASHRAE method, so the value* of 0.70 m² *could be taken as valid.

TABLE 1. MINIMUM REQUIRED FLOW RATE, ACCORDING TO CTE, FOR DWELLINGS (2)

	Caudal de ventilación mínimo exigido q_v en l/s		
	Por ocupante	Por m^2 útil	Por otros parámetros
Dormitorios	5		
Salas de estar y comedores	3		
Aseos y cuartos de baño			15 por local
Cocinas		2	50 por local (ventilación adicional)
Trasteros y sus zonas comunes		0,7	
Aparcamientos y garajes			120 por plaza
Almacenes de residuos		10	

TABLE 2. COMPARATIVE FLOW REQUIREMENTS FOR EDUCATIONAL FACILITIES (3 and 4)

Surface area (m2)	**Height (m)**	**No. of students**	**Flow (l/s) x person**	**Total flow (l/s)**	*~ Category IDA 3*
54,44	2,84	**25**	**8,6**	**214,74**	according to RITE *(linked to the period of occupancy)*
Surface area (m2)	**Height (m)**	**No. of students**	**Flow rate(l/s) x m2**	**Total flow (l/s)**	*classroom*
54,44	2,84	**25**	**2,2**	**119,77**	according to ASHRAE
Surface area (m2)	**Height (m)**	**No. of students**	**Flow rate(l/s) x m2**	**Total flow (l/s)**	*classroom*
54,44	2,84	**25**	**6,0**	**326,64**	EN 15251 (Category I)
54,44	2,84	**25**	**4,2**	**228,65**	EN 15251 (Category II)
54,44	2,84	**25**	**2,4**	**130,66**	EN 15251 (Category III)

4. CONCLUSIONS

Taking into account the values obtained from the above calculations, and always from the safety point of view, it is recommended that the surface of the opening required to promote night ventilation (freecooling effect) should be a minimum of **0.70 m²** .

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