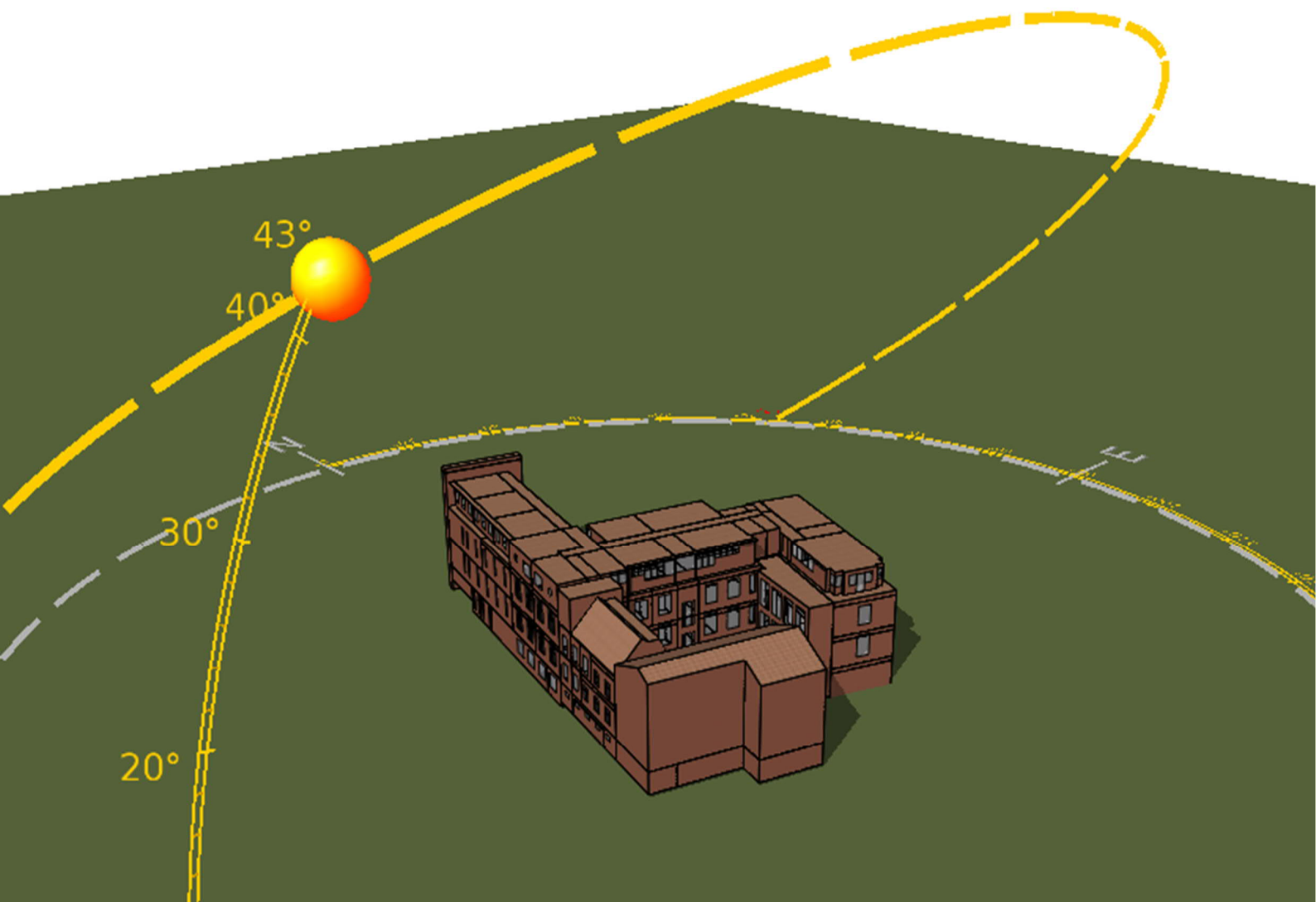




Bringing buildings to life
Highgate School Refurbishment and
Extension
Thermal Comfort Report
TBA-XX-XX-RP-TCF-0001

October 2018

JOB
Highgate School Refurbishment and Extension

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Thermal Comfort Report

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P01		S1 – Suitable for Information	October 2018	CS	CC

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Introduction

Highgate School Science Building in North London is a brick building dating back to the 1920's. Around 2005, a third floor was added to the top of the building.

The building will undergo a general refurbishment and extension. Small extensions are envisaged to the north façade (Garner Quad), and also a new glass atrium entrance and circulation area attached to the Biology Block in the Science Quad.

The building is currently naturally ventilated via openable windows. Overheating has been reported in the 3rd floor teaching spaces.

This report analyses the thermal comfort to BB101 2018 of occupants within the teaching spaces of the new build.

Methodology

Software

The analysis summarised in this report has been performed using IES-VE 2018 and in compliance with CIBSE AM11 Building Energy and Environmental Modelling.

Where possible, modelling data and inputs have been taken from architectural drawings and supplementary data detailing the construction materials, heating system and the ventilation strategy. Where no explicit room conditions were available, the NCM defaults were used. A list of all assumptions is provided in Appendix 1.

This analysis has been undertaken using the following IESVE 2018 modules:

- ApacheSIM to simulate the buildings environmental performance
- Suncast to model solar gains
- Macroflo to simulate airflows through openable windows
- VistaPro for BB101 frequency analyses

Weather files

The weather file chosen to represent current weather conditions is the CIBSE Design Summer Year (DSY) DSY1 2020 (50th percentile) for London.

BB101 Assessment of Thermal Comfort

CIBSE TM52 Adaptive Thermal Comfort

The new BB101 uses the TM52 thermal comfort test, which is also applicable to non-teaching occupied spaces. A zone passes the test if it passes at least two out of three criteria.

Criterion 1 – Hours of Exceedance

The first criterion sets a limit of 3% for the number of occupied hours that the operative temperature can exceed the threshold comfort temperature (upper limit of the range of comfort temperature) by 1° K or more during the occupied hours of a typical non-heating season (1 May to 30 September).

Criterion 2 – Daily weighted exceedance

The second criterion deals with the severity of overheating within any one day, which can be as important as its frequency, the level of which is a function of both temperature rise and its duration. This criterion sets a daily limit for acceptability in the form of a calculated weighted exceedance figure of 6.

Criterion 3 – Upper limit temperature

The third criterion sets an absolute maximum daily temperature for a room of 4K above the comfort temperature threshold.

Local thermal discomfort from draughts

Nat vent

When the outside air temperature is 5°C, and the heat emitters are switched off the minimum air temperature of air delivered to the occupied zone at seated head height should be not more than 5 K below the normal maintained operative temperature given in table 7-2. Seated head height should be taken as 1.1m above floor level for primary and 1.4m above floor level for secondary school classrooms.

Table Appendix 1.1 contains a full analysis of all existing major window types found in occupied spaces of the building. All window configurations pass the draught test.

Forced draught systems

In a mechanical system where the driving force for the supply air is a fan, the design should meet the values in table 7-4 for the maximum temperature difference between the operative temperature of the room and the temperature of the supply air jet or plume and the maximum local air speed of the jet or plume for the different comfort categories for schools. It will be assumed for the purposes of this report that NVHR/MVHR systems on the market are designed to meet these requirements.

Radiant temperature difference

Heating to all spaces will be via LTHW radiators, no radiant panels are envisaged.

Underfloor heating (UFH)

Heating to all spaces will be via LTHW radiators, no UFH is envisaged.

Indoor CO₂ concentrations

1. Where mechanical ventilation is used, or when hybrid systems are operating in mechanical mode in general teaching and learning spaces, sufficient outdoor air should be provided to

achieve a daily average concentration of carbon dioxide (CO₂) of less than 1000 ppm, during the occupied period¹, when the number of room occupants is equal to, or less than the design occupancy.

The maximum concentration should also not exceed 1500 ppm for more than 20 consecutive minutes each day when the number of room occupants is equal to, or less than the design occupancy.

2. In general teaching and learning spaces where natural ventilation is used or when hybrid systems are operating in natural mode the following standards apply:
 - a. sufficient outdoor air should be provided to achieve a daily average concentration of CO₂ of less than 1500 ppm, during the occupied period, when the number of room occupants is equal to, or less than the design occupancy.
 - b. the maximum concentration should also not exceed 2000 ppm for more than 20 consecutive minutes each day, when the number of room occupants is equal to, or less than the design occupancy.
 - c. the system should be designed to achieve a carbon dioxide level for the majority of the time of less than:
 - i. 1200 ppm for a new building (800 ppm above the outside carbon dioxide level, taken as 400ppm) for the majority of the occupied time during the year - this is the criterion for a category II building
 - ii. 1750ppm for a refurbished building (1350ppm above outside air level) for the majority of the occupied time during the year - this is the level for a category III building.²

Building Details

Building Fabric

The following building fabric parameters were assumed:

Building Element		Existing	Old Extension	New Extension
External Wall	U-value	1.20	0.35	0.26
Roof	U-value	2.44	0.25	0.18
Ground Floor	U-value	0.35	0.22	0.22

¹ See Section 8.1 for modelling assumptions including the occupied period

² See Table 6.7 for definitions of categories.

Windows	U-value	1.60	2.20	1.60
	g-value	0.40	0.65	0.40

Table 1 Fabric U-values

In line with the Highgate School Science Block Refurbishment Feasibility Pack, all teaching rooms and offices will be modelled with suspended plasterboard ceilings, a ceiling void of 0.6m is assumed, bulkheads are not accounted for.

Ventilation and cooling strategy for the school

All teaching rooms have openable windows. The maximum average air speed through vents should be <0.8m/s. Table Appendix 2.1 lists the window types and assumed opening configurations.

Window openings

BB101 requires window free areas to be reported as effective area A_{eff} , clear of frames mullions, cills, reveals and adjacent windows.

$$A_{eff} = A_f \times C_d$$

where A_f is the actual size of the aperture,

and C_d is the coefficient of discharge.

IES assigns values for C_d based on opening type are window dimensions and calculates the equivalent orifice area A_{eq} , which is then multiplied with the C_{do} for the ideal orifice of 0.65 to yield A_{eff} . The applicable C_d is not explicit in IES, but can be derived as follows:

$$C_d = A_{eq} / A_f \times 0.65 \text{ (} C_{do} \text{ of a sharp edged circular orifice).}$$

Table Appendix 2.1 shows how effective free areas for the window types were derived.

Assumed Loads

Occupancy

BB101 occupancies from 9.00 to 16.00 with break from 12.00 to 13.00 from 1st May to 30th September and occupancy levels shown in Table 1. Occupants have sensible heat gains of 70W and latent gains of 55W.

Location	Occupancy
Classrooms, Laboratories	32
Staff rooms	5m ² /p
All other areas	8m ² /p

Table 2 Occupancies in teaching areas

Lighting

A lighting load of 7.2W/m² to represent lighting gains has been assigned to teaching room.

Equipment

Classrooms have 10W/m^2 ICT gains, dedicated ICT and practical rooms have 25W/m^2 . Food Technology has the same internal heat gains as a standard classroom, as cooker loads are assumed to be removed by the extract.

Winter Comfort

The heat emitters in all occupied areas are assumed to be sized to achieve operative temperatures in accordance with CIBSE Guide A Table 1.5.

Results

Cold draughts

The buildings have different types of windows on different facades. All window types were tested for potential cold drafts at seated head height. All windows passed the test, provided

TM52 analysis

Iteration 1 – Basecase

All rooms were naturally ventilated with window openings as per table Appendix2.1 and external blinds (3 Level 3 classrooms of the west-facing old extension) and internal blinds shut. The New entrance extension was modelled with 6ACH of mechanical ventilation, as it has no openable windows.

The Ground Floor admin and staff areas all passed TM52, as well as Biology Labs and offices on the Second Floor.

Teaching spaces passing TM52 also had CO₂ concentrations below 1000ppm.

Iteration 2 – 6 ACH during occupied hours

Spaces failing under natural ventilation were tested with 6 ACH of mechanical ventilation.

The first and second floor laboratories now also pass. Only the 3rd floor teaching spaces and the first Floor east facing rooms on the west wing (unknown function, assumed to be classrooms) continue to fail and may require additional cooling.

Iteration 3 – 6 ACH including night purge

For rooms failing with 6 ACH mechanical ventilation during occupied hours, mechanical ventilation was set to continuous to allow for night purging.

This had a positive impact on all remaining failing rooms, but only resulted in additional passes for the high thermal mass First Floor east facing rooms on the North Road wing (unknown function, assumed to be classrooms) and SBR 5Laboratory on the 3rd floor. However, it indicates that using the thermal mass plus night purge can be beneficial. In Stage 3, the effect of phase change plasterboard ceilings or removing plasterboard ceilings altogether, should be explored.

Conclusions

Assuming that the existing window opening configurations will be retained in the replacement windows (see assumptions in table Appendix1.1), the windows all pass the down draught test.

Using a weather file simulating average summer weather in the 2020's, the Ground Floor admin and staff areas all passed TM52, as well as Biology Labs and offices on the Second Floor. The First and Second Floor Laboratories passed with up to 6 ACH of mechanical ventilation. The 3rd floor teaching spaces and the First Floor east facing rooms on North road (unknown function, assumed to be classrooms) may require additional cooling.

There are a number of other measures which could be explored in Stage 3:

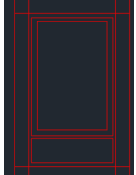
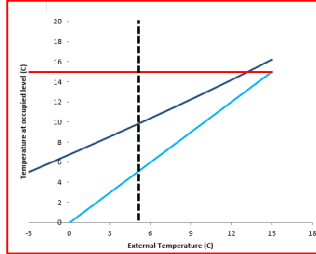
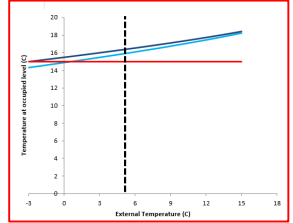
1. Fit external blinds to Third Floor windows
2. Introduce phase change ceilings or remove internal ceilings to expose more thermal mass to reduce the daytime ventilation/cooling requirements in combination with night purging.
3. Reduce g-value of glazing on south and west facades

Appendix 1 – BB101 draught test of existing window types for the building

Window dimensions were input into the BB101 Window line plume calculator to assess whether pupils would experience cold draughts from plumes of cold air dropping on them from open windows. The max. temperature difference at head height (1.4m for secondary schools) should be 5K (down to 5°C external temperature, dashed black line). Assuming a classroom temperature setpoint of 20°C (BB101 table 7-2), the temperature at head height should not be lower than 15°C (red line in graphs). The light blue line shows the temperature at 1.4m head height. In order for the window to pass the test, the light blue line must be above the red line to the right of the dashed black line.

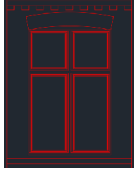
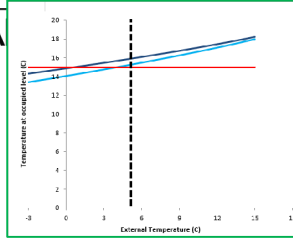
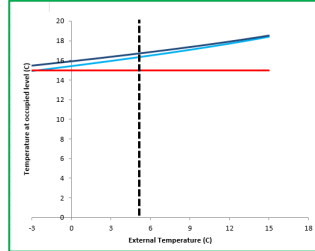
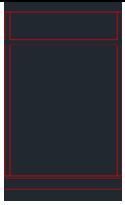
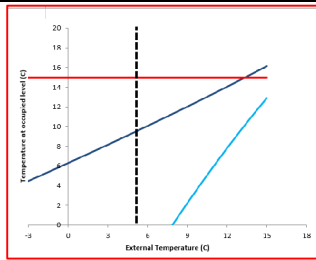
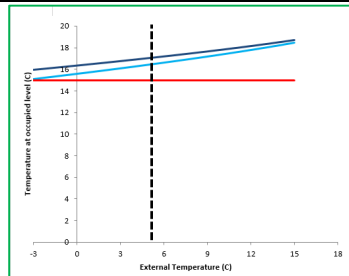
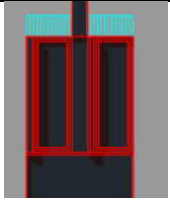
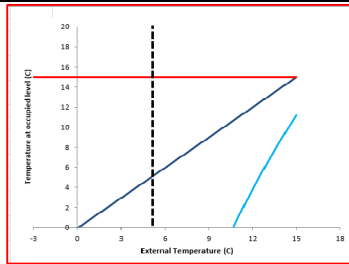
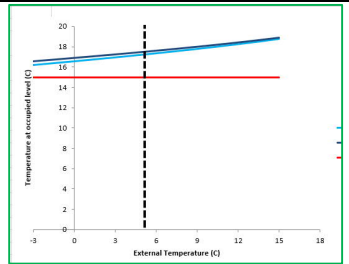
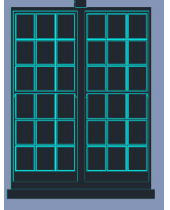
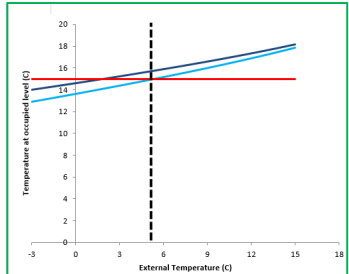
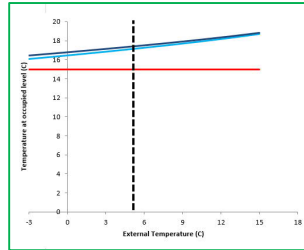
Most of the traditional style panelled windows with high level openings pass that test in both top and bottom hung configuration. However, the windows in the 3rd floor extension would only pass in a bottom hung configuration.

Note that the BB101 draught testing tool only has options for top and bottom hung windows. Sash windows should be considered as bottom-hung because their opening can be at the top. Side-hung windows should be considered as top-hung, because the cold air will enter the room along the full length of the window.

Sample room	Window type	Window dimensions		Results top hung	Results bottom hung
Unknown (east façade Southwood road)		Width of opening window/damper	3.3 m		
		Average temperature of classroom	20 C		
		Height from floor to top of opening window/damper	3.1 m		
		Vertical extent of opening high level window/damper	1.7 m		
		High level opening type	Bottom hung hopper w low		
		Number of occupants	32		
		Minimum fresh air rate per person	5 l/s		

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Breakout Room		Width of opening window/damper Average temperature of classroom Height from floor to top of opening window/damper Vertical extent of opening high level window/damper High level opening type Number of occupants Minimum fresh air rate per person	3.48 m 20 C 3.3 m 0.56 m Top hung window 32 5 l/s		
SBR 4 Laboratory		Width of opening window/damper Average temperature of classroom Height from floor to top of opening window/damper Vertical extent of opening high level window/damper High level opening type Number of occupants Minimum fresh air rate per person	8 m 20 C 2.55 m 1.3 m Bottom hung hopper window 32 5 l/s		
Chemistry Lab 4		Width of opening window/damper Average temperature of classroom Height from floor to top of opening window/damper Vertical extent of opening high level window/damper High level opening type Number of occupants Minimum fresh air rate per person	5.11 m 20 C 3.5 m 2.4 m Bottom hung hopper window 32 5 l/s		
Biology 2 Laboratory		Width of opening window/damper Average temperature of classroom Height from floor to top of opening window/damper Vertical extent of opening high level window/damper High level opening type Number of occupants Minimum fresh air rate per person	4 m 20 C 3.8 m 1.3 m Top hung window 32 5 l/s		

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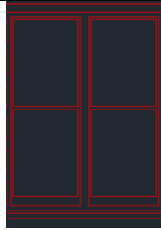
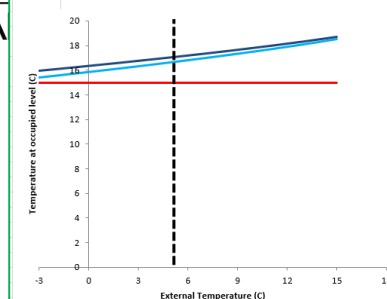
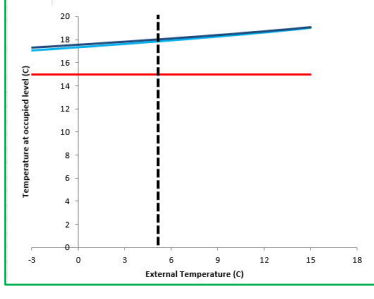
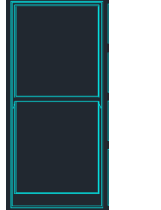
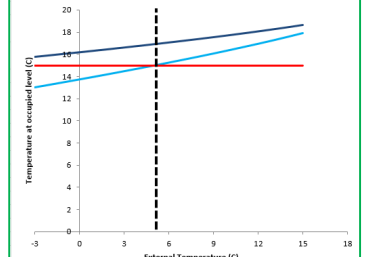
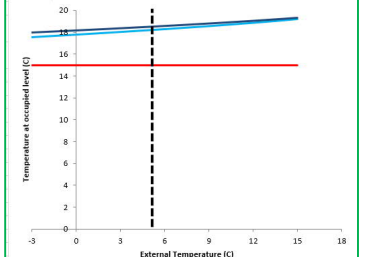
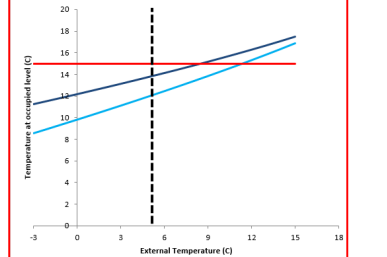
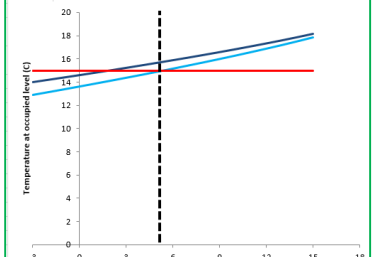
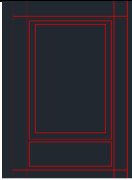
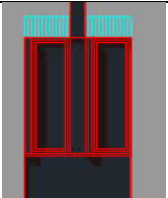
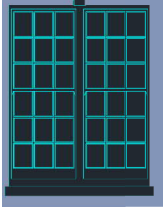
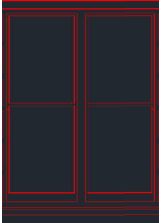
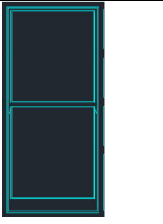
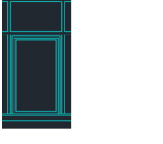
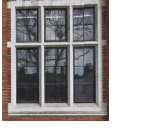
Staff work area		<table><tr><td>Width of opening window/damper</td><td>5 m</td></tr><tr><td>Average temperature of classroom</td><td>20 C</td></tr><tr><td>Height from floor to top of opening window/damper</td><td>1.2 m</td></tr><tr><td>Vertical extent of opening high level window/damper</td><td>1.2 m</td></tr><tr><td>High level opening type</td><td>Bottom hung hopper window</td></tr><tr><td>Number of occupants</td><td>32</td></tr><tr><td>Minimum fresh air rate per person</td><td>5 l/s</td></tr></table>	Width of opening window/damper	5 m	Average temperature of classroom	20 C	Height from floor to top of opening window/damper	1.2 m	Vertical extent of opening high level window/damper	1.2 m	High level opening type	Bottom hung hopper window	Number of occupants	32	Minimum fresh air rate per person	5 l/s		
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Vertical extent of opening high level window/damper	1.2 m																	
High level opening type	Bottom hung hopper window																	
Number of occupants	32																	
Minimum fresh air rate per person	5 l/s																	
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Number of occupants	2																	
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SBR 4 Classroom		<table><tr><td>Width of opening window/damper</td><td>4 m</td></tr><tr><td>Average temperature of classroom</td><td>20 C</td></tr><tr><td>Height from floor to top of opening window/damper</td><td>2.5 m</td></tr><tr><td>Vertical extent of opening high level window/damper</td><td>0.6 m</td></tr><tr><td>High level opening type</td><td>Bottom hung hopper window</td></tr><tr><td>Number of occupants</td><td>32</td></tr><tr><td>Minimum fresh air rate per person</td><td>5 l/s</td></tr></table>	Width of opening window/damper	4 m	Average temperature of classroom	20 C	Height from floor to top of opening window/damper	2.5 m	Vertical extent of opening high level window/damper	0.6 m	High level opening type	Bottom hung hopper window	Number of occupants	32	Minimum fresh air rate per person	5 l/s		
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Height from floor to top of opening window/damper	2.5 m																	
Vertical extent of opening high level window/damper	0.6 m																	
High level opening type	Bottom hung hopper window																	
Number of occupants	32																	
Minimum fresh air rate per person	5 l/s																	

Table Appendix 1.1 Draught test for window configurations. Graphs in red frame fail and those in green frame pass the test.

Appendix 2 – Window apertures in the model

Sample room	Window type	Opening configuration	Max aperture in m	Opening angle in °	Opening height in m	Opening width in m	Free Area A_f in m ²	IES % A in m ²	IES A_{eq} in m ²	Effective free area A_{eff} in m ²
Unknown (east façade Southwood road)		Top hung	0.1	3.4	1.7	1.2	0.29	14	0.29	0.18
Breakout Room		Top Hung	0.46	45	0.6	0.6	0.552	83	0.3	0.20
SBR 4 Laboratory		Top hung	0.1	4.4	1.3	1.08	0.25	17	0.25	0.16
Chemistry Lab 4		Top-hung	0.1	2.2	2.6	0.73	0.33	17	0.33	0.21

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Biology 2 Laboratory		Sash	Top half of window	N/A	1.2	0.75	0.9	95	0.9	0.59
Staff work area		Sash	Top half of window	45	1.24	1.0	1.24	95	1.18	0.77
Head's Office		Sash	Top half of window	N/A	0.87	0.8	0.7	95	0.7	0.46
SBR 4 Classroom		Top hung	0.38	45	0.5	1.0	0.38	77	0.38	0.25
		Bottom hung	0.1	4	1.4	0.9	0.99	6	0.06	0.04
Physics 2 Laboratory		Top hung	0.84	45	1.1 (estimate d)	0.6 (estimate d)	0.92	89	0.59	0.38

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SBR 8 Classroom		unknown	unknown	unknown	1.7	2.17	0.37	10	0.37	0.24
3 rd Floor classroom		Top hung (assumption)	0.1m	2.6	2.2	1.2	0.13	5	0.13	0.09
Bursar's Office		Bottom hung	0.2	7.1	1.6	1.5	0.3	12.5	0.3	0.2
00 Office		Top-hung	0.53	45	0.7	0.45	0.23	75	0.23	0.15
GF Office	unknown	unknown	unknown	unknown	1.28	1.24	0.16 assumption	10	0.16	0.1

Table Appendix 2.1

Appendix 3 – TM52 results

Iteration 1 - Basecase

Room Name	Criteria 1 (%Hrs Top- Tmax>=1K)	Criteria 2 (Max. Daily Deg.Hrs)	Criteria 3 (Max. DeltaT)	Criteria failing
00 IT office	0.3	1	1	-
00 Bursar's Office	1.4	4	2	-
00 Deputy Head's Office	0.9	2	1	-
00 Office	1.4	2	1	-
00 Head's Secretary	0.2	1	1	-
00 Head's Office	0.3	3	2	-
00 Office	1.4	2	1	-
00 Office	0.9	3	1	-
00 Office	0	0	0	-
00 Office	0	0	0	-
00 Bursary	0.6	2	1	-
00 Office	0	0	0	-
00 Bursar's Secretary	1.5	5	2	-
01 Biology 2 Laboratory	1.1	3	2	-
01 Physics Staff Room	0.8	3	2	-
01 Biology 1 Laboratory	0.9	3	2	-
01 Physics 5 Laboratory	3.7	6	3	1
01 Breakout Room	1.1	3	2	-
02 Biology Laboratory 4	0.8	3	2	-
02 Biology Laboratory 3	1.1	3	2	-
02 Biology Staffroom	0.3	3	2	-
02 Office	1.2	3	2	-
02 Office	0.9	3	2	-
02 Chemistry Staff Room	1.1	3	2	-
03 Meeting Room 1 / Meeting Room 2	1.5	6	3	-
New entrance	2	4	3	-
Staff Common room	1.5	3	2	-
Staff work area	1.5	3	2	-
00 Science Display Area	97.2	72	16	1 & 2 & 3
00 Unknown	4.9	10	2	1 & 2
01 Physics 4 Laboratory	11.3	14	5	1 & 2 & 3
01 Physics 2 Laboratory	6.6	10	4	1 & 2

01 Physics 3 Laboratory	11.5	14	5	1 & 2 & 3
01 Physics 1 Laboratory	7	11	4	1 & 2
01 Unknown	18.7	22	6	1 & 2 & 3
01 Unknown	19.6	22	6	1 & 2 & 3
01 Unknown	16.8	19	5	1 & 2 & 3
02 GB SC1 Laboratory	8.3	12	4	1 & 2
02 GB SC2 Laboratory	7	12	4	1 & 2
02 Chemistry Laboratory 1	6.1	10	4	1 & 2
02 Chemistry Laboratory 5	3.7	8	4	1 & 2
02 Chemistry Laboratory 4	14.8	15	5	1 & 2 & 3
02 Chemistry Laboratory 3	14.7	16	6	1 & 2 & 3
02 Chemistry Laboratory 2	4	7	4	1 & 2
03 Circ	9.8	17	4	1 & 2
03 SBR 1 Classroom	36.7	34	9	1 & 2 & 3
03 SBR 8 Classroom	56.6	34	8	1 & 2 & 3
03 Classroom	23.7	26	7	1 & 2 & 3
03 Classroom	57	40	10	1 & 2 & 3
03 Classroom	72.9	48	11	1 & 2 & 3
03 SBR 2 Classroom	34.1	32	8	1 & 2 & 3
03 SBR 4 Classroom	12.4	17	6	1 & 2 & 3
03 SBR 4 Laboratory	11.3	19	6	1 & 2 & 3
03 SBR 3 Laboratory	75.5	46	10	1 & 2 & 3
03 SBR 5 Laboratory	8	18	5	1 & 2 & 3
03 Staff Room	13.3	14	4	1 & 2
03 Prep Room	6.6	11	3	1 & 2
03 Plant room	7.8	13	5	1 & 2 & 3
03 Staff room	4.4	8	3	1 & 2

Table Appendix 3.1

Iteration 2 – 6ACH during occupied hours

Room Name	Criteria 1 (%Hrs Top-Tmax>=1K)	Criteria 2 (Max. Daily Deg.Hrs)	Criteria 3 (Max. DeltaT)	Criteria failing
00 Unknown	2.8	7	2	2
01 Physics 4 Laboratory	3.8	6	3	1
01 Physics 2 Laboratory	2.6	6	3	-
01 Physics 3 Laboratory	4	6	3	1
01 Physics 1 Laboratory	2.6	6	3	-
02 GB SC1 Laboratory	0.9	3	2	-

02 GB SC2 Laboratory	1.7	3	2	-
02 Chemistry Laboratory 1	2.4	5	3	-
02 Chemistry Laboratory 5	2	6	3	-
02 Chemistry Laboratory 4	3.5	6	3	1
02 Chemistry Laboratory 3	3.8	6	3	1
02 Chemistry Laboratory 2	1.8	5	3	-
03 Staff Room	0.8	3	2	-
03 Prep Room	1.4	3	2	-
03 Staff room	0.8	3	2	-
New entrance	1.1	4	3	-
00 Science Display Area	43.4	31	9	1 & 2 & 3
01 Unknown	4.1	8	4	1 & 2
01 Unknown	4.4	9	4	1 & 2
01 Unknown	4.1	9	4	1 & 2
03 Circ	6.6	14	4	1 & 2
03 SBR 1 Classroom	11.6	15	6	1 & 2 & 3
03 SBR 8 Classroom	7.2	10	4	1 & 2
03 Classroom	6.6	10	4	1 & 2
03 Classroom	9.9	15	5	1 & 2 & 3
03 Classroom	15.1	18	6	1 & 2 & 3
03 SBR 2 Classroom	10.4	15	5	1 & 2 & 3
03 SBR 4 Classroom	5.4	9	4	1 & 2
03 SBR 4 Laboratory	5.8	10	4	1 & 2
03 SBR 3 Laboratory	10.2	15	5	1 & 2 & 3
03 SBR 5 Laboratory	3.7	10	4	1 & 2

Table Appendix 3.2

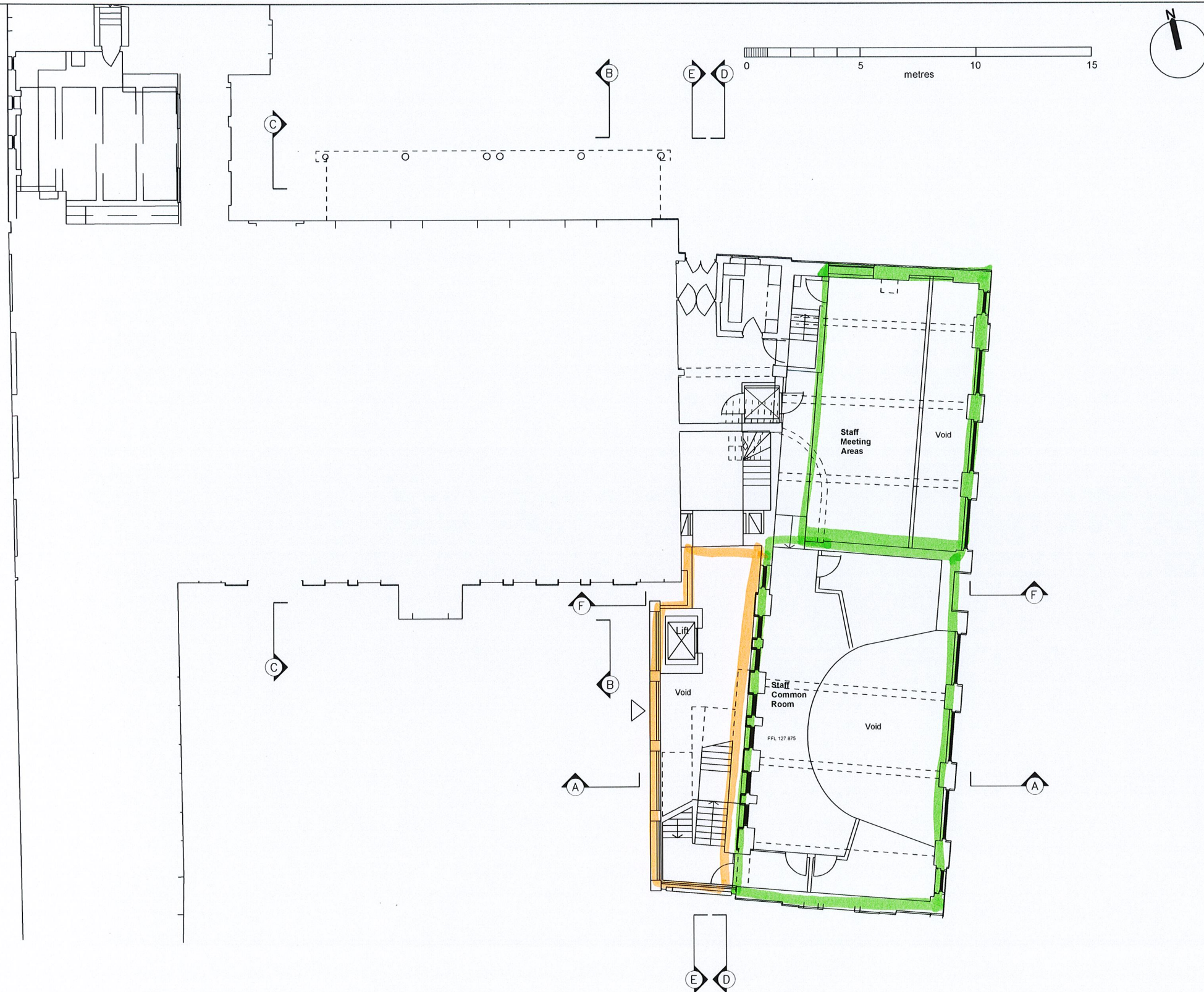
Iteration 3 – 6 ACH continuous

Room Name	Criteria 1 (%Hrs Top-Tmax>=1K)	Criteria 2 (Max. Daily Deg.Hrs)	Criteria 3 (Max. DeltaT)	Criteria failing
03 SBR 5 Laboratory	2.8	8	3	2

01 Unknown	2.8	6	3	-
01 Unknown	2.9	6	3	-
01 Unknown	2.6	6	3	-
00 Science Display Area	43.4	31	9	1 & 2 & 3
03 Circ	6.6	14	4	1 & 2
03 SBR 1 Classroom	11.6	15	6	1 & 2 & 3
03 SBR 8 Classroom	7.2	10	4	1 & 2
03 Classroom	6.6	10	4	1 & 2
03 Classroom	9.9	15	5	1 & 2 & 3
03 Classroom	15.1	18	6	1 & 2 & 3
03 SBR 2 Classroom	10.4	15	5	1 & 2 & 3
03 SBR 4 Classroom	5.4	9	4	1 & 2
03 SBR 4 Laboratory	5.8	10	4	1 & 2
03 SBR 3 Laboratory	10.2	15	5	1 & 2 & 3

Table Appendix 3.3

Appendix 4 – Mark up of proposed ventilation strategy



- NATURAL VENTILATION
- MECHANICAL VENTILATION
- COOLING

Revision:

ed toovey architects

Ed Toovey Architects
Studio 401 Royle Building
31 Wenlock Road
London N1 7SH
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Email: edtoovey@yahoo.co.uk

Project

**Highgate School
Science Project**

Drawing title

Mezzanine floor plan proposed

Drwg. No.

1177_GA_012 Rev. ☐

Scale 1:200 @ A3

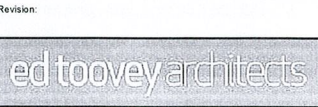
Date March 2017

Status ☒ For information ☐ For tender ☐ For construction

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-  NATURAL VENTILATION
-  MECHANICAL VENTILATION
-  COOLING



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Project
**Highgate School
Science Project**

Drawing title
First floor plan proposed

Drwg. No.
1177_GA_013 Rev. ☐

Scale 1:200 @ A3
Date March 2017

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- NATURAL VENTILATION
- MECHANICAL VENTILATION
- COOLING

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Project

Highgate School Science Project

Drawing title

Second floor plan proposed

Drwg. No.

1177_GA_014

Rev.

☐

Scale

1:200 @ A3

Date

March 2017

Status

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- NATURAL VENTILATION
- MECHANICAL VENTILATION
- COOLING

Revision:

ed toovey architects

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Project

Highgate School
Science Project

Drawing title

Third floor plan proposed

Drwg. No.

1177_GA_015

Rev. ☐

Scale

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Date

March 2017

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