Hall School

OVERHEATING ANALYSIS REPORT

June 2021

ELEMENTA

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Project Office
Elementa Consulting
3d Floor
10 Whitechapel High Street
London
E1 8QS
+44(0)203 697 9300

Project Contact:

Nick Kennedy

Nick.kennedy@elementaconsulting.com

www.elementaconsulting.com

V1.0

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1 Executive Summary

Elementa Consulting has been commissioned to carry out an overheating risk analysis for the Hall School, Hampstead, in the London Borough of Camden.

The proposed development is an extensive redevelopment of a boy's prep school in Belsize Park, a conservation area.

The design incorporates several passive and active strategies to maintain a comfortable environment in summer, such as: openable windows, louvres, cross ventilation thanks to rooflights in the classrooms, glazing solar control, mechanical ventilation.

The scheme was originally developed in 2017, the applicable standard for thermal comfort at that time was BB101(V1). The updated overheating analysis incorporates amendments to the scheme whereby the thermal comfort strategy uses mechanical ventilation for general ventilation and openable windows for control of internal temperatures. The analysis of teaching spaces was carried out following BB101(V1) guidance, with results quoted also for BB101(V2). Non-teaching spaces were assessed against TM52 criteria.

The results of the overheating risk analysis show that all teaching rooms met the BB101(V1) criteria of the overheating risk. All of the office rooms and some of the atria spaces failed TM52. All office rooms will receive cooling to mitigate overheating risk and ensure thermal comfort for occupants.

All rooms meet criterion 3 of Part L2A by implementing sufficient passive measures to limit solar gains limits

2 Introduction

Elementa Consulting has been commissioned to carry out an overheating risk analysis for the Hall School, Hampstead, in the London Borough of Camden.

2.1 Overview

The proposed development is an extensive redevelopment of a boy's prep school in Belsize Park, a conservation area. The redevelopment will include the demolition and rebuild of Wathen Hall to incorporate a new hall and gymnasium. The works will also include the refurbishment of the street facing elevation and an extension in order to enhance the school's contribution to the conservation area.

This report provides an overheating assessment for the development, which has been carried out using the guidance published by the Department for Education (DFE) - DFE Technical Annex 2F: Mechanical Services and Public Health Engineering (2020). This guidance references the summertime overheating criteria stipulated within TM52 'The limits of thermal comfort: avoiding overheating in European buildings' (2013).

2.2 Overheating Criteria

2.2.1 BB101(V1) Compliance

All teaching spaces will be assessed using BB101(V1). The performance standards for summertime overheating for teaching and learning areas are:

a) *Criterion 1 - There should be no more than 120 hours when the air temperature in the classroom rises above 28°C*
b) *Criterion 2 - The average internal to external temperature difference should not exceed 5°C (i.e. the internal air temperature should be no more than 5°C above the external air temperature on average)*
c) *Criterion 3 - The internal air temperature when the space is occupied should not exceed 32°C.*

In order to show that the proposed school will not suffer overheating two of these three criteria must be met.

2.2.2 TM52 Compliance

All occupied non-teaching space have been assessed using TM52 methodology. The following three criteria defined by CIBSE Technical Memorandum TM52 'The limits of Thermal comfort: avoiding overheating in European buildings'.

The following three criteria, taken together, are used to assess the risk of overheating of buildings in the UK and Europe. A room or building that fails any two of the three criteria is classed as overheating.

a) *The first criterion sets a limit for the number of 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 (1st May to 30th September).*

b) *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.*

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c) *The third criterion sets an absolute maximum daily temperature for a room, beyond which the level of overheating is unacceptable.*

The weather file used for this overheating analysis is London_LWC_DSY1_2020High50.

2.3 Modelling Methodology

To carry out the dynamic thermal simulations, Elementa Consulting uses the industry standard IES VE 2019 software suite from Integrated Environmental Solutions Ltd. The software is CLG approved and compliant with CIBSE Guide AM11 (Building Energy and Environmental Modelling).

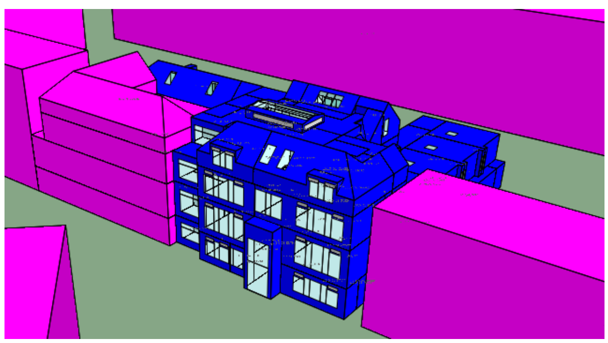
IES is an integrated suite of applications based around one 3D geometrical model. The modules used for this project include 'SunCast' for solar shading analysis, "Apache-Sim" for thermal simulation calculations, 'MacroFlo' for bulk air flow modelling and 'VE Compliance' for Part L2A assessment.

SunCast generates shadows and internal solar insulation from any sun position defined by date, time, orientation, site latitude and longitude. This shading information is stored in a database and used to take account of shading from surroundings in subsequent thermal simulation calculations.

Apache-Sim is a dynamic thermal simulation program based on first-principles mathematical modelling of the heat transfer processes occurring within and around a building. It qualifies as a Dynamic Model in the CIBSE system of model classification and exceeds the requirements of such a model in many areas. The program provides an environment for the detailed evaluation of building and system designs, allowing them to be optimised regarding comfort criteria and energy use.

MacroFlo is a program for analysing bulk air movement in buildings, driven by buoyancy induced pressures and external wind flow.

Figure 2-1 Image of 3D Thermal Model



3 Modelling Assumptions

The following tables detail the modelling assumptions and design parameters utilised within the thermal model to carry out the assessment.

3.1 Building Construction Data

Table 3-1 Summary of Applied Constructions

Element	Proposed Value
External Wall U-Value (W/m².K)	0.13
Ground Floor U-Value (W/m².K)	0.12
Roof U-Value (W/m².K)	0.10
Glazing U-Value (W/m².K)	1.0
Glazing G-Value (-)	0.40
Rooflight U-Value (W/m².K)	1.0
Rooflight G-Value (-)	0.38 (All spaces except Atrium – 0.18)
Glazed Door U-Value (W/m².K)	1.0
Glazed Door G-Value (-)	0.40
Internal Blinds	Modelled only in classrooms, for the non-openable windows

3.1.1 Infiltration

The air permeability of the building envelope must conform to the standard set by Criterion 2 of Part L2A (2013), namely a maximum permeability of 10m³/h/m² at 50Pa.

However, it is proposed that the air permeability of the development will be significantly less than the maximum allowable value. The air permeability value used within the assessment was 2m³/h/m² at 50Pa, which equates to an infiltration rate of 0.10 air changes per hour (calculated by the thermal modelling software).

3.2 Location Data

Table 3-2 Summary of Location Data

Data	-
Building Type	Secondary School
Weather Location	London
Weather File	London_LWC_DSY1_2020High50.epw
Latitude	51.546 North
Longitude	-0.172 West
Elevation	62m

3.3 Internal Gains

An overview of the internal gains applied to the different room types is provided in table below. The room occupancy, lighting gains, equipment gain and ventilation rate for each space is used by the thermal model along with the building fabric and weather (temperature, solar gains and wind) data to predict the resultant internal temperature.

The occupancy profile has been assumed to be 9:00–15:30 for classrooms and 9:00–18:00 for office/staff spaces.

An average of 65W sensible gain and 55W latent gains were assumed per person. For the Main Hall it assumed up to 3 classes will use space during teaching hours, and 12 classes will use the space at lunch time.

Table 3-3 Internal Gains Applied to the Thermal Model

Room Type	Lighting	Small Power	Occupancy
Classrooms	4.5 W/m^2 (09:00-15:30)	5 W/m^2 (09:00-15:30)	22 People (09:00-15:30)
Office and staff rooms	4.5 W/m^2 (09:00-16:00)	15 W/m^2 (09:00-16:00)	8m^2/person (09:00-16:00)
Main Hall	4.5 W/m^2 (09:00-15:30)	4.0 W/m^2 (09:00-15:30)	9:00-10:00 – 200 people 10:00-13:00 – 50 people 13:00-14:00 – 200 people 14:00 – 15:30 – 50 people
Atrium	4.5 W/m^2 (09:00-15:30)	5 W/m^2 (09:00-15:30)	8 People (09:00-15:30)

3.4 Ventilation Strategy

The building is ventilated with mixed mode, mechanical ventilation operates for most of the year to guarantee ventilation rates, but openable windows, louvers and skylights are provided for natural ventilation when external air temperature permits.

3.4.1 Natural Ventilation Strategy

Natural ventilation during occupied and non-occupied hours is provided by windows, safe louvers and roof-lights.

Windows have been assumed to begin to open when the room temperature is over 20°C and to be fully open when the temperature is over 24°C or the CO2 concentration is over 1000ppm and the internal room temperature is higher than the external temperature during occupied hours. During non-occupied hours windows have been assumed to be fully shut for safety reasons. Fully open windows are modelled with an equivalent openable area of 20%.

Safe louvers and roof-lights have been assumed to begin to open when the room temperature is over 20°C and to be fully open when the temperature is over 24°C or the CO2 concentration is over 1000ppm and the internal room temperature is higher than the external temperature.

During non-occupied hours louvers and roof-lights are considered to be fully open when the room temperature is over 18°C. Roof lights are modelled with an equivalent openable area of 20%.

The operable louvers and windows within circulation areas have been generally considered to be fully open when the room air temperature is over 20°C during the hours of operation of the building (9:00-18:00). Fully open louvers are modelled with an equivalent openable area of 43%.

The fully glazed stairs' windows are considered to be fully open also when the room temperature is over 18°C during non-occupied hours.

The actual achievable free areas should be confirmed by Architects and compared with the free area requirements stated in this report.

3.4.2 Mechanical Ventilation

Mechanical ventilation via MVHR is provided with following ventilation rates:

Table 3-4 Mechanical Ventilation Rates

Room Type	Vent rate
Classrooms	10 l/s/p
Office and staff rooms	12 l/s/p
Main Hall	10 l/s/p
Atrium	Naturally ventilated

4 Results

The table below shows the results for the occupied spaces assessed, comparing against the criterion set out in Section 2.2.

4.1 Results of Summertime Overheating Assessment – Teaching Spaces

Teaching spaces must comply with at least two of the three criteria in the table below. A fourth criterion is shown for reference which is the BB101(V2) standard for overheating.

Table 4-1 Results of BB101 Summertime Overheating Assessment

Room Type	BB101(V1) Criterion 1 Hours of Exceedance Target ≤ 120 hours (For Information)	Criterion 2 Average internal to external temperature difference Target ≤5°C	Criterion 3 Upper Limit Temperature Target≤32°C	BB101(V2) Hours of Exceedance Target ≤ 40 hours (Min Requirement)	Pass Or Fail [BB101(V2)]
L00.0_01_CLASS	53.1	0.73	34.77	53.1	Pass
L00.0_02_CLASS	46.8	0.83	33.83	46.8	Pass
L00.0_03_CLASS	33.3	0.75	33.88	33.3	Pass
L00.0_05_CLASS	36.1	0.34	34.02	36.1	Pass
L00.0_06_CLASS	39.0	0.35	34.06	39.0	Pass
L00.0_07_CLASS	35.4	0.41	33.91	35.4	Pass
L00.0_01_SCIEN	71.6	0.96	35.21	71.6	Pass
L00.0_04_CLASS	28.3	0.39	32.3	28.3	Pass
L01.0_01_SCIEN	76.5	1.13	35.6	76.5	Pass
L01.0_02_SCIEN	58.1	1.15	34.79	58.1	Pass
L01.0_03_SCIEN	28.3	0.70	33.52	28.3	Pass
L02.0_02_CLASS	47.5	-0.09	34.47	47.5	Pass
L02.0_01_CLASS	35.4	-0.26	34.12	35.4	Pass
L01.0_04_SCIEN	98	0.86	36.23	105.6	Pass
L02.0_03_CLASS	48.9	0.38	34.78	48.9	Pass
L-1.0_01_WHALL_LOWER	63.8	0.86	34.97	63.8	Pass

L02.5_01_ARTRO	20.5	3.25	33.36	20.5	Pass

The hours of exceedance have been calculated using the annual occupied hours, as shown below.

Classroom Occupied Hours	109 days x 6.5 hours (09:00-15:30) = 708.5 hours

4.2 Results of Summertime Overheating Assessment – Non-Teaching Spaces

Non-teaching spaces must comply with the criteria of TM52. Results are shown in the table below.

Table 4-2 TM52 Results

Room Type	Criterion 1 Hours of exceedance Target < 3%	Criterion 2 Daily weighted exceedance Target < 6	Criterion 3 Upper limit temperature Target <4K	Pass Or Fail
L-1.0_01_OFFIC	6	17	4	Fail
L-1.0_02_OFFIC	7.4	18	4	Fail
L-1.0_03_OFFIC	6.4	14	4	Fail
L-1.0_04_OFFIC	8.9	18	5	Fail
L-1.0_01_STAFF	3.4	9	3	Fail
L02.0_03_SUPPO	17.2	31	6	Fail
L02.0_01_OFFIC	14.1	30	5	Fail
L02.0_01_SUPPO	9	31	6	Fail
L02.0_02_SUPPO	9.4	32	6	Fail
L00.0_01_OFFIC	12.9	29	7	Fail
L02.5_01_APREP	88.4	88	17	Fail

The hours of exceedance have been calculated using the annual occupied hours, as shown below.

Office Occupied Hours	**109 days x 7 hours (09:00-16:00) = 763 hours**

4.3 Results of Part L2A Criterion 3

Table 4 below has been exported from the IES thermal model and based on the design parameters outlined within this report, **demonstrates compliance** with the requirements of Criterion 3 of Part L2A (2013) of the Building Regulations for occupied (or cooled spaces).

Table 4.2 – Solar gains Criterion 3

Criterion 3: The spaces in the building should have appropriate passive control measures to limit solar gains

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
L-2.0_01_OFFIC	N/A	N/A
L-1.0_01_ATRIU	NO (-99.4%)	NO
L-1.0_01_OFFIC	NO (-54.8%)	NO
L-1.0_02_OFFIC	NO (-65.6%)	YES
L-1.0_03_OFFIC	N/A	N/A
L-1.0_04_OFFIC	NO (-69%)	YES
L-1.0_01_STAFF	NO (-71.7%)	YES
L00.0_01_CLASS	NO (-45.8%)	YES
L00.0_02_CLASS	NO (-66.1%)	YES
L00.0_03_CLASS	NO (-59.5%)	YES
L00.0_05_CLASS	NO (-82.9%)	NO
L00.0_06_CLASS	NO (-81.3%)	NO
L00.0_07_CLASS	NO (-87.9%)	YES
L00.0_01_SCIEN	N/A	N/A
L00.0_04_CLASS	NO (-88.1%)	NO
L01.0_01_SCIEN	NO (-44.9%)	YES
L01.0_02_SCIEN	NO (-56.3%)	YES
L01.0_03_SCIEN	NO (-73.9%)	YES
L02.0_02_CLASS	NO (-69.8%)	YES
L02.0_01_CLASS	NO (-60.2%)	YES
L02.0_03_SUPPO	N/A	N/A
L02.0_01_OFFIC	NO (-80%)	YES
L02.0_01_SUPPO	NO (-53.5%)	NO
L02.0_02_SUPPO	NO (-51.9%)	NO
L01.0_04_SCIEN	N/A	N/A
L02.0_03_CLASS	NO (-33.6%)	YES
L-1.0_01_WHALL_UPPER	NO (-28.9%)	NO
L-1.0_01_WHALL_LOWER	NO (-93.5%)	NO
L00.0_01_OFFIC	NO (-30.2%)	NO
L02.5_01_CHIMN	N/A	N/A
L02.5_01_APREP	N/A	N/A
L02.5_01_ARTRO	NO (-69.2%)	NO

4.4 Analysis

The results detail that the teaching spaces comply with at least two of the BB101(v2) criterion, which is satisfactory for compliance. In several spaces Criterion 3, which limits the peak internal temperature, is not met; measures that could address this include addition of blinds or shading:

- External Shading: External shading would reduce peak internal temperatures, however it has not been possible to meet the architectural requirements associated with the development being within a Conservation Area while incorporating external shading
- Window Reveal Depth: As with external shading, increased window reveal depth would have an impact (albeit much lower) on peak internal temperatures, however architectural requirements prevent the incorporation of deeper reveals.
- Internal Blinds: The use of internal blinds is limited to fixed lights. This is due to the usage: as a school, robust materials are required: and blinds on opening lights are difficult to successfully execute: the use roller blinds obstruct air flow, and vertical slatted blinds get broken in use, as do blinds fixed to the opening; interstitial blinds are difficult to repair and maintain.

As such the design has been developed to operate without the use of blinds on the opening lights in classrooms.

Within the teaching spaces, it is proposed to further enhance the thermal comfort using the proposed MVHR systems, using night purge and air tempering (using the heat recovery device, as opposed to providing active cooling of the supply air); these will be developed and tested in the next stage.

The potential thermal comfort performance of the non-teaching spaces demonstrates that natural ventilation is not viable for these areas; the design intent has been to maximise teaching areas, with priority given to these for daylight access, natural ventilation etc over non-teaching areas, as occupancy will vary more significantly. As such, it is necessary to provide mechanical ventilation and/or cooling to these areas to ensure a healthy environment for the occupants.

The Atrium design has been developed to optimise natural light, providing connectivity to outside; the consequence of this is that there is a risk of overheating. The client and architect have been engaged regarding the use of blinds or providing smaller openings/higher G values – the preference being for the design without blinds.

5 Conclusions

The design incorporates several passive and active strategies to maintain a comfortable environment in summer, such as: openable windows, doors, fanlights and louvres, cross ventilation thanks to rooflights, glazing solar control and mechanical ventilation.

The analysis of teaching spaces was carried out following BB101(V1) guidance, with results quoted also for BB101(V2). Non-teaching spaces were assessed against TM52 criteria.

The results of the overheating risk analysis show that all teaching rooms met the BB101(V1) criteria of the overheating risk. All of the office rooms and some of the atria spaces failed TM52. All office rooms will receive cooling to mitigate overheating risk and ensure thermal comfort for occupants. The art prep room is windowless so under the current design it will also need to receive cooling.

All rooms meet criterion 3 of Part L2A by implementing sufficient passive measures to limit solar gains limits.

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