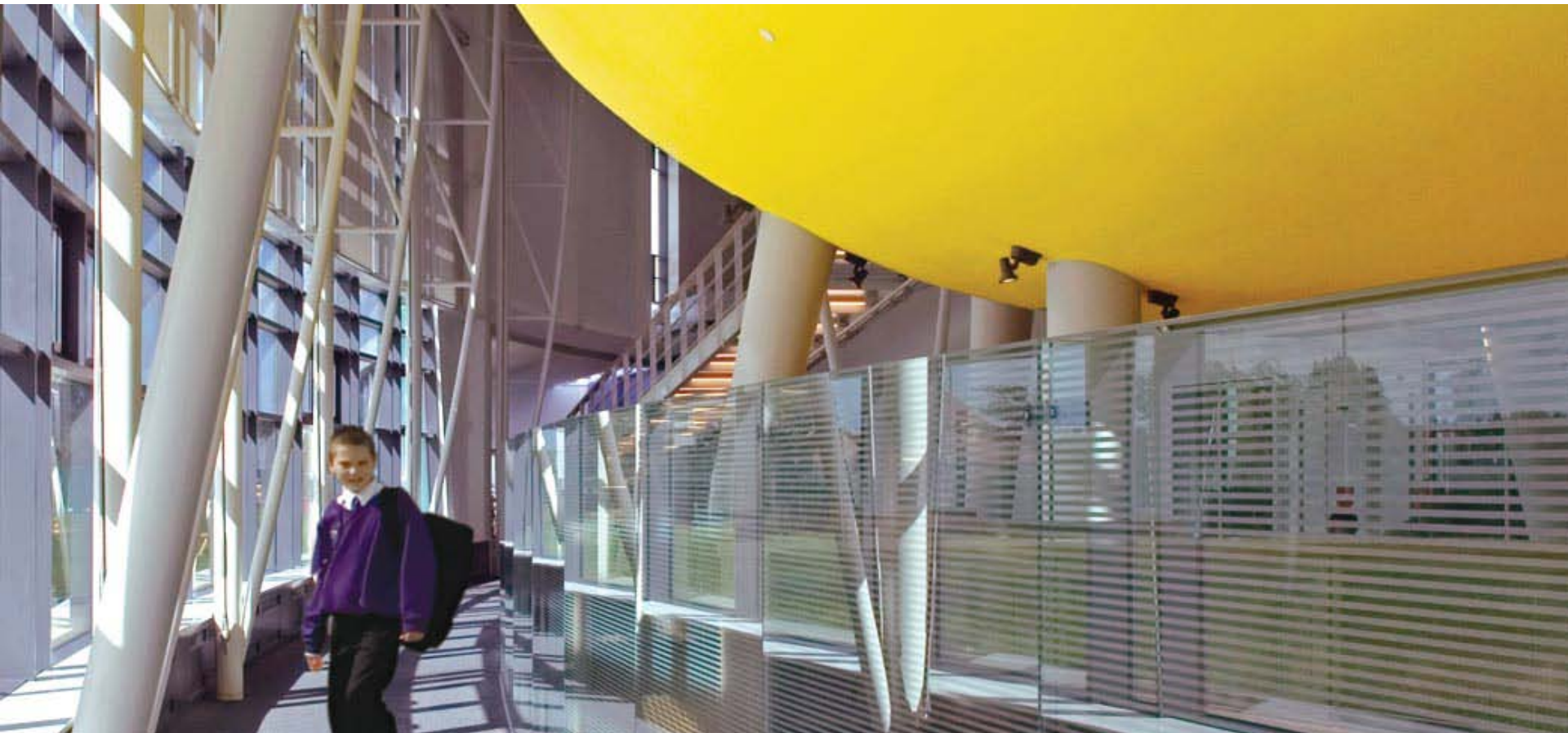
FABER MAUNSELL | AECOM

Natural Ventilation in Schools

Regulations and Guidance

John Palmer – Faber Maunsell (Chair CIBSE Schools Design Group)



Design Criteria

The appropriate design conditions for **ventilation, thermal comfort, daylighting and noise** in schools are given in:

- Building Bulletin 101 – Ventilation in School Buildings
- Building Bulletin 87 – Guidelines for Environmental Design in Schools
- Building Bulletin 90 – Lighting Design for Schools
- Building Bulletin 93 – Acoustic Performance in Schools

Ventilation Regulatory Requirement – Part F

DCSF Building Bulletin 101 states that:

"*When measured at seated head height, during the continuous period between the start and finish of teaching on any day, the average concentration of carbon dioxide should not exceed 1500 parts per million (ppm)*"

Advisory Performance Standards

- At any occupied time, including teaching, the occupants should be able to lower the concentration of carbon dioxide to 1000 ppm.
- The maximum concentration of carbon dioxide should not exceed 5000 ppm during the teaching day.

Equivalence of Advisory Performance Standards*

These reflect the needs of the School Premises Regulations and the recommendations of the Health and Safety Executive

8 l/s per person ~ 1000ppm

5 l/s/per person ~ 1400ppm

3 l/s per person ~ 2100ppm

1.1 l/s per person ~ 5000ppm

*adult emission rate

Thermal Comfort in Summer

DCSF Building Bulletin 101 states that:

"The performance standards for summertime overheating in compliance with Approved Document L2 for teaching and learning areas are:

a) There should be no more than 120 hours when the air temperature in the classroom rises above 28℃,

b) The average internal to external temperature difference should not exceed 5℃ (i.e. the internal air temperature should be no more than 5℃ above the external air temperature on average)

c) The internal air temperature when the space is occupied should not exceed 32℃".

Thermal Comfort in Winter

DCSF Building Bulletin 87 “Guidelines for Environmental Design in Schools” requires that teaching spaces are heated to an air temperature of 18°C under winter conditions of external temperature.

Daylighting

- DCSF Building Bulletin 87 “Guidelines for Environmental Design in Schools” states that “*natural light should be the prime means of lighting during daylight hours*” and advises that “*A space is likely to be considered well lit if there is an average daylight factor of 4% - 5%*”.
- DCSF Building Bulletin 90 suggests that daylight factors below 2% will require frequent use of electric light.

Noise

DCFS Building Bulletin 90 states that:

- "if the design uses a *minimum fresh air supply rate* that is equal or greater than 3 l/s per person, the indoor ambient noise levels with this ventilation rate should not exceed the upper limit for the indoor ambient noise of 35 dB LAeq,30min in classrooms, tutorial rooms, seminar rooms, and language laboratories.
- when the *design capability supply rate* of 8 l/s per person is provided by natural ventilation, the design should achieve the BB93 performance standards for the indoor ambient noise levels when they have been increased by 5 dB LAeq,30min".

Design Tools

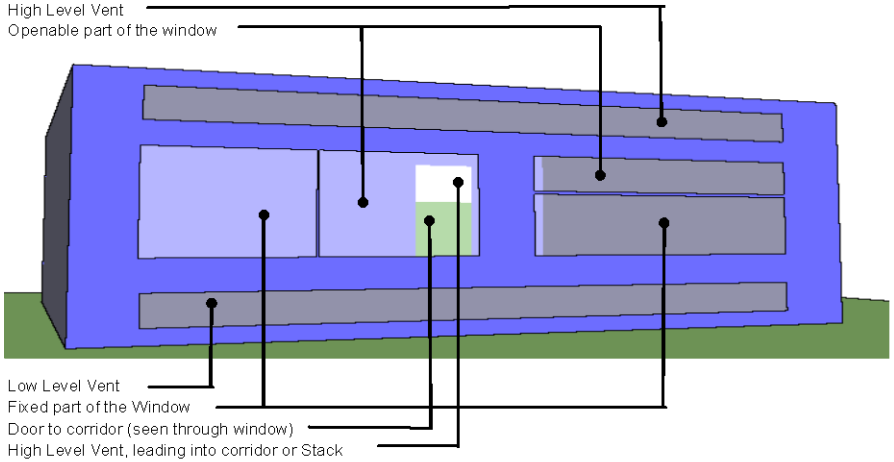
- ClassVent - DCSF
- Classcool - DCSF
- ClassLight - Faber Maunsell

ClassVent

- Natural Ventilation Design & Part F Compliance Tool

This Spreadsheet produces the area of ventilation openings required for the supply of a specific volume flow per person

Legend of typical ventilation elements



Standard ClassRoom Geometry and Occupancy

ClassRoom Geometry	
Width - m	7.25
Depth - m	8
Height - m (ceiling height or highest level for opening)	4

ClassRoom Occupancy	
Number of Pupils	30
Teacher (1 or 2?)	2

Design and Enviromental Variables		
Temperature Profile - default season or user input		User
Default temperatures	Outside	Inside
Winter	5	20
MidSeason	11	20
Summer	24	27
Other - User defined temperatures	1	28

Go to any strategy by clicking	
Single Vent	Here
Twin Vents	Here
Vent & Window	Here
CrossFlow	Here
Stack	Here
Stack (multiple rooms)	Here

Required Volume flow	12 l/sec/per

This spreadsheet is a simple tool to predict the area of the openings needed to provide external air under specified conditions
The recommended values are: 3, 5 or 8 litres/second/person
The User should enter the geometry and occupancy for the room and then progress throught the various design scenarios as indicated on the tabs below
Six possible combinations are given that include variations of Single Sided, Crossflow and Stack ventilation.
The "Single Vent" is either a single opening like a window or a vent; the "Twin Vent" has two (identical) vents at different heights.
The "Vent Window", allows the user to change the window area (which will then produce a different area for the inlet vent).
The "CrossFlow" and "Stack(single)" and "Stack(multiple)" ventilation cases allow further inputs for windspeed and up to 3 floors in the stack cases.

The temperatures recommended as the default conditions for each period of the year are as shown in the table above
Note: the areas predicted are effective areas - i.e. they will pass the same volume of air as a square edged orifice of the same area.
The "hole in the wall" to install an actual ventilator that provides this effective area will be greater than these calculations imply.

ClassCool – Avoiding Overheating Design & Part L Compliance Tool for Classrooms

Window Area

g-value

Louvres

Classroom Selection by orientation and floor

Overhang

MidPane Blinds

Casual Gains

Thermal Mass

Day Ventilation

Night Ventilation

Classroom Definition

The basic classroom is assumed to have a floor area of ~54m² and a volume of ~162m³. This tool does not allow a change in these variables, as it cannot replace proper thermal modelling.

Note to the user:- do **not** cut 'n' paste cells **unless using /edit/value** which will preserve the formatting of the cells.

		Gf		1F
Window Area	Percentage of Façade Area (between 20% and 60%)	60		60
g-value	Choose between No, Partial, Full solar control (between 0.675 and 0.38)	No Solar Control	Partial Solar Control	
	If choosing "Other", provide input from Glazing datasheets here ===>>		and here>	0.668
Louvres	Numbers of louvre blades, 0 to 6	0	0	

ientation and floor

		Gf	Max	1F	Orientation	Gf	1F
Overhang	Width in cm, **North East** (120cm for 100% shading of a 185cm window)	0	120	0	North East	☑	☑
	Width in cm, **East** (169cm for 100% shading of a 185cm window)	0	169	169	East	☑	☑
	Width in cm, **South East** (120cm for 100% shading of a 185cm window)	120	120	60	South East	☑	☑
	Width in cm, **South** (98cm for 100% shading of a 185cm window)	98	98	98	South	☑	☑
	Width in cm, **South West** (120cm for 100% shading of a 185cm window)	120	120	60	South West	☑	☑
	Width in cm, **West** (169cm for 100% shading of a 185cm window)	169	169	84.5	West	☑	☑
	Width in cm, **North West** (120cm for 100% shading of a 185cm window)	120	120	60	North West	☑	☑
	Width in cm, **North** (98cm for 100% shading of a 185cm window)	98	98	49	North	☑	☑

MidPane Blinds	Shading Coefficient : - Choose "Full", "Half", "None", or "Other"	Half	Half	
	If choosing "Other", provide input in here ==========>>		and here>	0.878
Casual Gains	Between 15 W/m² and 115 W/m²	115		115
Thermal Mass	Low (1.18 W/K/m²), Medium (3.0 W/K/m²), High (4.9 W/K/m²), (GF).	Middle Weight	Middle Weight	
	If choosing "Other", provide input in here ==========>>			
Day Ventilation	Day Ventilation, l/sec/person - between 5 l/sec			
Night Ventilation	Night Ventilation 0 to 512 l/sec (~12 ach)			
	Inpu			

Results
Hours of Overheating above 28°C (figures
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	Hours >28°C		Avg Delta T		Max Tint	
Orientation	Gf	1f	Gf	1f	Gf	1f
North East	255	265	6.9	6.3	>35°C	>35°C
East	230	250	7.3	5.9	>35°C	34.5
South East	230	260	6.7	6.3	34.7	35.0
South	215	250	6.3	5.7	34.4	34.5
South West	230	255	6.4	6.3	34.6	34.6
West	245	255	6.5	6.6	34.4	34.3
North West	250	280	6.5	6.2	34.9	34.4
North	240	275	6.4	6.1	34.8	>35°C

ClassLight – Faber Maunsell Daylight Analysis Tool

Mean Daylight Factor (mean DF) Calculator

version 0.41e

Fill the green cells with the data for your building, leave other cells empty

Notes on this project

Juniors 1 classroom, First floor. Façade with 80% glazing area with 2.6m overhang, ph= 28°, plus 2 roof lights 1.05m x 0.75m with phi= 170°.

Glazing selected for the façade is VELFAC CLEAR SAFETY ENERGY SAFETY 1, LT = 0.80, g = 0.64

Glazing selected for the rooflight is VELFAC SUN 1/Clear because of its neutral appereance. This glazing has a LT of 0.67 and a g value of 0.37

Result — **mean Daylight Factor, mean DF =** **5.0 %**

Room Geometry	
Width - m	2.60
Depth - m	2.80
Ceiling height - m	2.35
Window sill height	1
Area of "intrusion"	0.0

Reflectance of the walls	
Façade	0.7
right wall	0.7
left wall	0.7
back wall	0.7
ceiling	0.8
floor	0.3

Maintenance Coefficient	clean
Window Frame Coefficient	30 %

Reference data

Typical Reflectance Values	
Paint colour	Reflectance
White	0.85
Pale Cream	0.8
Light Grey	0.7
Mid-Grey	0.45
Dark Grey	0.15
Dark Brown	0.1
Black	0.05
Internal Material	Reflectance
White paper	0.8
carpet	0.1 - 0.45
Brickwork	0.2 - 0.3
Quarry tiles	0.1

Typical Glazing Transmittance Values	
Glazing	Transmittance
Pilk - k-glass 6/16/6	0.73
Pilk - Suncool HP 70/40	0.70
SGG CLIMAPLUS - Plani	0.79
SGG CoolLikeK/Planilux	0.41
SGG CoolLikeK/Diamant	0.69
-	-
SGG - single, laminated	0.88

Glazing summary

façade glazing percentage	39%	left wall glazed area - m²	0
façade glazed area - m²	2.4	right wall glazed area - m²	0.7992
rear wall glazed area - m²	0	ceiling glazed area - m²	0

Window / Glazed Area 1	
Location	Façade
Orientation	vertical
Windows (number)	1
Width - m	2.00
Depth - m	1.20
phi °	80
Transmittance	0.79
More glazing areas?	yes

Window / Glazed Area 2	
Location	right wall
Orientation	vertical
Windows (number)	1
Width - m	0.67
Depth - m	1.20
phi °	80
Transmittance	0.79
More glazing areas?	no

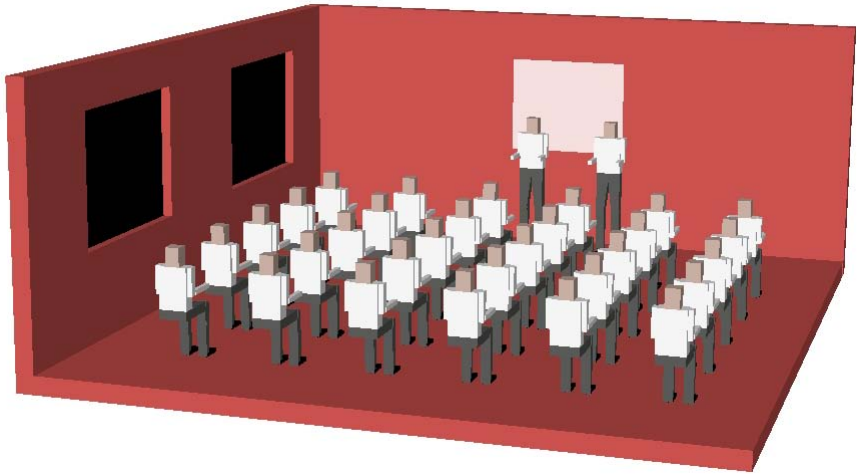
Comment sheet | How to use | **mean DF - Room Input** | mean DF - Atrium-corridor | References | Notes | Version | Variables

Integrated Design Solutions - CFD

- Thermal Comfort
  - Temperature distribution
  - Draughts
  - PMV
- Indoor IAQ
  - Winter – 8 l/s per person
  - Summer
- Daylight

Model assumptions

- For the modelling study **34** various natural and mechanical ventilation design options were investigated. Each providing 8l/s per person
- The classroom dimension: 7.0m deep and 7.7m wide with floor-to-ceiling height of 3.0m.
- The class compromised of 30 pupils and 2 teachers, each generating sensible heat of 100W. Additionally there was an interactive whiteboard (IWB) installed generating 355W.



Some Design Examples

Perimeter heating with louvre windows

- **Wintertime ventilation performance – ideal**. The window design is able to provide the ventilation rate of 8 litres of fresh air per second per person.
- **Thermal comfort in winter - satisfactory**

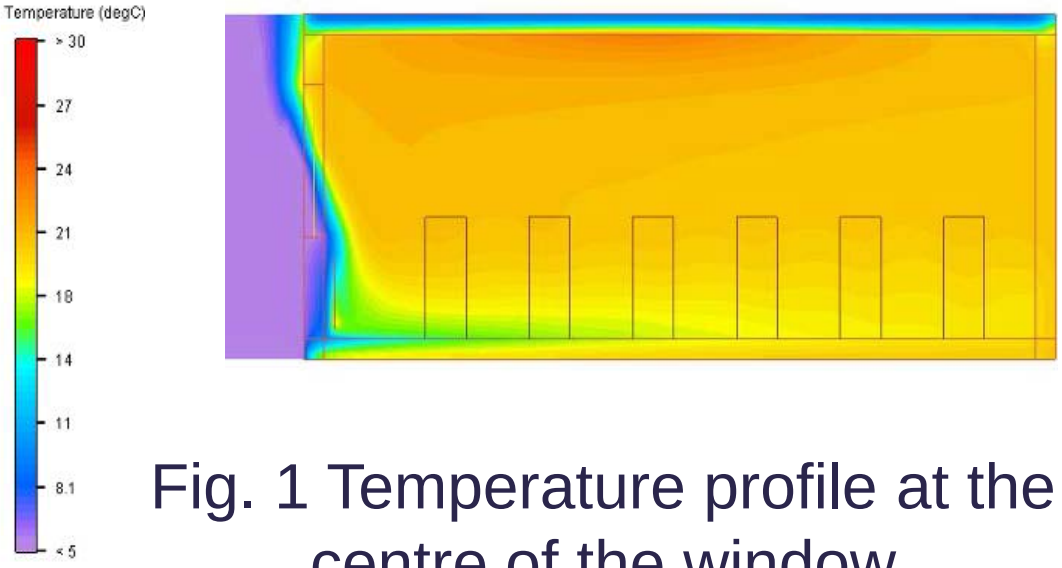


Fig. 1 Temperature profile at the centre of the window

- **Summertime Overheating- satisfactory**

Perimeter heating with mid-façade centre pivot windows

- **Wintertime ventilation performance – satisfactory**. Two windows each of 2m by 1.5m with an opening width restricted to 100mm are capable of providing the ventilation rate of 8 litres of fresh air per second per person.

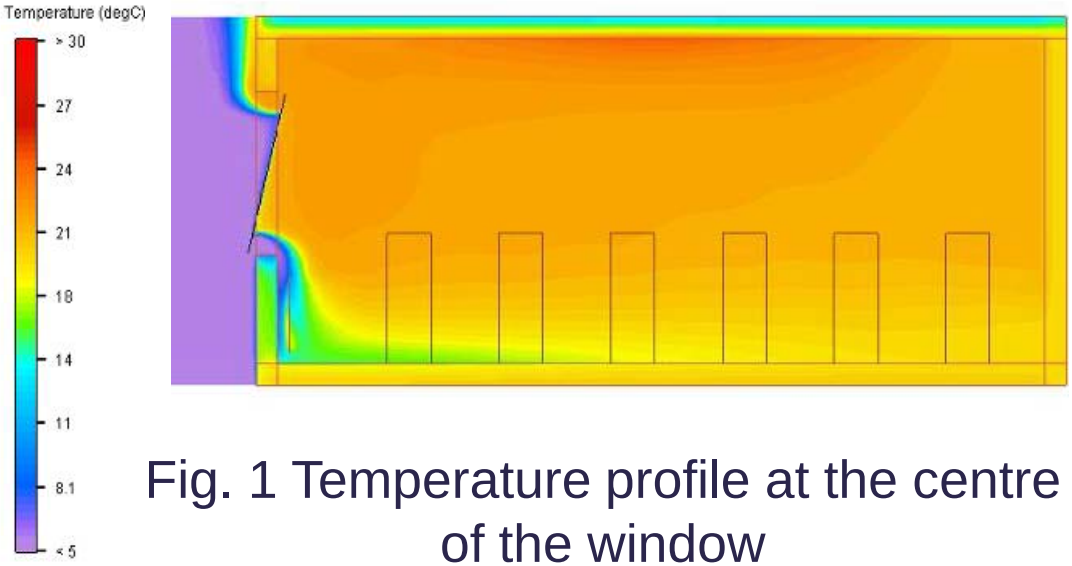


Fig. 1 Temperature profile at the centre of the window

- **Thermal comfort in winter – satisfactory**
- **Summertime Overheating – satisfactory in certain conditions**

Underfloor heating with top hung windows

- **Wintertime ventilation performance – satisfactory in certain conditions**. Two windows each of 2m by 1.5m are capable of providing the ventilation rate of 8 l/s per person if an opening width is **not** restricted to 100mm.

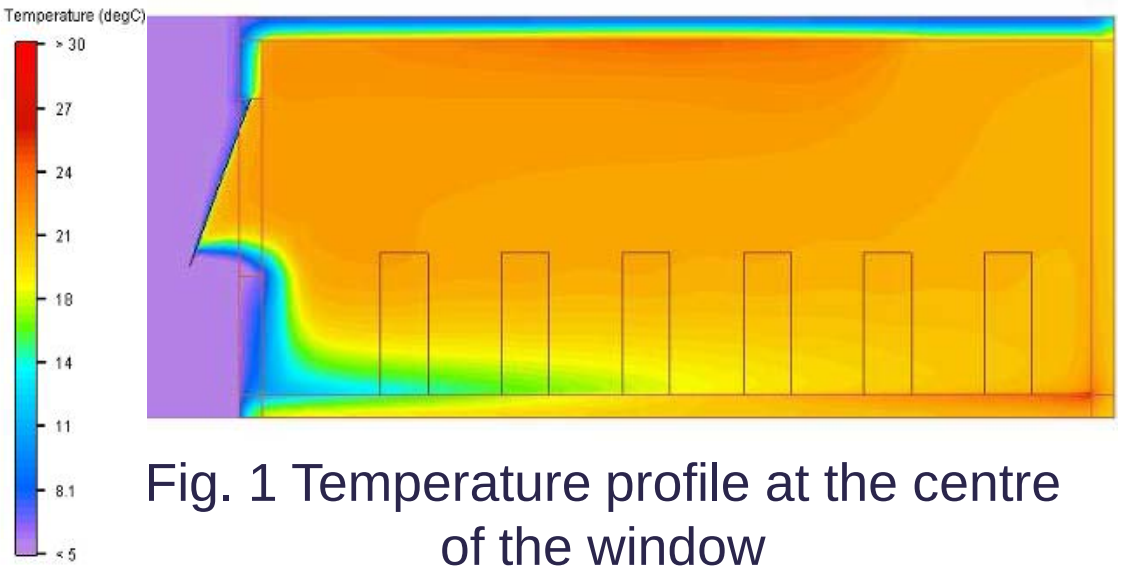


Fig. 1 Temperature profile at the centre of the window

- **Thermal comfort in winter – satisfactory in certain conditions**
- **Summertime Overheating – unsatisfactory**

Underfloor heating with top hung windows

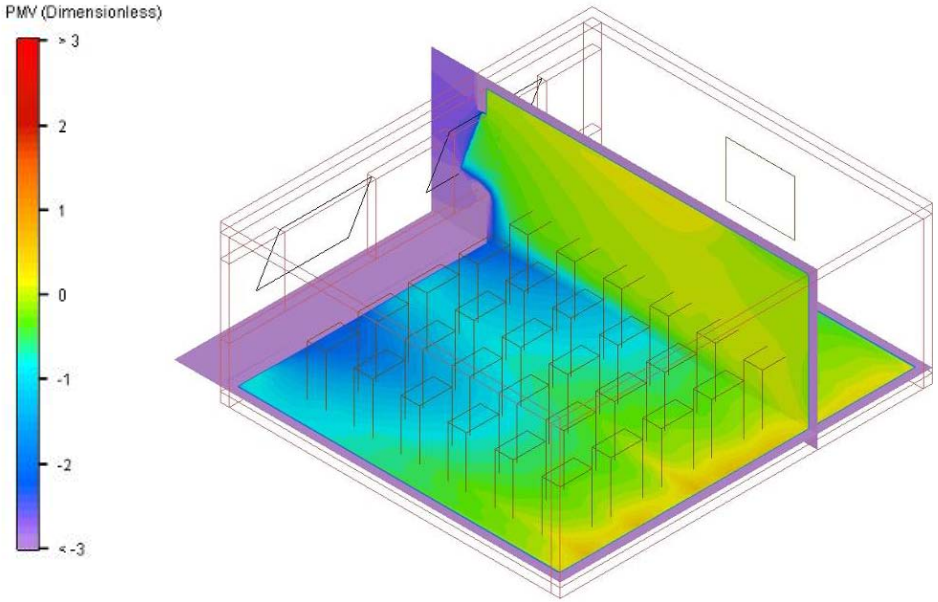


Fig. 2 PMV profile at the centre of the window and at the distance 0.1m above the floor

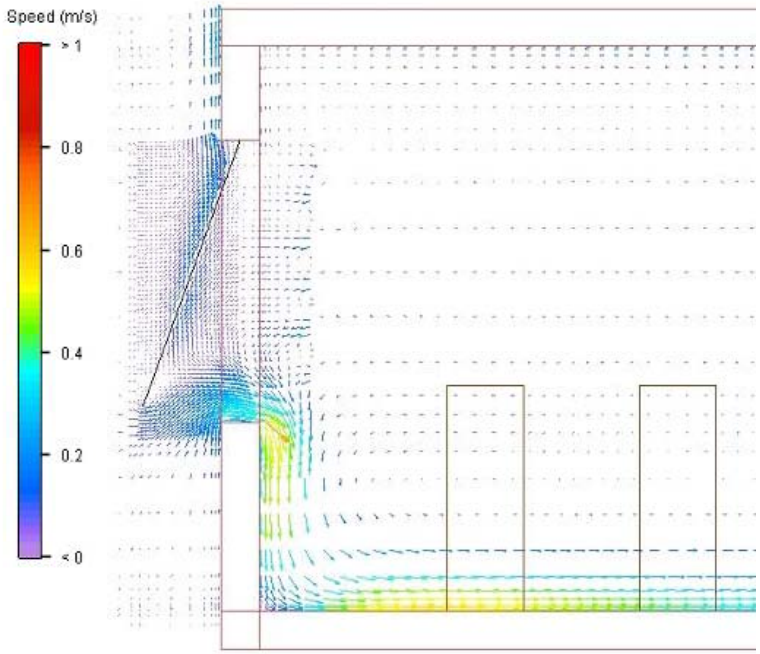


Fig. 3 Velocity vector profile at the centre of the window

Modelling design strategies and indoor environmental conditions rating

The best and worst design strategies

	DESIGN OPTION	Heating strategy	Wintertime Ventilation Performance (IAQ)	Thermal Comfort in Winter	Summertime Ventilation Performance (IAQ)	Summertime Overheating	Daylighting	Environmental impact
15	Louvres windows	PH						
16	Louvres windows	UH						
17	Front low level and rear high level openings	PH						
…	…							
10	Top hung windows	PH						
32	Floor mounted supply swirl diffusers and ceiling mounted extract grilles	AH						
11	Top hung windows	UH						

IDEAL

SATISFACTORY

SATISFACTORY IN CERTAIN CONDITIONS

UNSATISFACTORY

Comments

- Natural ventilation should be always considered as a first design option for school buildings
- School building design should always consider and integrate the building construction and components (thermal mass, window design) with all building systems (ventilation, heating, lighting, control system)
- An integrated design with natural ventilation can be successful for most teaching and learning spaces

Victorian Classroom

Typical modern classroom

Mechanical Ventilation

Air Handling Ductwork

The End

Thank You