Project Documentation
Gebäude-Dokumentation

1 Abstract / Zusammenfassung

Harris Academy Sutton, UK
Passivhaus Secondary School for 1,275 students (ages 11-18)

1.1 Data of building / Gebäudedaten

Year of construction/ Baujahr	2019	**Space heating / Heizwärmebedarf**	**15 kWh/(m²a)**
U-value external wall/ U-Wert Außenwand	0.21 W/(m²K)		
U-value basement ceiling/ U-Wert Kellerdecke	0.16 W/(m²K)	**Primary Energy Renewable (PER) / Erneuerbare Primärenergie (PER)**	-
U-value roof/ U-Wert Dach	0.12 W/(m²K)	**Generation of renewable energy / Erzeugung erneuerb. Energie**	-
U-value window/ U-Wert Fenster	0.97 W/(m²K) (incl. doors)	**Non-renewable Primary Energy (PE) / Nicht erneuerbare Primärenergie (PE)**	120 kWh/(m²a)
Heat recovery/ Wärmerückgewinnung	77% (average)	Pressure test n_{50} / Drucktest n_{50}	0.3 h-1
Special features/ Besonderheiten	Technical teaching spaces incl. specialist laboratories and workshops. Hybrid structure: concrete ground floor, cross-laminated timber CLT on upper floors, timber frame infill. External airtightness strategy.		

1.2 Brief Description

Harris Academy Sutton is the UK's first Passivhaus Secondary School, accommodating up to 1,275 students from ages 11-18. The building has a GIFA of 10,625m^2 and spans across four storeys providing flexible teaching accommodation – including classrooms, laboratories, technical workshops, and Sports, Drama & Assembly Halls. The building has a special focus on the science disciplines aiming to inspire pupils through providing a school with exemplar learning environments, minimal operational carbon and certainty of energy savings.

Teaching spaces are light and inspiring with optimised spatial orientation, shading and glazing proportions – a result of early analysis and testing using PHPP, daylight and dynamic overheating tools. Natural materials have been used throughout the building from structure through to finishes. Cross laminated timber structure has been exposed throughout the upper floors, with non-toxic materials providing excellent air quality and low-carbon environmental credentials. The central spine of the school has alternating wings and halls spanning off the main axis, to provide an optimised massing which deals well with the challenging, tight site constraints and prioritises optimum orientation for all teaching spaces.

The school has proven to be another excellent example of the Passive House standard delivering high quality low-energy buildings which perform as predicted. The client, pupils and staff are delighted with the amount of energy and money being saved on running costs, and there's continued positive feedback about how comfortable the school is for teaching, working and learning.

Kurzbeschreibung der Bauaufgabe

Die Harris Academy Sutton ist die erste Passivhaus-Sekundarschule Großbritanniens und bietet Platz für bis zu 1.275 Schüler im Alter von 11 bis 18 Jahren. Das Gebäude verfügt über eine GIFA von 10.625 m² und erstreckt sich über vier Stockwerke und bietet flexible Unterrichtsunterkünfte – darunter Klassenzimmer, Labore, technische Werkstätten sowie Sport-, Theater- und Versammlungssäle. Das Gebäude legt einen besonderen Schwerpunkt auf die naturwissenschaftlichen Disziplinen und zielt darauf ab, Schüler zu inspirieren, indem es einer Schule beispielhafte Lernumgebungen, minimalen betrieblichen CO2-Ausstoß und die Gewissheit von Energieeinsparungen bietet.

Lehrräume sind hell und inspirierend mit optimierter räumlicher Ausrichtung, Beschattung und Verglasungsproportionen – ein Ergebnis früher Analysen und Tests mit PHPP, Tageslicht und dynamischen Überhitzungstools. Im gesamten Gebäude wurden von der Struktur bis zur Fertigstellung natürliche Materialien verwendet. In den oberen Stockwerken wurde eine Struktur aus Brettsperrholz freigelegt, wobei ungiftige Materialien für eine hervorragende Luftqualität und eine CO2-arme Umweltverträglichkeit sorgen. Das zentrale Rückgrat der Schule besteht aus abwechselnden Flügeln und Hallen, die sich über die Hauptachse erstrecken, um eine optimierte Masse zu schaffen, die den anspruchsvollen, engen Standortbeschränkungen gut gerecht wird und eine optimale Ausrichtung aller Unterrichtsräume in den Vordergrund stellt.

Die Schule hat sich als ein weiteres hervorragendes Beispiel für den Passivhaus-Standard erwiesen, der hochwertige Niedrigenergiegebäude liefert, die die erwartete Leistung erbringen. Der Kunde, die Schüler und das Personal freuen sich über die Menge an Energie und Geld, die bei den laufenden Kosten eingespart werden, und es gibt weiterhin positive Rückmeldungen darüber, wie komfortabel die Schule zum Lehren, Arbeiten und Lernen ist.

1.3 Responsible project participants / Verantwortliche Projektbeteiligte

Client / Klient	London Borough of Sutton
Architect / Entwurfsverfasser	Architype Ltd
Main Contractor / Bauunternehmer	Wilmott Dixon
Building services engineering / Gebäudetechnik	BDP, Jones King, CMB Engineering & DES Group
Structural engineering / Baustatik	Price & Myers, KLH with Rambol
Passive House project planning / Passivhaus-Projektierung	Architype Ltd
Landscape Architect / Landschaftsarchitekt	Churchman Ltd
Quantity Surveyor / Mengengutachter	Synergy Construction
Certifying body / Zertifizierungsstelle	WARM: Low Energy Building Practice
Certification ID / Zertifizierungs ID	6861
Author of project documentation / Verfasser der Gebäude-Dokumentation	Sioned Holland
Date, Signature/ Datum, Unterschrift	13.02.2024

2 Views of Harris Academy, Sutton

2.1 External views

Approach to main school entrance on north of site – view from NW corner.

East elevation showing vertical shading on east façade, horizontal brise-soleil on south façades. Curtain wall glazing has been used in limited areas to highlight the stair cores.

© Jack Hobhouse / Architype

South elevations – teaching wings (left) span from central wing (right). MVHR units are located externally on the roof and are concealed behind metal mesh screening. The green canopy on south façade identifies the secondary rear entrance door from central spine. © Jack Hobhouse / Architype

West elevation of central spine with vertical shading. Assembly Hall (with copper cladding) & front teaching wing (with brise-soleil) span from the central spine. | © Jack Hobhouse / Architype

2.2 Internal views

Art classroom © Jack Hobhouse / Architype
Excellent daylight and air quality is achieved from large openable, shaded windows, providing teachers and pupils the comfort of controlling their learning environment.

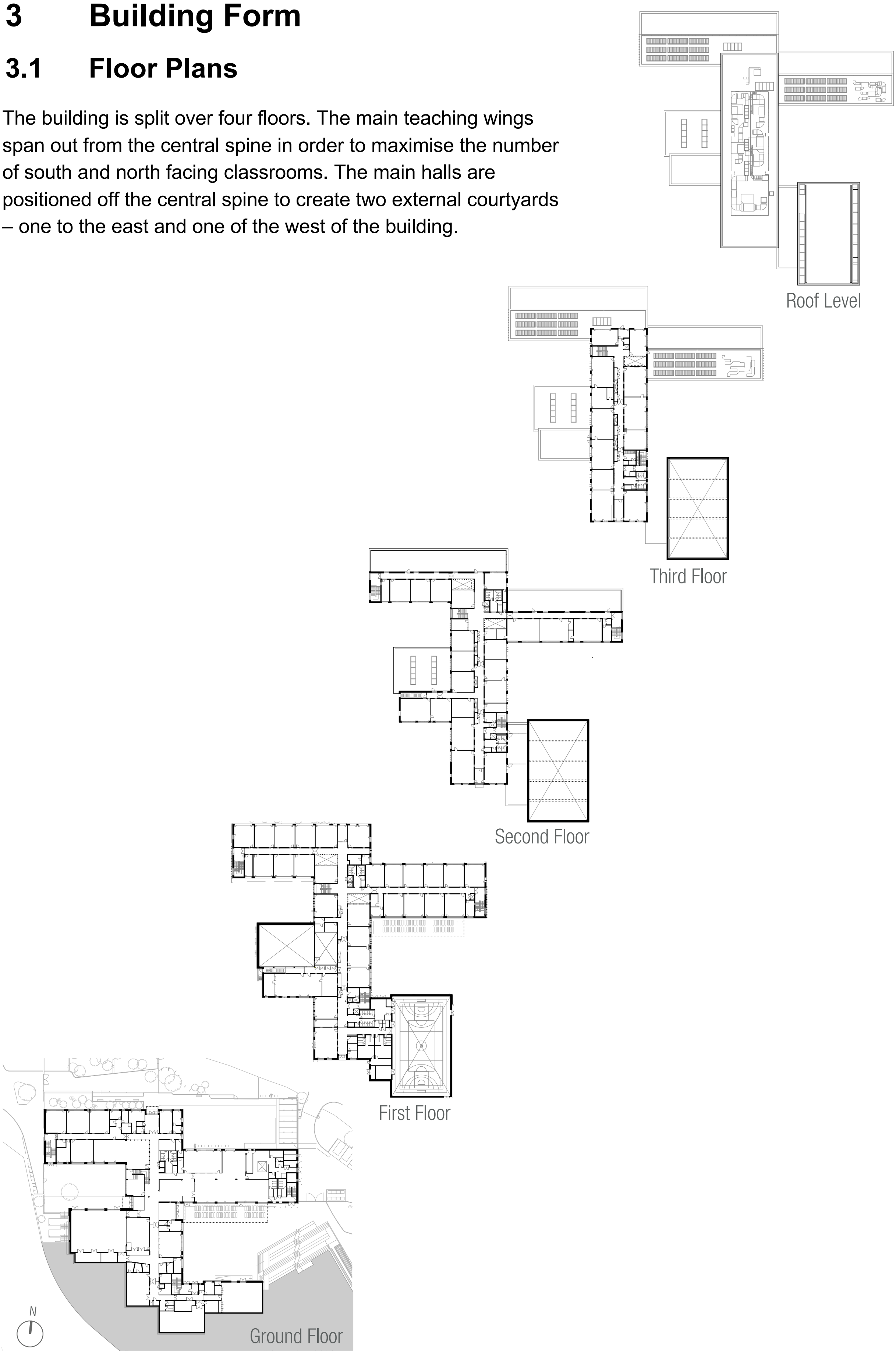
Left: Dining space below central atrium rooflight.
© Jack Hobhouse / Architype

Top right: Bright, science laboratory.
Bottom right: Dining space with exposed concrete soffit on ground floor to benefit from thermal mass.

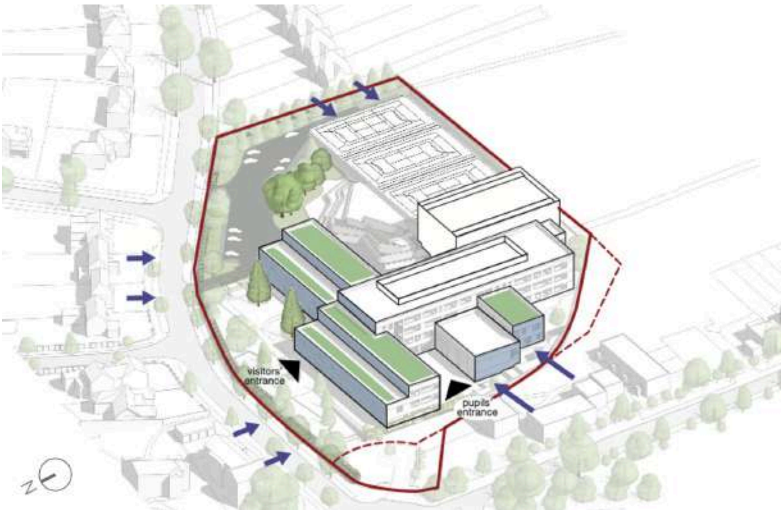
3 Building Form

3.1 Floor Plans

The building is split over four floors. The main teaching wings span out from the central spine in order to maximise the number of south and north facing classrooms. The main halls are positioned off the central spine to create two external courtyards – one to the east and one of the west of the building.



3.2 Site massing



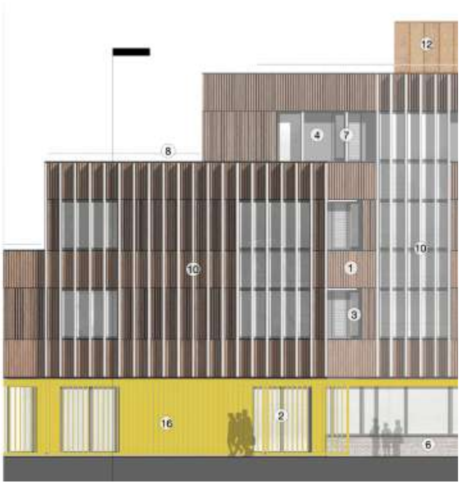
Form factor
1.8
Heat Loss Area / TFA

A series of massing options were thoroughly tested during the Planning process. The area constraints of the site, proximity to neighbours, presence of existing trees and area requirements for external amenity, all resulted in a final massing less compact that originally planned. The building however still had a low form factor (HLA / TFA = 1.8) due to the large scale of the building.

Treated Floor Area = 8,954 m^2

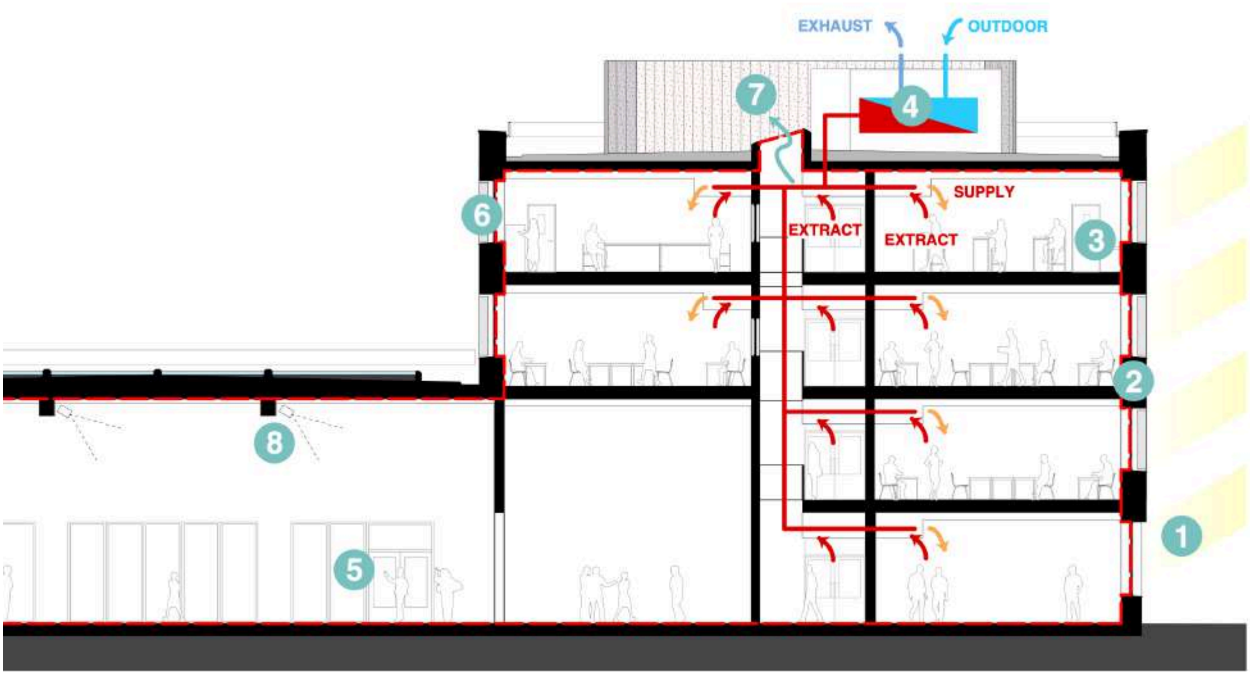
Total Thermal Envelope = 15,827 m^2

3.3 Site Sections & Elevations



4 Section drawings

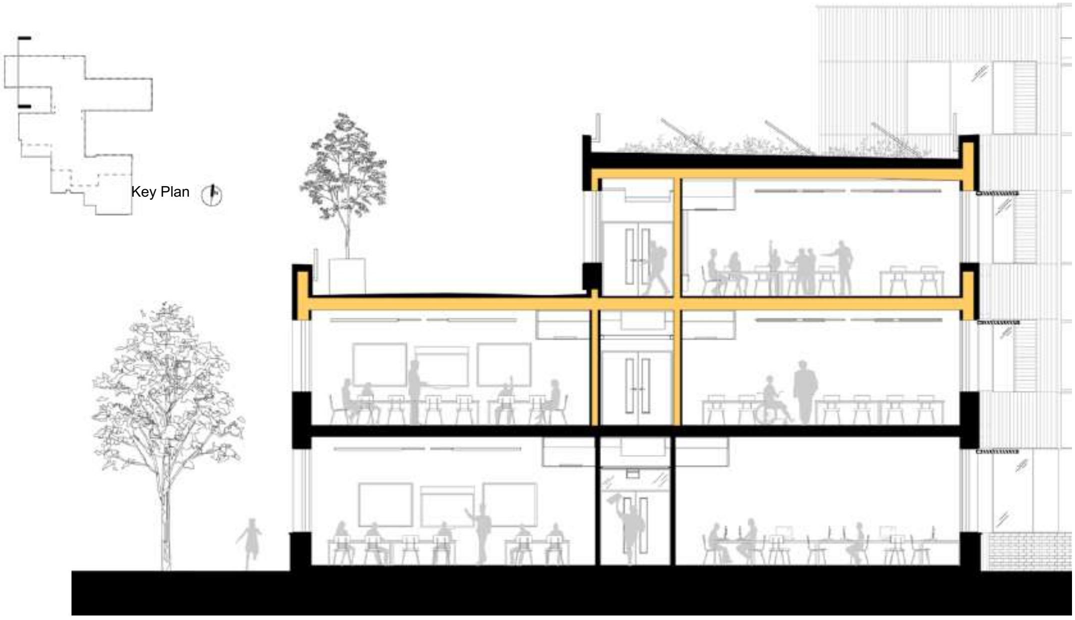
4.1 Overview section through central spine & assembly hall



Overview of environmental strategy (details on each to follow):

1. Glazing and shading design optimised to benefit from useful solar gains in winter and minimal solar gains in summer
2. Continuous high-performance insulation – details was carefully developed to minimise thermal bridges
3. Fully airtight envelope – achieved with airtight membrane installed to external face of CLT / glulam frame on upper floors and external face of timber frame infill on ground floor (internal to insulation)
4. PH Certified MVHR units to recover heat - located externally on roof. Fresh tempered air enters classrooms through bulkheads and is cascaded through corridors and extracted from WCs and atriums to minimise the volume of air being supplied and associated heat loss.
5. High comfort levels for occupants through VAV controls and openable windows.
6. Triple glazed windows and doors.
7. Natural ventilation in temperate months through openable windows and atrium rooflights.
8. Reduction in lighting demand through efficient specification and optimised glazing design.

4.2 Overview section through north teaching wing



Overview of structure - Key features

- Concrete structure was chosen for ground floor and critical areas like fire rated staircores. Exposed concrete soffits increase thermal mass, noticeably reducing temperature fluctuations in summer and winter.
- CLT structure was used on the upper 3 floors to reduce embodied carbon and overall weight of building which meant that raft slab foundations could be used in place of deep concrete piles, further minimising the embodied carbon.

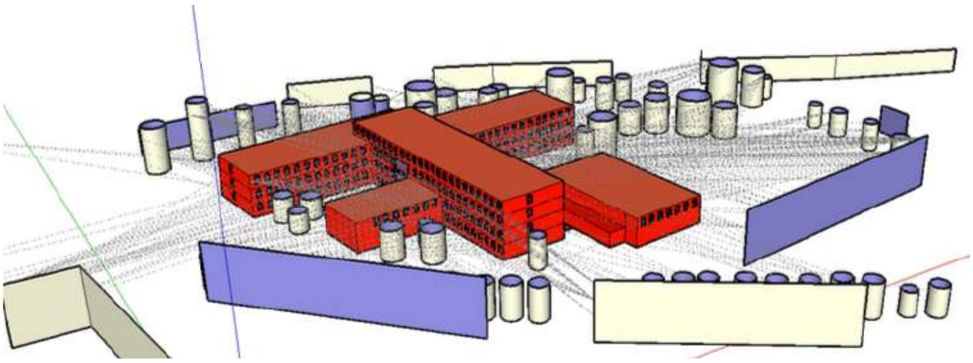
Orientation & façades – Key features

- Majority of teaching classrooms are orientated north & south to minimise uncontrolled solar gains. Depth of floor plan was optimised to ensure uniform daylight across classrooms, with window head heights increased to maximise the amount of daylight penetrating deep into the classrooms.
- The diagram below highlights the different shading depths used on each façade to optimise useful solar gains in winter and minimise overheating in summer.

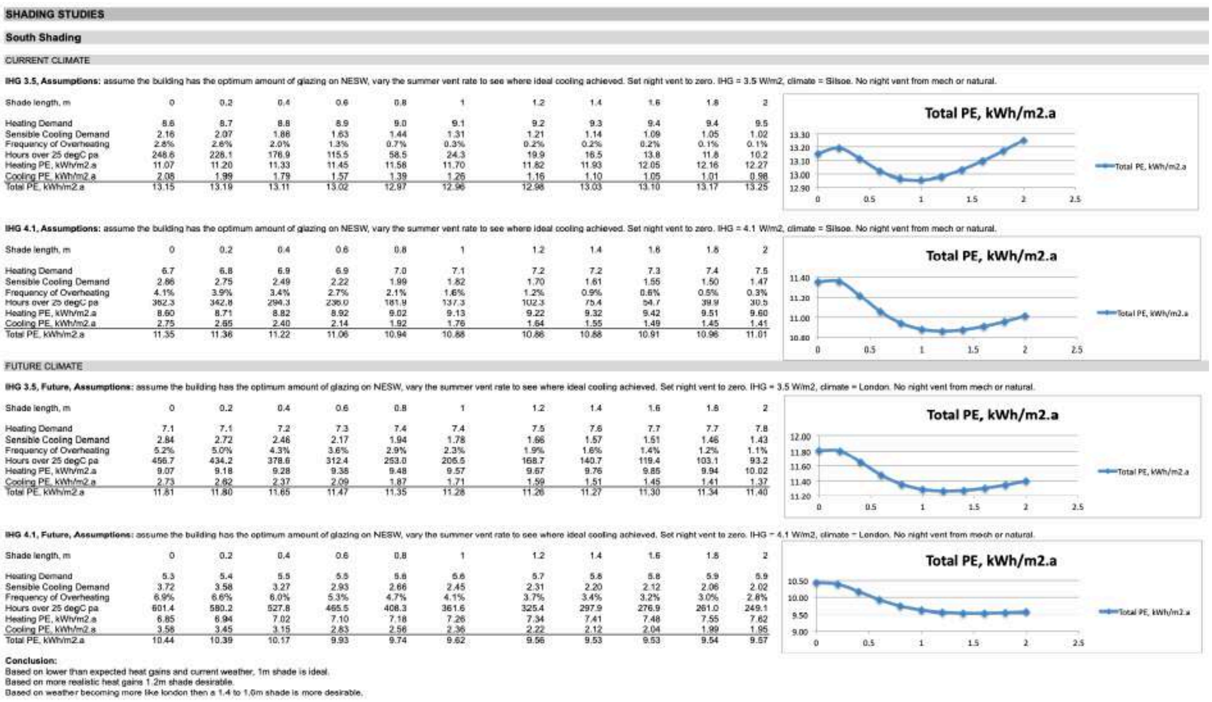
4.3 Glazing & Shading strategies

Refining the façade, glazing and shading design required a substantial amount of work testing and re-testing results from PHPP, daylight and overheating analysis to find the optimum balance of solar gain vs. minimising risk of overheating.

A single classroom was initially modelled to test daylight levels and classroom depth. The glazing areas were then then tested in PHPP for heating & overheating performance. A full DesignPH model was created at RIBA Stage 2 to test different glazing areas and shading depths and their impact on overall PE demand. Results from the shading analysis for south façade are shown below:



4.3.1 Results from Shading Analysis



SHADING STUDIES

South Shading

CURRENT CLIMATE

IHG 3.5, Assumptions: assume the building has the optimum amount of glazing on NESW, vary the summer vent rate to see where ideal cooling achieved. Set night vent to zero. IHG = 3.5 W/m2, climate = Silsoe. No night vent from mech or natural.

Shade length, m	0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2
Heating Demand	8.6	8.7	8.8	8.9	9.0	9.1	9.2	9.3	9.4	9.4	9.5
Sensible Cooling Demand	2.16	2.07	1.88	1.63	1.44	1.31	1.21	1.14	1.09	1.05	1.02
Frequency of Overheating	2.8%	2.6%	2.0%	1.3%	0.7%	0.3%	0.2%	0.2%	0.2%	0.1%	0.1%
Hours over 25 degC pa	248.6	228.1	176.9	115.5	58.5	24.3	19.9	16.5	13.8	11.8	10.2
Heating PE, kWh/m2.a	11.07	11.20	11.33	11.45	11.58	11.70	11.82	11.93	12.05	12.16	12.27
Cooling PE, kWh/m2.a	2.08	1.99	1.79	1.57	1.39	1.26	1.16	1.10	1.05	1.01	0.98
Total PE, kWh/m2.a	13.15	13.19	13.11	13.02	12.97	12.96	12.98	13.03	13.10	13.17	13.25

Total PE, kWh/m2.a

IHG 4.1, Assumptions: assume the building has the optimum amount of glazing on NESW, vary the summer vent rate to see where ideal cooling achieved. Set night vent to zero. IHG = 4.1 W/m2, climate = Silsoe. No night vent from mech or natural.

Shade length, m	0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2
Heating Demand	6.7	6.8	6.9	6.9	7.0	7.1	7.2	7.2	7.3	7.4	7.5
Sensible Cooling Demand	2.86	2.75	2.49	2.22	1.99	1.82	1.70	1.61	1.55	1.50	1.47
Frequency of Overheating	4.1%	3.9%	3.4%	2.7%	2.1%	1.6%	1.2%	0.9%	0.6%	0.5%	0.3%
Hours over 25 degC pa	362.3	342.8	294.3	236.0	181.9	137.3	102.3	75.4	54.7	39.9	30.5
Heating PE, kWh/m2.a	8.60	8.71	8.82	8.92	9.02	9.13	9.22	9.32	9.42	9.51	9.60
Cooling PE, kWh/m2.a	2.75	2.65	2.40	2.14	1.92	1.76	1.64	1.55	1.49	1.45	1.41
Total PE, kWh/m2.a	11.35	11.36	11.22	11.06	10.94	10.88	10.86	10.88	10.91	10.96	11.01

Total PE, kWh/m2.a

FUTURE CLIMATE

IHG 3.5, Future, Assumptions: assume the building has the optimum amount of glazing on NESW, vary the summer vent rate to see where ideal cooling achieved. Set night vent to zero. IHG = 3.5 W/m2, climate = London. No night vent from mech or natural.

Shade length, m	0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2
Heating Demand	7.1	7.1	7.2	7.3	7.4	7.4	7.5	7.6	7.7	7.7	7.8
Sensible Cooling Demand	2.84	2.72	2.46	2.17	1.94	1.78	1.66	1.57	1.51	1.46	1.43
Frequency of Overheating	5.2%	5.0%	4.3%	3.6%	2.9%	2.3%	1.9%	1.6%	1.4%	1.2%	1.1%
Hours over 25 degC pa	456.7	434.2	378.6	312.4	253.0	206.5	168.7	140.7	119.4	103.1	93.2
Heating PE, kWh/m2.a	9.07	9.18	9.28	9.38	9.48	9.57	9.67	9.76	9.85	9.94	10.02
Cooling PE, kWh/m2.a	2.73	2.62	2.37	2.09	1.87	1.71	1.59	1.51	1.45	1.41	1.37
Total PE, kWh/m2.a	11.81	11.80	11.65	11.47	11.35	11.28	11.26	11.27	11.30	11.34	11.40

Total PE, kWh/m2.a

IHG 4.1, Future, Assumptions: assume the building has the optimum amount of glazing on NESW, vary the summer vent rate to see where ideal cooling achieved. Set night vent to zero. IHG = 4.1 W/m2, climate = London. No night vent from mech or natural.

Shade length, m	0	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2
Heating Demand	5.3	5.4	5.5	5.5	5.6	5.6	5.7	5.8	5.8	5.9	5.9
Sensible Cooling Demand	3.72	3.58	3.27	2.93	2.66	2.45	2.31	2.20	2.12	2.06	2.02
Frequency of Overheating	6.9%	6.6%	6.0%	5.3%	4.7%	4.1%	3.7%	3.4%	3.2%	3.0%	2.8%
Hours over 25 degC pa	601.4	580.2	527.8	465.5	408.3	361.6	325.4	297.9	276.9	261.0	249.1
Heating PE, kWh/m2.a	6.85	6.94	7.02	7.10	7.18	7.26	7.34	7.41	7.48	7.55	7.62
Cooling PE, kWh/m2.a	3.58	3.45	3.15	2.83	2.56	2.36	2.22	2.12	2.04	1.99	1.95
Total PE, kWh/m2.a	10.44	10.39	10.17	9.93	9.74	9.62	9.56	9.53	9.53	9.54	9.57

Total PE, kWh/m2.a

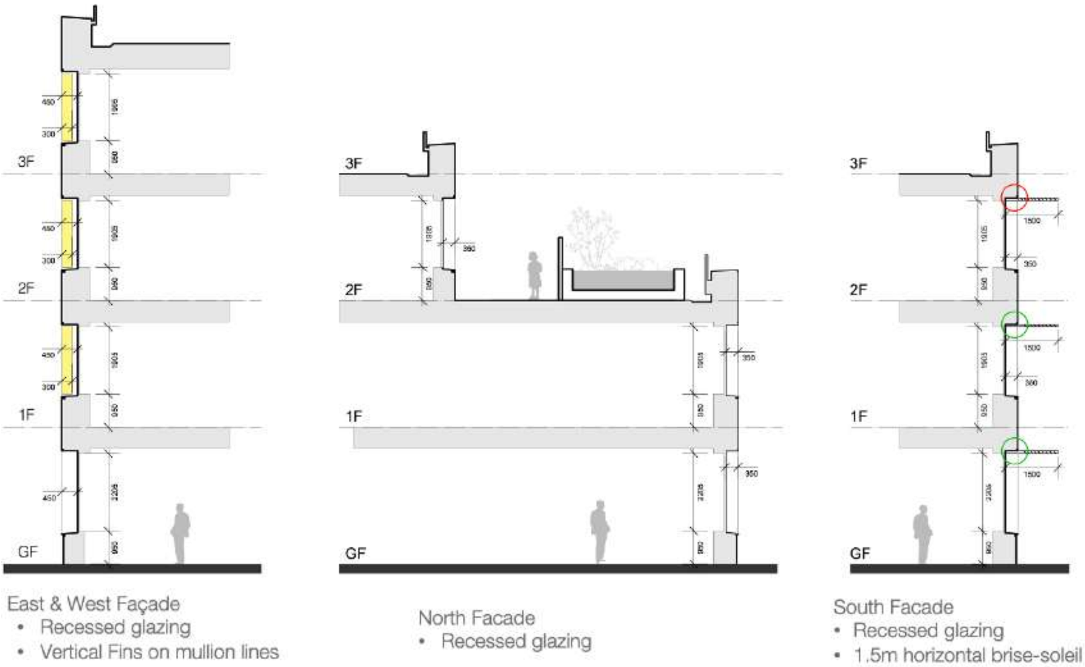
Conclusion:
Based on lower than expected heat gains and current weather, 1m shade is ideal.
Based on more realistic heat gains 1.2m shade desirable.
Based on weather becoming more like london then a 1.4 to 1.6m shade is more desirable.

Conclusion from above analysis was that a 1.5m deep horizontal brise-soleil on south façades would result in the lowest energy consumption overall.

4.3.2 Results from Glazing Analysis

The PHPP, overheating & daylight analysis resulted in the optimum glazing ratios noted below. Glazing was reduced to the minimum required for daylight requirements on the north, east & west façades. On south facades the glazing ratio was increased to 31% with the 1.5m deep horizontal shading to obstruct direct solar gains in summer.

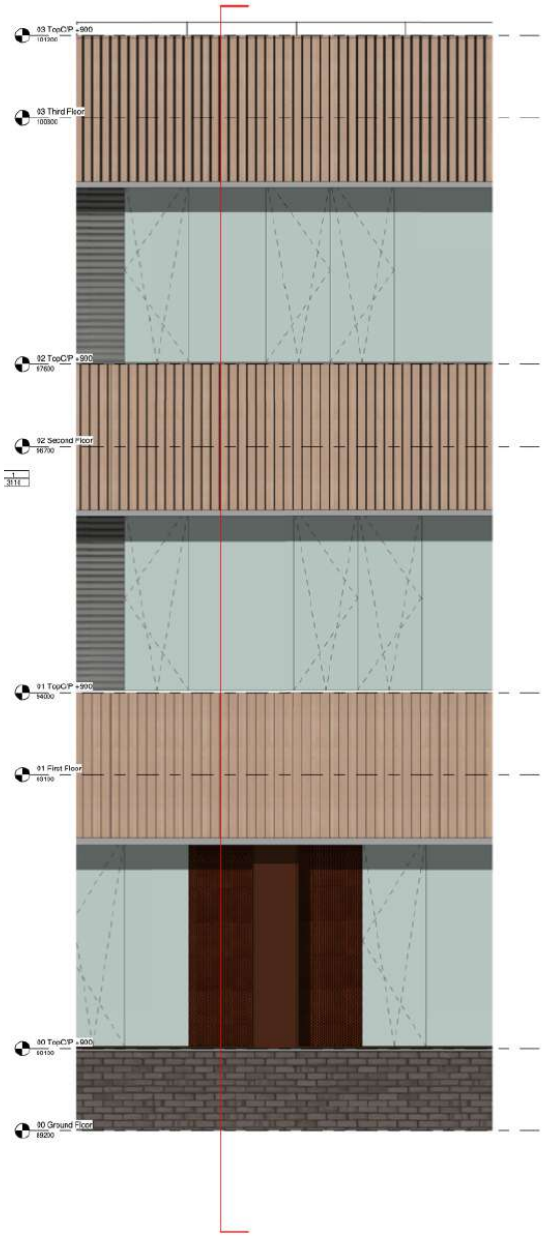
Resultant glazing ratios



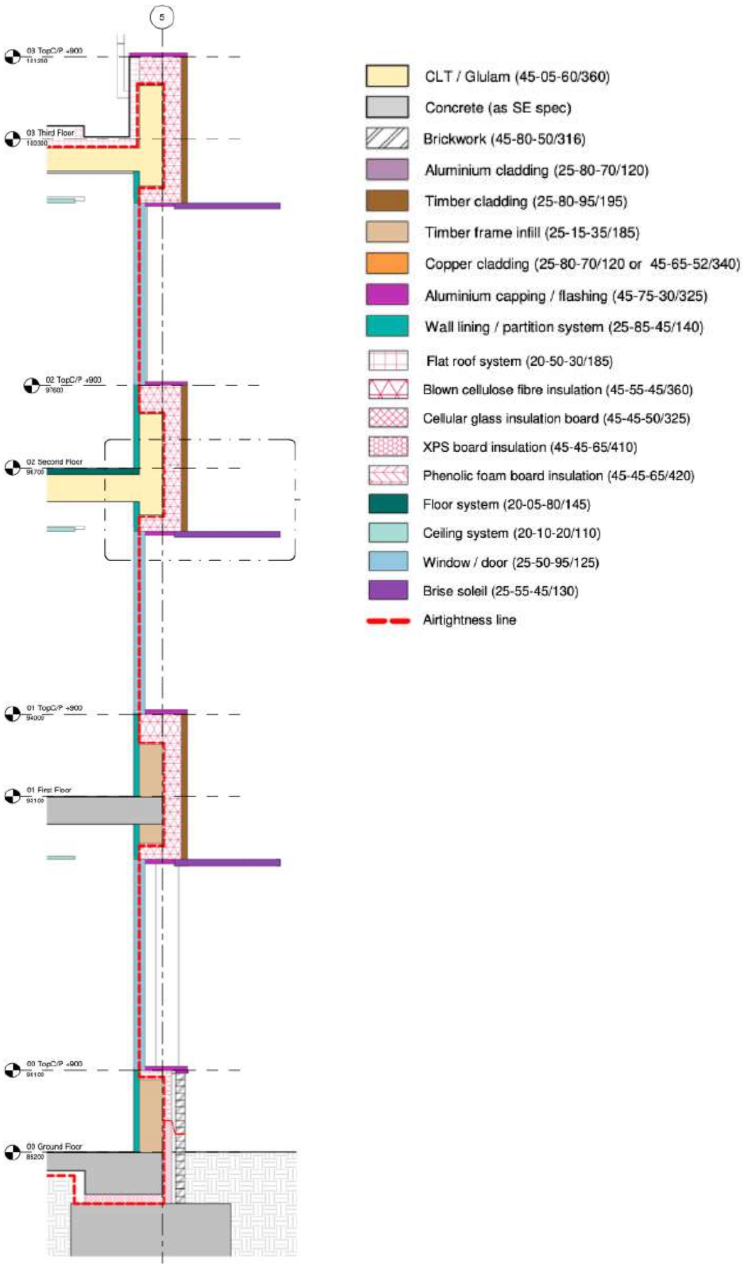
Resultant shading strategy in sections (above) and completed photos (below)

5 Construction details of the envelope

5.1 Overview of construction build-up



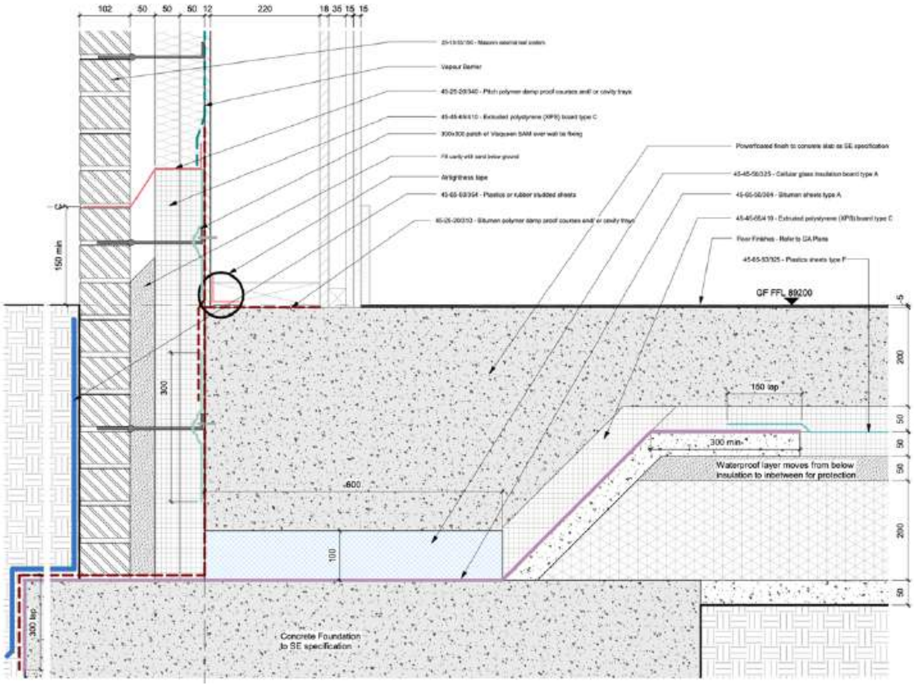
South-façade showing
detailed section in context



Detailed section showing
typical construction of
external wall (south façade)

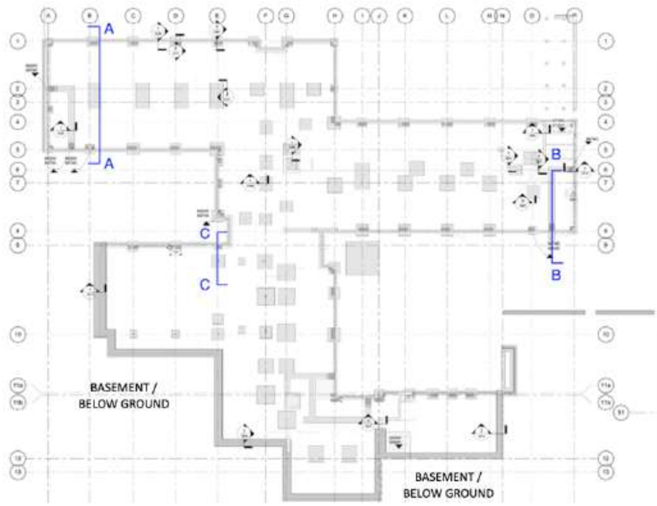
5.2 Floor slab construction

Due to the large scale of the building, low ratio of ground floor footprint area to exposed perimeter length, and cost constraints, the thickness of below-ground insulation was reduced to 100mm XPS insulation – thinner than the typical smaller Passive House projects that we've delivered. The thickness was agreed following extensive thermal bridge analysis to test surface temperatures around the perimeter where ground temperatures fluctuate more than below the centre of the slab's footprint.

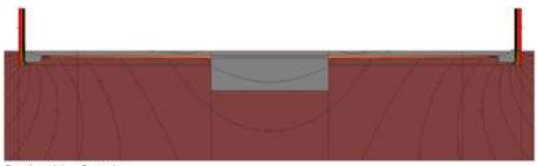


From top: Below-slab XPS; Formwork for prior to pouring reinforced concrete onto insulation; Vertical insulation at low-level for continuous thermal layer.

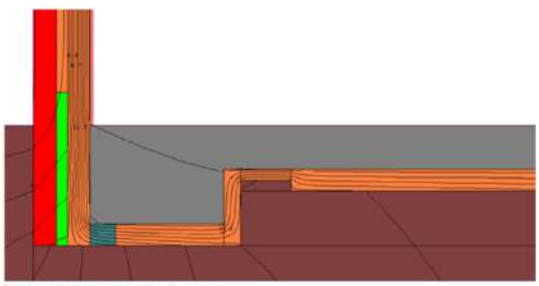
Ground floor	Concrete blinding, 2x 50mm XPS insulation, 200mm RC slab with perimeter insulation, liquid applied DPM, carpet/vinyl /lino/timber finish.	U-value **0.32** W/m²K (excl. perimeter correction factor)



Markup of Thermal Bridges assessed on ground floor foundation plan



Section AA – Overview



Section AA – Detailed view

Thermal bridge calculations checking surface temperatures at perimeter

5.4 Exterior wall construction

Typical wall	Typical wall build-up (upper floors – shown in below detail): 21 mm vertical Douglas Fir timber rainscreen cladding, softwood 38x50 mm battens, vapour control membrane, 195 mm framed JJI-joist structure filled with blown cellulose insulation, vapour and airtight membrane, 18mm magnesium oxide sheathing board, glulam columns with timber frame infill, 38 mm insulated service cavity, 2x15mm gypsum board wall lining.	U-value **0.15** W/m^{2}K

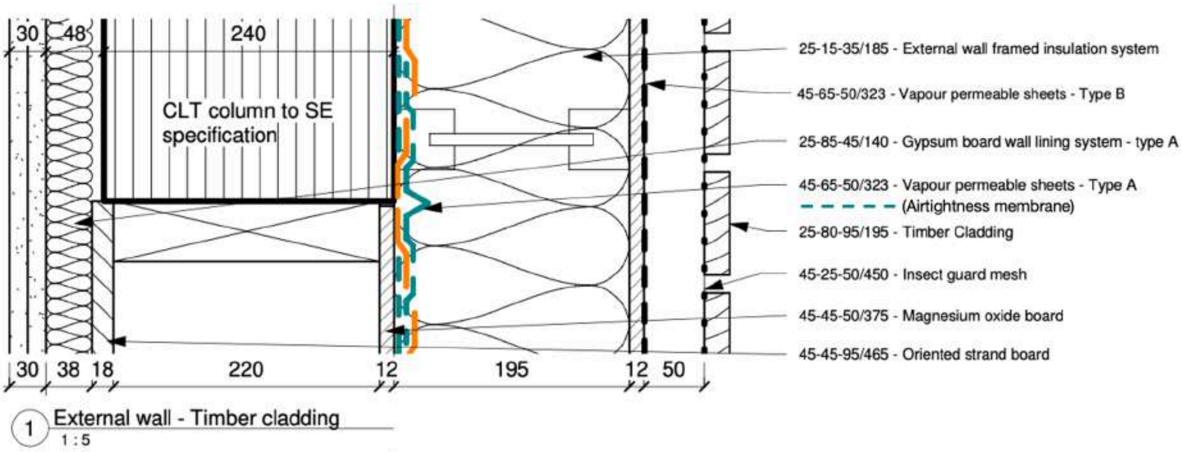
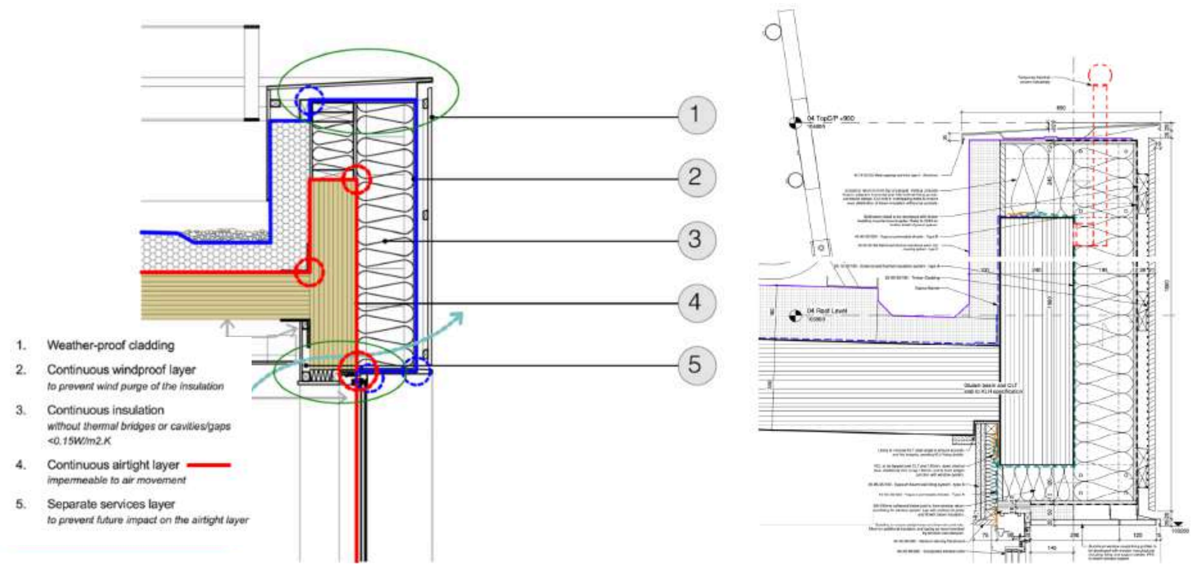


Photo showing framed JJI-joist structure (195 mm) fixed to glulam / timber frame infill. Zone was boarded (visible on left wing) before being fully-filled with blown insulation.

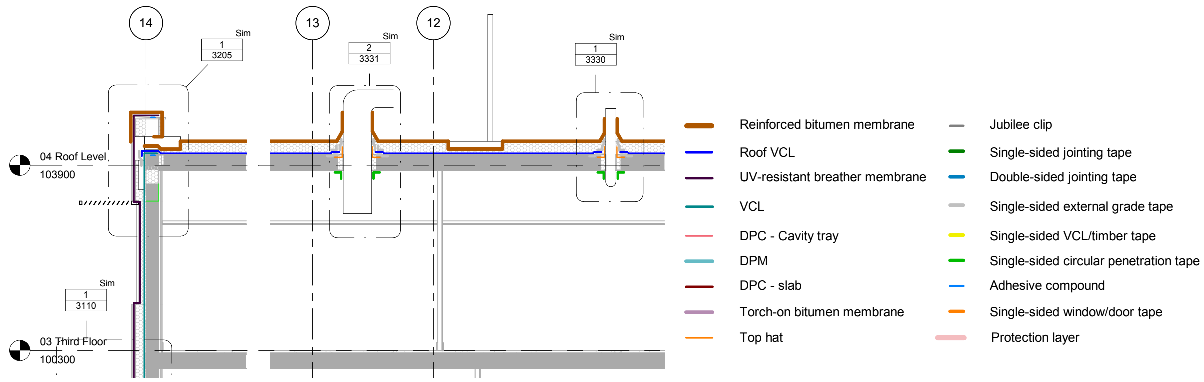
5.5 Roof construction

Cross laminated timber exposed structural deck, with a reinforced bitumen warm roof system with tapered boards above uniform PIR insulation boards. Penetrations were minimised by grouping services and through specification of weighted guarding. Where penetrations were unavoidable e.g. service penetrations, proprietary products like gaskets and sleeves were used to ensure penetrations were airtight.

Typical Roof	Reinforced bitumen membrane warm roof covering system with tapered (EPS) above uniform (PIR) insulation roof boards, vapour control layer on 250/300 mm cross laminated timber exposed structural deck	U-value **0.12** W/m^{2}K Ave. tapered & uniform



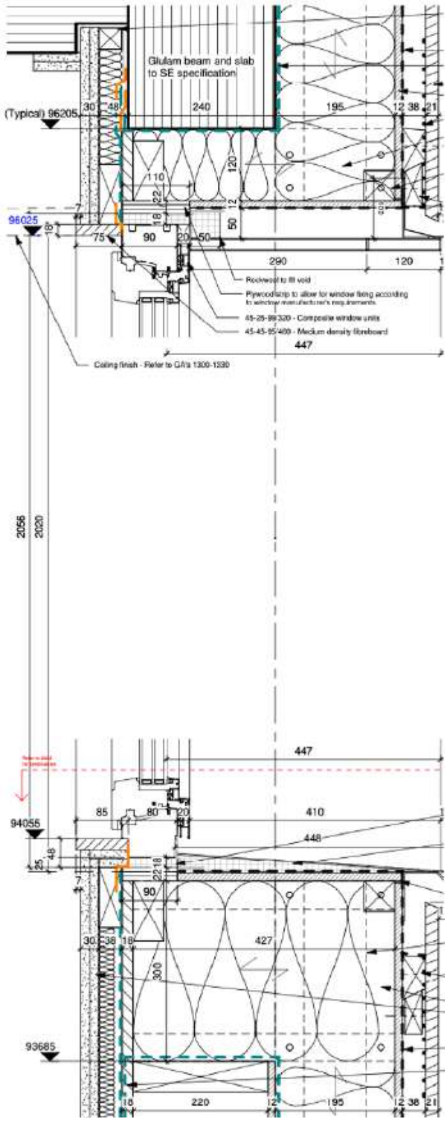
Detailed section from early planning stage (left) and construction stage (right) highlighting critical components of the parapet detail to ensure it's built to be airtight and thermally continuous.

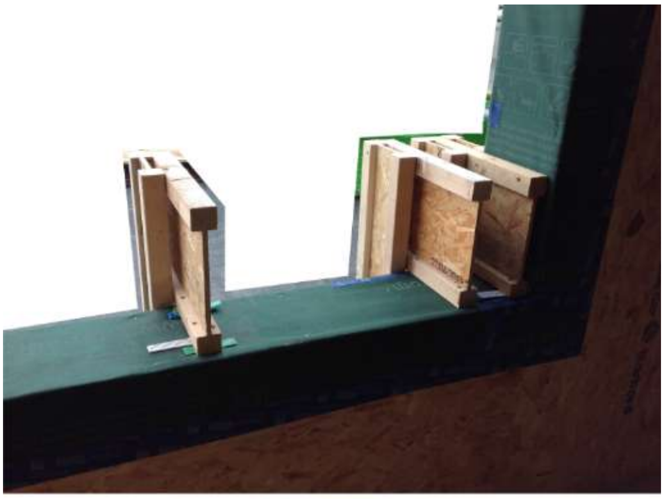


Detailed section showing the membranes and airtightness products used to ensure roof penetrations were made airtight.

5.6 Window data

Windows	Frame: Composite (timber and aluminium) windows & doors. Glazing: Triple argon-filled glazing: g-value = 0.5 | U_g-value 0.69 = W/m²K	Installed U_w-value **0.97** W/m²K (includes entrance doors higher U-values due to security requirements)





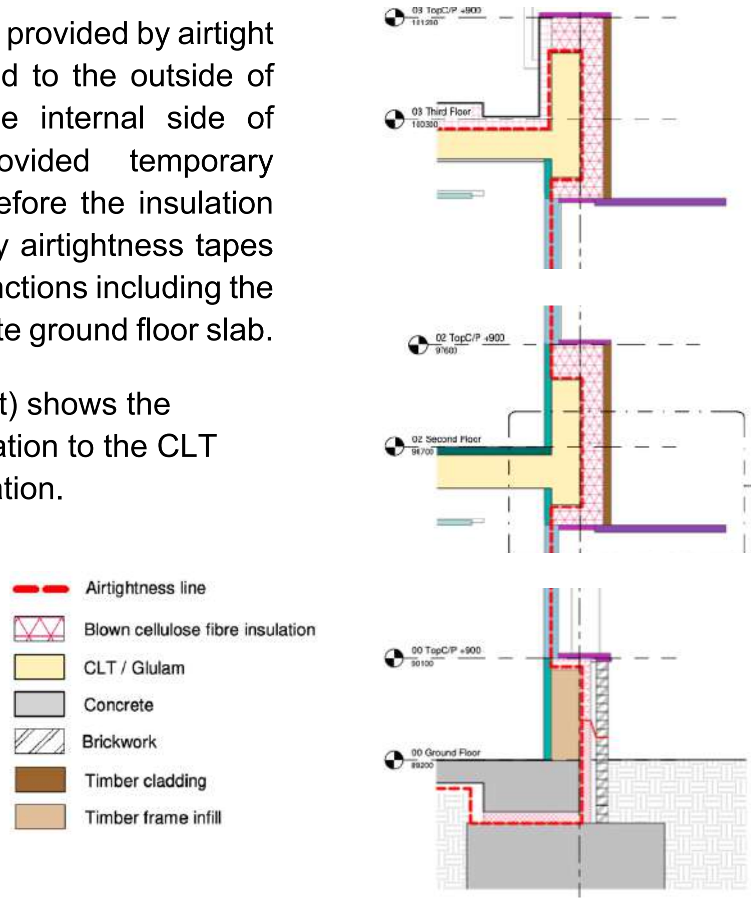
Left: Section detail - window head & cill.
Top right: Construction photos showing overlapping of tapes and membranes around the composite window frame – prior to initial room airtightness test.
Bottom right: Completed east elevation with deep vertical fins providing shading (refer to section 4 for more details on glazing & shading design).

6 Airtight envelope

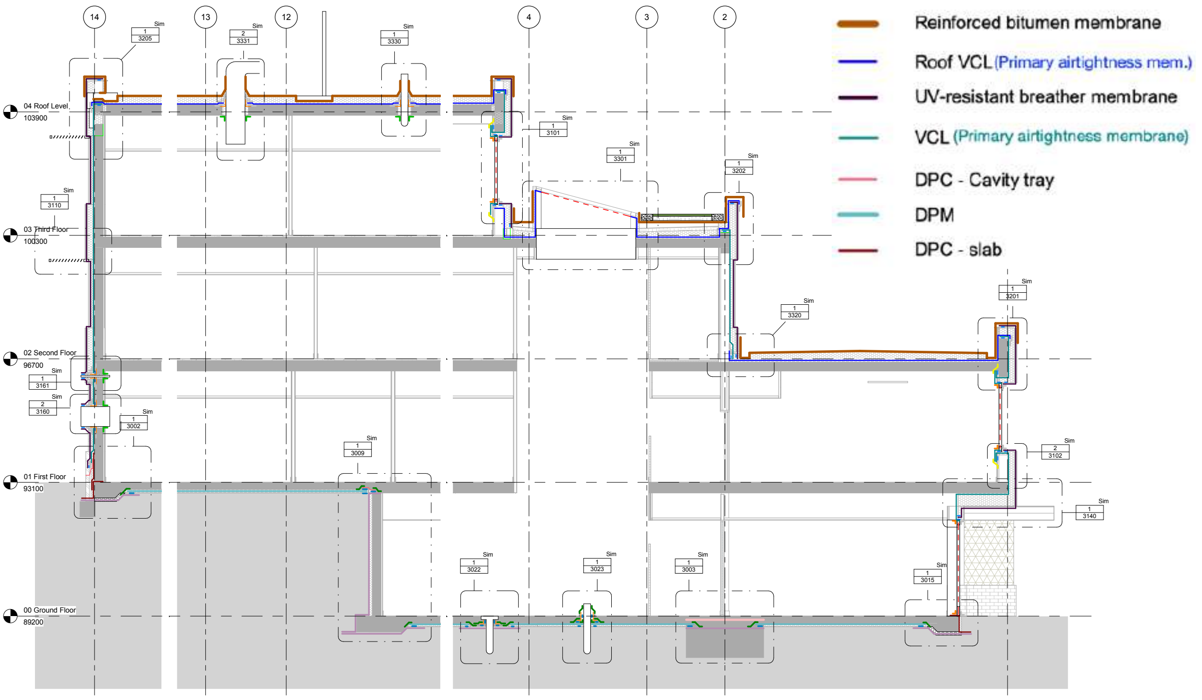
6.1 Description of the airtight envelope

The airtight layer to walls and roof is provided by airtight vapour control membranes installed to the outside of the CLT & glulam frame, on the internal side of insulation. The membrane provided temporary weatherproofing to the structure before the insulation was installed externally. Proprietary airtightness tapes were used to seal membranes at junctions including the junction to the airtight in-situ concrete ground floor slab.

The diagrammatic section (see right) shows the position of airtight membrane in relation to the CLT structure and blown cellulose insulation.



The cross-section below highlights the primary airtight membranes in blue and teal, along with the other membranes and tapes installed to complete the envelope.



6.2 Quality control for meeting the airtightness target

Tender documentation was carefully developed to provide a robust airtightness strategy – in the form of detailed drawings and specification setting out the procurement process for meeting the airtightness target. The contractor was required to arrange mock-ups and on-site training in the use of specialist airtightness products such as membranes, tapes and sealants, and the airtight installation of windows and doors with the specific manufacturers. The contractor appointed a designated Passivhaus champion to provide oversight of all Passivhaus related work.

Construction team workshops (above): Early-stage mock-ups were used to familiarise the team with available airtightness products e.g. membrane, tapes and gaskets.

Early-stage air tests (above): An initial air test was carried out following installation of the first window (highlighted in pink) to check for problematic areas and confirm the installation quality was adequate. Further sectional air tests were undertaken before the final blow door test.

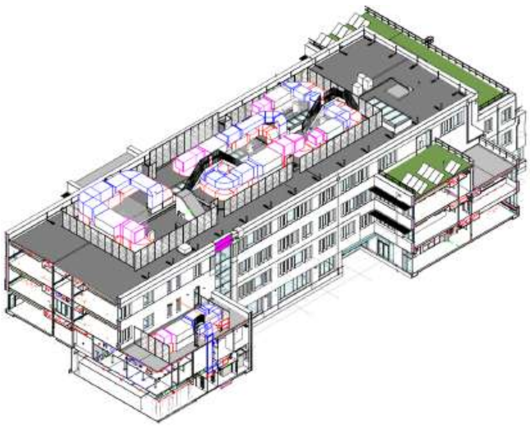
The final test was undertaken by BSRIA with the results shown below:

Design Air Leakage Criteria	Air Change Rate @ 50 Pa	0.60 ACH
Measured at Positive Pressure	Air Change Rate @ +50 Pa	0.30 ACH
Measured at Negative Pressure	Air Change Rate @ -50 Pa	0.30 ACH
Average Result	Air Change Rate @ 50 Pa	0.30 ACH

7 Ventilation

7.1 MVHR units

The building is served by 6 air handing units (AHUs) located externally on the roof of the building. Certified units were used – Swegon RX models varying in size. Some of the larger units of the same range were not certified at the time therefore project-specific calculations were undertaken by the PHI to calculate HR% of the larger units. Heat recovery efficiency of the units varied from 75 per cent to 82 per cent.



3D view & photograph of AHUs and ductwork on roof central roof

7.2 Overview of ventilation strategy

The building operates a mixed model ventilation system. When external conditions allow (during temperate months), the building can be naturally ventilated through manually openable windows, rooflights and secure louvred panels. When it is not possible to maintain comfortable internal conditions through natural ventilation, mechanical ventilation is used.

A cascade strategy is implemented to reduce supply air volume based on demand. Air is supplied to all teaching spaces through VAVs in ceiling bulkheads. The air moves through extract grilles into adjacent circulation spaces, and is extracted from WCs and circulation spaces back to the air handling unit for heat recovery prior to rejecting the air externally. Variable Air Volume (VAV) dampers are controlled by the BMS based on room occupancy, CO_2 & temperature sensors within the room (see diagram below).

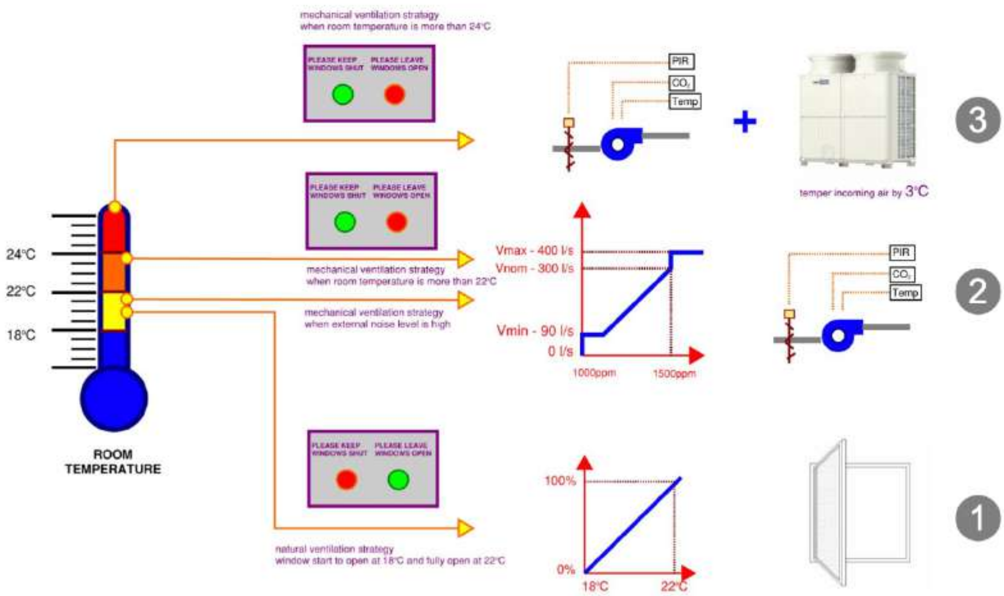
During summer months, the mechanical ventilation system provides free-cooling by night-time or out-of-hours cooling – by distributing cool outdoor air through the building so that temperatures are reduced back down to 18°C (min.) at the beginning of the day.

A dedicated kitchen extract system consists of an extract & supply hood connected to volume control dampers. A heat recovery coil enables waste heat from the extract air to be recovered to preheat the incoming fresh air with no cross-air contamination.

7.3 Ventilation & temperature controls

To mitigate the risk of overheating the ventilation and cooling system is set up to follow a 3-step strategy illustrated in the diagram below:

1. Natural ventilation
2. Mechanical ventilation
3. Mechanical ventilation + peak lop of 3°C



Each classroom has a "Window Open/Close" indicator installed next to the teacher's desk – visible to teachers and pupils. The unit indicates that windows can be opened when outdoor temperatures are appropriate if interior temperatures exceed 18°C or CO_2 levels are high to optimise thermal comfort whilst minimising risk of energy loss through windows.

8 Heating supply

8.1 Heating

Heating within the building is met by the heat recovery ventilation system in addition to low temperature hot water heating system. This is served from a central plant located on the ground floor which comprises two 150kW gas fired condensing boilers (one for back-up). The wall-mounted gas boilers are shown in the photograph below in comparison to a typical heating system for a similar scale secondary school.

Typical heating system required for 6-form entry secondary school - shown for comparison with Harris Academy (right)

Harris Academy heating system – 2x 150kW boilers (one as back-up). The size of radiators in classrooms was also reduced due to low temperature fluctuations necessitating less heating load.

8.2 Domestic Hot Water

Hot water requirements are met with the following plant:

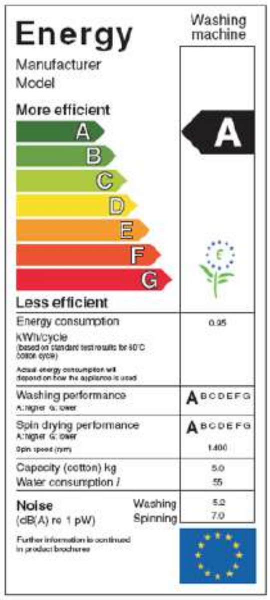
- 26x localised electric point of use electrical water heaters– serving toilets and teaching sinks requiring hot water (e.g. science laboratories, the quantity of hot water tapping points was reduced to minimise demand and losses);

- 2x indirect semi-storage calorifiers – school changing areas (showers) connected to the hot water from heating system;

- 2x gas-fired domestic hot water heaters – serving commercial kitchen.

9 Small Power & Equipment Loads

Energy demand of plug-in equipment was thoroughly assessed and refined to optimise energy efficiency and equipment specifications across the school. The most challenging equipment for predicting and reducing energy demand was the appliances in the Commercial Kitchen, Design & Technology spaces and IT equipment and servers . Equipment schedules were developed and refined with the client and end-users to provide certainty on quantities and predicted usage patterns.



Photographs of low-energy equipment in the Commercial Kitchen and Design Technology Classroom

10 PHPP Calculation & Results

10.1 "Verification" worksheet

Passive House Verification

Building:	Harris Academy Sutton	
Street:	2 Chiltern Road	
Postcode/City:	SM2 5RD	Sutton
Province/Country:	Surrey	GB-United Kingdom/ Britain
Building type:	Secondary school	
Climate data set:	GB0002a-Silsoe	
Home o	Search documents and filenames for text	
Street:	24 Denmark Road	
Postcode/City:	SM5 2JG	Carshalton
Province/Country:	Surrey	GB-United Kingdom/ Britain

Architecture:	Architype Ltd		**Mechanical system:**	CMB / DES / Jones King	
Street:	13 Mill Street		Street:		
Postcode/City:	SE1 2BH	London	Postcode/City:		
Province/Country:		GB-United Kingdom/ Britain	Province/Country:		GB-United Kingdom/ Britain
Energy consultancy:	Architype Ltd		**Certification:**	WARM: Low Energy Building Practice	
Street:	13 Mill Street		Street:	3 Admirals Hard	
Postcode/City:	SE1 2BH	London	Postcode/City:	PL1 3RJ	Plymouth
Province/Country:		GB-United Kingdom/ Britain	Province/Country:	Devon	GB-United Kingdom/ Britain

Year of construction:	2019	Interior temperature winter [°C]:	19.4	Interior temp. summer [°C]:	25.0
No. of dwelling units:	1	Internal heat gains (IHG) heating case [W/m²]:	3.2	IHG cooling case [W/m²]:	3.2
No. of occupants:	1375.0	Specific capacity [Wh/K per m² TFA]:	96	Mechanical cooling:	x

Specific building characteristics with reference to the treated floor area

		Value		Criteria	Alternative criteria	Fullfilled?[2]
	Treated floor area m²	8953.6				
Space heating	Heating demand kWh/(m²a)	15	≤	15	-	yes
	Heating load W/m²	9	≤	-	10	
Space cooling	Cooling & dehum. demand kWh/(m²a)	0.3	≤	15	15	yes
	Cooling load W/m²	0	≤	-	11	
	Frequency of overheating (> 25 °C) %	-	≤	-		-
	Frequency excessively high humidity (> 12 g/kg) %	0	≤	10		yes
Airtightness	Pressurization test result n_{50} 1/h	0.3	≤	0.6		yes
Non-renewable Primary Energy (PE)	PE demand kWh/(m²a)	120	≤	120		yes

[2] Empty field: Data missing; '-': No requirement

I confirm that the values given herein have been determined following the PHPP methodology and based on the characteristic values of the building. The PHPP calculations are attached to this verification.

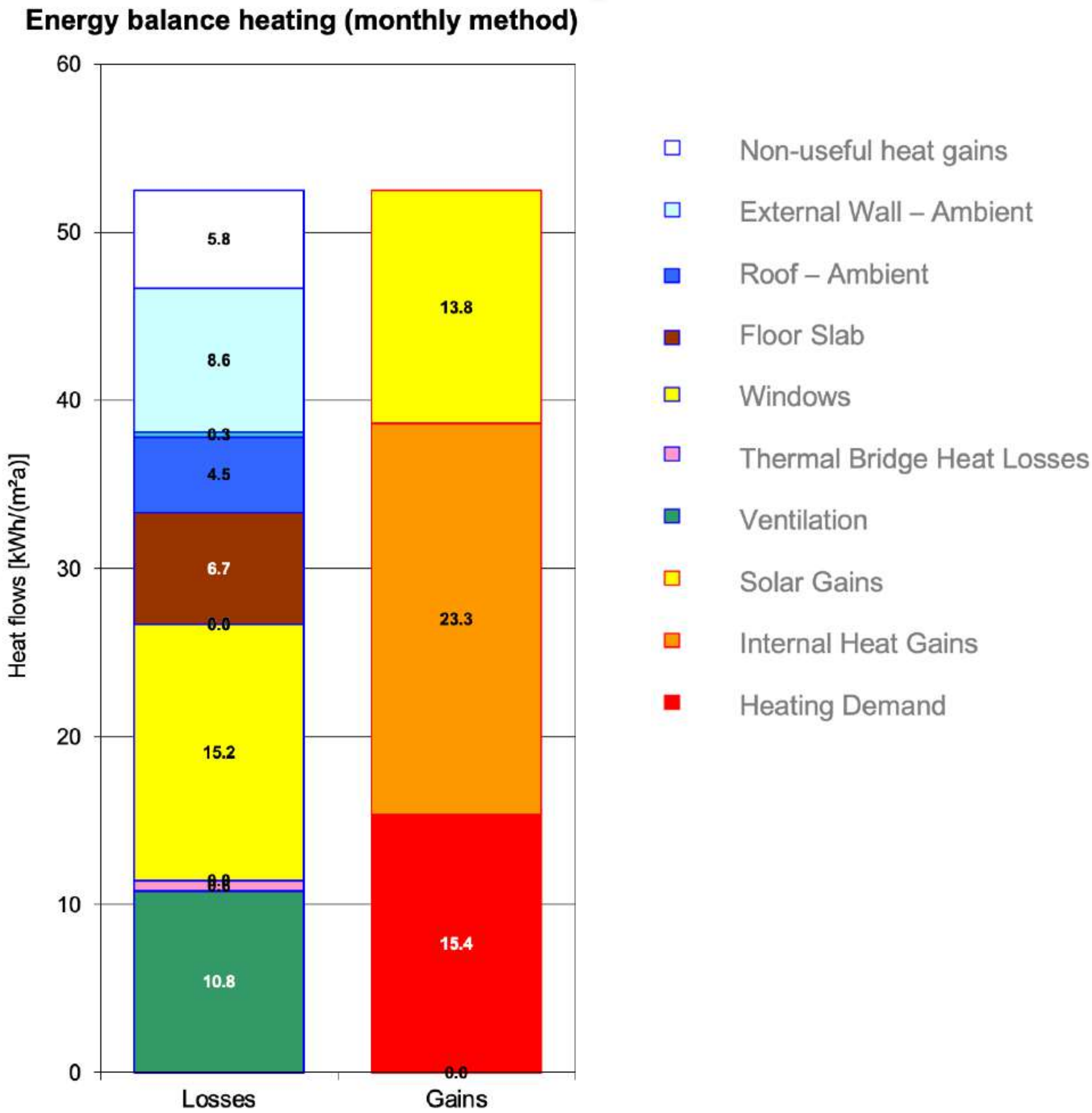
Passive House Classic? yes

Task:	First name:	Surname:	Signature:
2-Certifier	Sally	Godber	

Certificate ID	Issued on:	City:
32609-32698_WARM_PH_20211221_SG	17/12/21	Plymouth

The building achieved a final Heating Demand of 15 kWh/(m^{2}a) and Primary Energy Demand of 120 kWh/(m^{2}a). Photovoltaic arrays are installed on the roof of the teaching wings to reduce demand from the local grid, however certification was based on the Primary Energy target rather than the Primary Energy Renewable limit.

10.2 Energy Balance



The Energy Balance graph shows the breakdown of losses and gains. The windows account for roughly a third (29%) of the heat losses across the building however they also contribute roughly a third (26%) in solar gains. This balance was carefully managed through optimising the glazing and shading design to provide useful solar gains in winter, and minimising risk of overheating in warmer months.

The ventilation is the 2nd largest loss in the energy balance. The ventilation losses were significantly reduced from early MEP proposals by maximising opportunities for cascade ventilation and natural ventilation to reduce supply air volume, and critically by developing a demand-based control strategy which responds to fluctuating occupancy profiles.

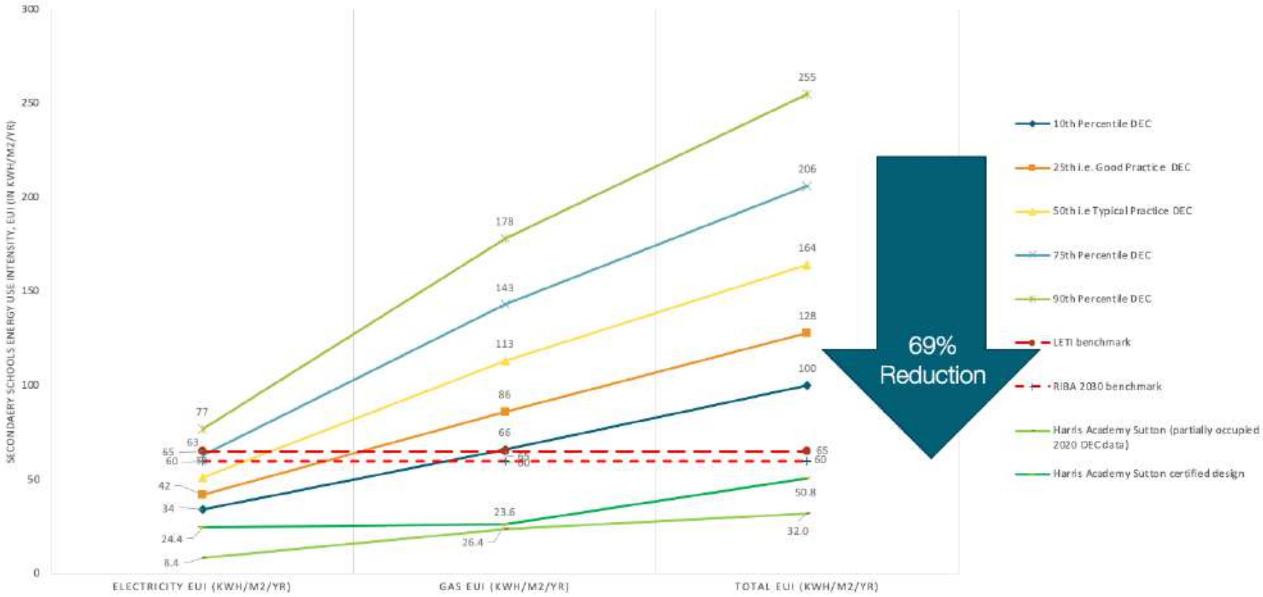
11 Costs

Project costs were approx. £38 million with a meter square rate of approx. £2,764/m^2.

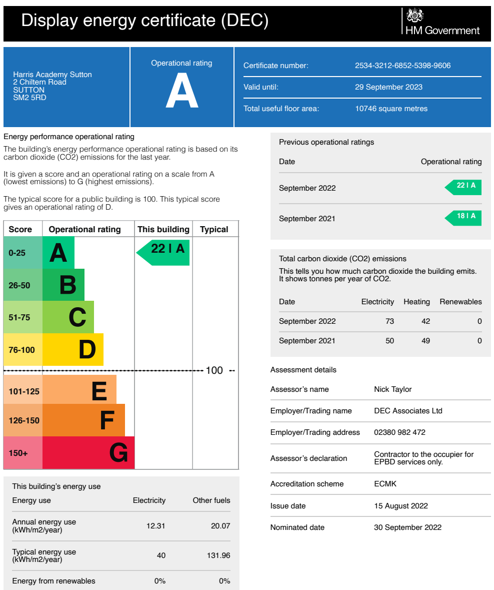
12 Measured results in use

Initial monitoring of Harris Academy Sutton shows that the total energy usage is five times lower than the Academy's comparable non-Passivhaus secondary schools. This meant that in 2020, the Academy saved over £60,000 in annual energy bills – a figure that will be even higher given the recent uplift in energy prices.

Comparison of Operational Energy
Harris Academy vs. Benchmarks for Secondary Schools



Passivhaus Certificate & Display Energy Certificate showing predicted and on-going operational energy performance.



Display energy certificate (DEC)

HM Government

Harris Academy Sutton
2 Chiltern Road
SUTTON
SM2 5RD

Operational rating
A

Certificate number:	2534-3212-6852-5398-9606
Valid until:	29 September 2023
Total useful floor area:	10746 square metres

Energy performance operational rating

The building's energy performance operational rating is based on its carbon dioxide (CO2) emissions for the last year.

It is given a score and an operational rating on a scale from A (lowest emissions) to G (highest emissions).

The typical score for a public building is 100. This typical score gives an operational rating of D.

Score	Operational rating	This building	Typical
0-25	A	22 I A	
26-50	B		
51-75	C		
76-100	D		100
101-125	E		
126-150	F		
150+	G		

This building's energy use

Energy use	Electricity	Other fuels
Annual energy use (kWh/m2/year)	12.31	20.07
Typical energy use (kWh/m2/year)	40	131.96
Energy from renewables	0%	0%

Previous operational ratings

Date	Operational rating
September 2022	22 I A
September 2021	18 I A

Total carbon dioxide (CO2) emissions

This tells you how much carbon dioxide the building emits. It shows tonnes per year of CO2.

Date	Electricity	Heating	Renewables
September 2022	73	42	0
September 2021	50	49	0

Assessment details

Assessor's name	Nick Taylor
Employer/Trading name	DEC Associates Ltd
Employer/Trading address	02380 982 472
Assessor's declaration	Contractor to the occupier for EPBD services only.
Accreditation scheme	ECMK
Issue date	15 August 2022
Nominated date	30 September 2022

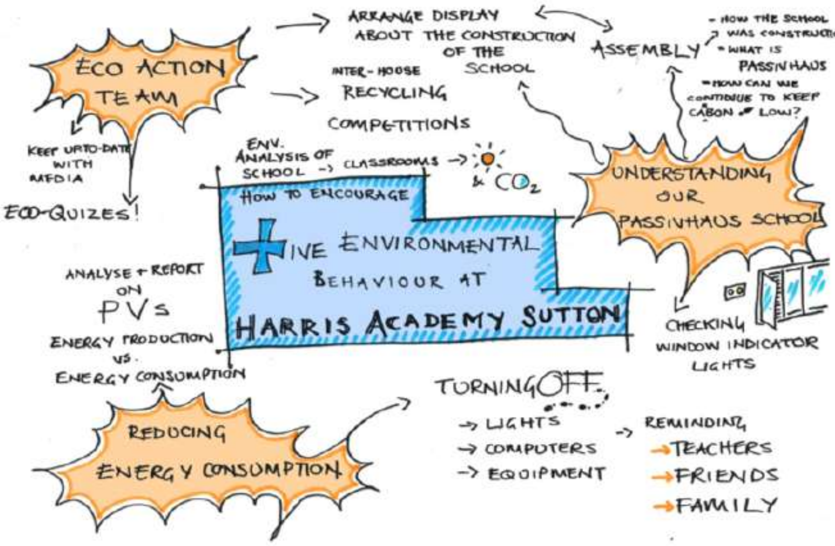
12.1 User feedback

The school opening in 2019 and there continues to be very positive feedback from the pupils, teachers, staff members and the wider community.

> *"It really is a spectacular learning environment where our students will thrive academically and develop long-life interests and talents... A building which delivers, not only on quality and looks, but also on environmental targets… Our new school provides an inspiring new space for students and teachers alike."*

James Fisher, Headteacher, Harris Academy Sutton

The mind map below was developed with the Academy's 'Eco Team' during a workshop after the building was handed over. Following a discussion on how the saves energy and promotes environmental performance, the group created the mind map setting out steps to continue encouraging positive environmental behaviour whilst using the school and lessons to share at home.



"This is much less stuffy than our classrooms last year" Year 8 student	"My favourite places are the bright classrooms" Year 7 student

Feedback from Harris Academy students when they moved in to their new school building.

13 References

13.1 Publications

Architype (Architects & Passivhaus Designer) – information and drawings
https://architype.co.uk/project/harris-academy-sutton/

Willmott Dixon (Lead Contractor) – information and video
https://www.willmottdixon.co.uk/projects/passivhaus-secondary-school-in-sutton

Passivhaus Plus Journal
https://passivehouseplus.ie/magazine/feature/inside-the-uk-s-largest-passive-school-harris-academy-sutton-delivers-top-class-comfort-superb-air-quality-for-pupils

RIBA Case Study
https://www.architecture.com/awards-and-competitions-landing-page/awards/riba-regional-awards/riba-london-award-winners/2022/harris-academy-sutton

RIBA Building Stories – video recording of an online event that took place on 24 January 2023
https://youtu.be/uTzenu0fKFQ?feature=shared

Harris Academy Sutton is also featured in the following publications:

- ‘Embodied Carbon Case Studies’ 2022 by LETI.
- ‘Cross Laminated Timber: A design stage primer', 2021 by Nic Crawley.
- ‘Timber Arch Vol. 02’, 2021 by KLH.
- ‘Rethink Design Guide; Architecture for a Post-pandemic World’ 2021 by Park, Gillen & Nissen.
- ‘The Mass Timber Insurance Playbook’ 2023 by ASBP

13.2 Awards

Harris Academy Sutton has won a wide range of awards since completion, including:

- RIBA National Award 2022
- RIBA London Sustainability Award 2022
- RIBA London Award 2022
- ASBP Awards 2023 - Project Category, both Judges & Peoples Prize
- SPACES ‘Civic Building of the Year’ 2021
- SPACES Sustainability Award 2021
- Building Awards 2020: Building Performance Award.
- CIBSE Project of the Year 2023 Non-domestic – Shortlisted