BURO HAPPOLD

Design Note

Project	Printworks
Subject	Overheating assessment
Project no	049225
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P01	Printworks PBSA Overheating Assessment summary	RT	07/12/2023	RT

Overview

This design note summarises the outcomes of the overheating analysis undertaken to date in line with CIBSE TM52 and TM59. These have been considered alongside assessments of acoustic risk on the proposed design in line with Part O guidance and methodologies.

Together, these assessments indicate that a cooling strategy compliant with thermal and acoustic requirements would need a mixed strategy of natural ventilation and active ventilation for the student bedrooms. Heat gains will therefore be minimised as far as possible through passive measures which will be supplemented by active cooling. The below cooling hierarchy outlines the design approach to managing high external temperatures and maintaining comfortable internal temperatures.

Cooling strategy

Reduce the amount of heat entering a building

Passive design principles have been prioritised where possible aiming to reduce the energy demands, maintain thermally comfortable conditions, and provide enough daylighting withing the spaces. A balance is critical between maintaining optimum daylight, reduced solar gains and energy requirements. In addition, the applicant is committed to achieve ambitious U-values (increased insulation) beyond Part L 2021 notional building standards aiming to reduce the heat losses from the thermal envelope.

The design team minimised the overall window to wall ratio, with the current design submitted to planning having an optimised ratio of around 31.5% overall to limit the unwanted solar gains and high cooling demands. In addition, the bedroom windows will be recessed back with minimum reveal widths of 200mm, increasing to 300mm at the lintel. This provides shading and acts as overhangs and vertical fins, therefore preventing increased solar radiation entering the spaces.

The g-values of the glazing have been reduced as far as possible without compromising vertical light transmittance. Engagement with product suppliers has highlighted the potential to specify a low g-value of 0.3 while maintaining visible light transmittance (VLT) of 0.6. The current standard for glazing products is for a g-value of 0.3 to be associated with a lower VLT of just 0.55.

The Part L Criterion 3 assessment indicates that, even without reliance on internal blinds, none of the relevant occupied areas exceed the solar gain limit. Indeed, all but two of the bedrooms undershoot the solar gain limit by more -50%, demonstrating a façade and glazing that is highly effective in minimising solar heating. The use of internal blinds is however still recommended for the development to address glare in the bedrooms.

Following the optimisation of the glazing, a sample assessment was undertaken on the bedrooms to identify the potential impact of integrating further external shading into the façade. An example of one of the shading solutions tested is provided in section 0 below. This shows an extensive shading arrangement across the bedroom windows to understand the sensitivity of overheating results to such an intervention. The results of these assessments demonstrate that with significant shading over the window areas, a 5% reduction can be achieved in the number of hours that the bedrooms are non-compliant with night-time cooling criteria.

These results demonstrate that solar gains would be reduced by the addition of further external shading but the savings would be relatively minor, particularly given the very low solar gain risk highlighted by Criterion 3 analysis. These savings also need to be considered alongside the potential implications for heating demand from integrating additional solar shading into the current façade.

The potential increase in cold bridging from the addition of further structural elements protruding from the façade and the reduction in annual solar gains would both directly increase the heating requirements of the building. The Part L assessment indicates that energy required for heating the development will be roughly double the energy required for cooling. Assuming a 5% reduction in cooling energy demand from additional external shading – directly in line with the reduction in night-time non-compliance hours – it would only take an increase in heating energy demand of 2.5% to offset all of the energy savings from the additional shading. This indicates there is an extremely a low likelihood of achieving a net decrease in energy demand across the year through the integration of additional shading.

On top of this, there would be a significant increase in embodied carbon due to the additional shading elements. Given the rapidly decarbonisation of the electricity grid, it would not be possible to offset these additional emissions throughout the building lifecycle using even if a marginal saving in energy consumption could be achieved.

It was therefore concluded that the integration of additional solar shading into the façade is not appropriate for the design. While a small decrease in solar gains may be realised, this is unlikely to result in net savings of energy and would increase the whole life carbon of the development.

Minimise internal heat generation

All heating pipework services of the proposed development will be provided with adequate insulation to limit the internal heat gains during the production of domestic hot water. Insulation on pipework will meet the requirements of CIBSE code of practice for heat networks CP 1 2020.

In addition, the internal heat gains assigned for occupancy, equipment and lighting have been assessed using realistic and conservative values for student accommodation, given the non-standard use of the bedrooms. However efficient LED lighting will be used throughout the development to further reduce the internal heat gains.

Manage the heat within the building

There is no exposed thermal mass internally due to the fitout requirements for student accommodation. However, high thermal mass is mostly beneficial if combined with a night-purge ventilation to enable the heat trapped within the bedrooms released and reduce daytime peak temperatures. The strategy of the proposed development cannot rely on night-time ventilation due to high acoustic noise levels therefore this approach is not recommended.

Provide passive ventilation

Openable windows are incorporated into the design to allow for passive cooling and purge ventilation. Initial overheating assessments of the bedrooms indicate that of the rooms can meet the criteria for TM52 and TM59 (night-time) with the provision of sufficient free area (see Section 0).

However, it has not been possible to follow a cooling strategy solely based upon natural ventilation due to the acoustic constraints of the site. Part O of Building Regulation outlines that in locations where external noise is an issue, the overheating mitigation strategy should take into account windows being closed during sleeping hours (11pm to 7am). The regulation sets maximum limits for bedrooms' internal noise levels that cannot be exceeded. Acoustic assessments of the site highlight that most the facades have either a high or medium acoustic risk – see Figure 0-1: Night-time level 1 risk assessment under section 6.3 Acoustic Modelling – which will preclude the opening of bedroom windows at night time. Without the ability to open windows the bedrooms throughout the night, it is not possible to achieve the night-time TM59 criteria for overheating.

Acoustic louvres were considered as an alternative option for night-time cooling, but it is not possible to achieve the required free area using this approach without compromising the glazing area and natural light in the bedrooms. The inclusion of extensive acoustic louvres would also have a significant negative impact on air tightness and heat loss from the bedrooms.

The site is also in an area of high vehicle circulation and it is thus anticipated to be a polluted environment. Whilst some residents might not be equally affected by noise than others, air quality is of significant importance and should be considered when opening windows for natural/passive ventilation means.

Regardless the constraints, the design of the proposed development incorporates openable windows for provision of fresh air as well as providing increased ventilation measures during daytime. However, it will not be possible to rely only on natural ventilation for night-time cooling due to the constraints of Part O. As such, we have to also incorporate additional mitigations measures via mechanical ventilation to reduce the overheating risk and maintain sufficient air quality internally.

Provide mechanical ventilation

Given the acoustic constraints listed above, mechanical ventilation with heat recovery (MVHR) is proposed for the student rooms including a summer by-pass mode to allow for free cooling of the space using external air. MVHR systems will be designed to meet 15 l/s per bedroom exceeding minimum fresh air requirements to ensure that window opening is only required for purge scenarios. This approach also allow for a more controlled and highly efficient way to deliver required minimum ventilation requirements in winter, certainly when compared to natural ventilation only.

MVHR systems allow for a controlled and highly efficient way to deliver ventilation requirements in winter, particularly when compared to a natural ventilation strategy. Up to 95% of internal heat can be recovered in winter months and re-distributed via the supply air, significantly reducing space heating demand.

Demand side control will be incorporated into the design of the MVHR systems. PIR sensors will be integrated with the controls of the MVHR units to vary the speed dependent on occupancy levels.

We have also investigated using mechanical ventilation via the normal MVHR units as a method of overheating mitigation. However, even with provision of ventilation capacity that exceeds Part F1 requirements for residential, the units are not sufficiently large to provide sufficient air volume to prevent overheating.

Provide active cooling systems

Only after following the initial passive steps of the cooling hierarchy and demonstrating that these are insufficient was it concluded that providing cooling by mechanical means is the only viable option for meeting thermal comfort criteria, considering the noise constraints of the development. By concluding to this decision, the design team has proposed a strategy for the development which minimises the reliance on active cooling systems thanks to a mixed strategy combining natural ventilation and mechanical cooling.

The preference is for natural ventilation through openable windows. This is supplemented by MVHR to provide additional ventilation when required. Active cooling will then be used as a last report when these strategies are insufficient for maintaining comfortable temperatures. The cooling system will therefore be centrally controlled and will utilise high temperature set points to limit use, while interrupter controls will also prevent the system from activating when the windows are open.

High efficiency modular air-cooled chillers shall provide the chilled water for air conditioning via 4-pipe fan coil units to the spaces which require it. Thermal storage will be incorporated to act as a buffer during periods of peak demand and prevent short cycling of the chillers during low load conditions. Variable speed pumps will control the cooling flow rate based on demand and will be selected to ensure they are able to operate at minimum flow conditions.
For the subsequent design stages, the project team will aim to maintain all the passive measures and the excellent fabric standards. Moreover, the mechanical ventilation and active cooling systems will be designed in detail using a dynamic thermal model, ensuring the design is both optimised and that the capacity is sufficient for a mitigated overheating risk in line with Part O/CIBSE TM59 criteria.

Adapting to future weather profiles

The provision of a mixed mode ventilation strategy means that the development is well placed to adapt to increases in future average and peak temperatures. Solar gains have been minimised through efficient façade design, enhanced MVHR has been provided for increased ventilation and active cooling is in place to address peak temperatures. Increases in future peak temperatures are likely to see an increase in use of the active cooling systems, however this will continue to be used as part of a mixed mode strategy. The effectiveness of the cooling strategy and capacity of the cooling system will need to be monitored throughout operation. At the end of life for the current cooling systems, this should inform the sizing and performance of the replacement system. It is also possible that the move towards electric vehicles could reduce the acoustic restrictions in the future, enabling greater use of natural ventilation.

Assessment parameters

CIBSE TM52 criteria – Tests against human adaptability and fail criteria

In line with current industry best practice for the assessment of overheating, the CIBSE TM52 methodology has been pursued for this study. The methodology includes an adaptability range over the comfortable limit. This limit varies by region and climate and is generated based on the weather files used. The CIBSE TM52 methodology has three criteria for assessing risk across the summer months. Two of these criteria must be passed for each space within a dwelling for it be considered a pass.

Criterion 1 - 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°C or more during the occupied hours of a typical non-heating season (1st May to 30th September).
Criterion 2 - 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.
Criterion 3 - The third criterion sets an absolute maximum daily temperature for a room, beyond which the level of overheating is unacceptable.

CIBSE TM59 criteria - Bedroom overheating criteria

Whilst TM52 is an effective assessment for overheating, its scope is limited for student residential projects. TM59 is an overheating assessment designed specifically for residential buildings including thermal comfort in bedrooms during the night, allowing for a 24-hour realistic assessment. Furthermore, TM59 details standardised thermal templates (occupancy, equipment, lighting, etc.) for occupied zones and guidance on how to model openings, ventilation, and heat losses from equipment.

Dynamic thermal modelling has been undertaken using the methodology and overheating criteria as laid out in CIBSE TM59. For bedrooms, TM59(b) specifically targets night-time operative temperatures at 26°C, beyond which can severely impact an occupant's quality of sleep. TM59(b) recommends that no more than 32 hours at night throughout a year exceed this limit, and thus 33 hours or more is recorded as a fail for that bedroom. Dynamic weather data London_LWC_DSY1_2020High50.epw has been used for this assessment which includes a peak outdoor temperature of 33.6°C.

Modelling assumptions

The standard bedrooms for the scheme have been assessed at this early stage and have been modelled using the 'Double Bedroom' standardised template, due to the bedrooms including double beds and thus two occupants could potentially be present in any bedroom at any time.

The following design details have been utilised for the modelling:

- External Wall U Value – 0.14 W/m^2.K
- Roof U Value – 0.11 W/m^2.K
- Ground Floor Value – 0.11 W/m^2.K
- Glazing U Value (including frame) – 1.0 W/m^2.K
- Glazing g value – 0.3
- Infiltration allowance – 0.1 AC/H

Weather Scenarios and Weather Data Used

DSY 1 2020 - London_LWC_DSY1_2020High50.epw
DSY 2 2020 - London_LWC_DSY2_2020High50.epw
DSY 3 2020 - London_LWC_DSY3_2020High50.epw
DSY 1 2050 - London_LWC_DSY1_2050High50.epw
DSY 1 2080 - London_LWC_DSY1_2080High50.epw

Window Openings

Assumed maximum opening angle – 45 degrees (top hung)
Acoustically restricted bedrooms can open their windows during the day only.
Unrestricted bedrooms can open the windows during the day or night.
Controls in line with recommendations in TM59 and Approved Document O

Internal Gains and Ventilation

Bedrooms
Occupancy – 2 people
Equipment – 5 W/m^2
Lighting 5.2 W/m^2
MVHR Rate – 15 l/s per bedroom (on 24/7)
MVHR summer bypass incorporated

Kitchen Diner Living Spaces
Occupancy - Various depending on sample (3, 10 and 12 person spaces sampled)
Equipment – 10 W/m^2
Lighting 5.2 W/m^2
MVHR Rate – 12 l/s per person

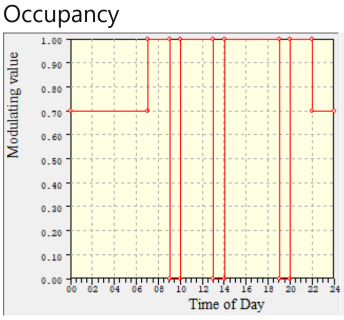
Amenity Space
Occupancy – 10 m^2/person
Equipment – 5 W/m^2
Lighting 5.2 W/m^2
MVHR Rate – 12 l/s per person

Internal Corridors
Pipework heat gain – 5 W/m from LTHW (flow) and DHW (flow and return) pipework
Ventilation rate – 1 air change per hour

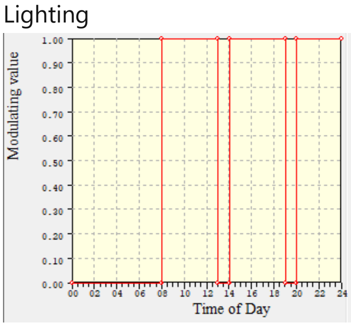
Profiles

Bedrooms

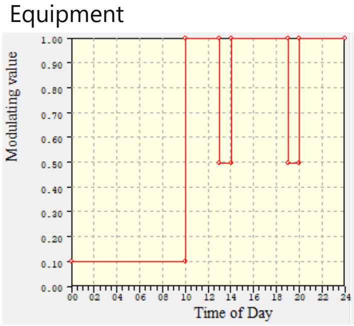
Occupancy



Lighting

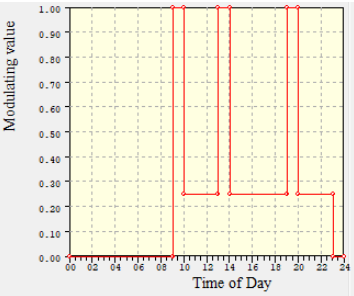


Equipment

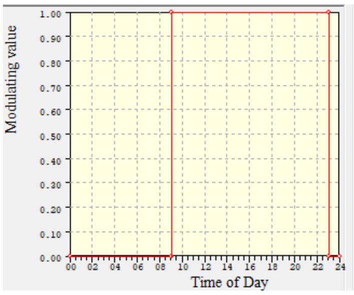


KDL areas

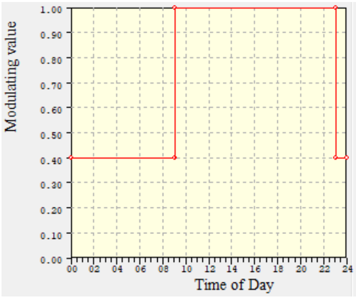
Occupancy



Lighting

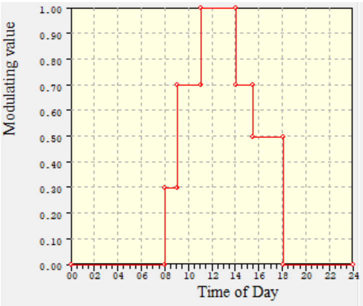


Equipment

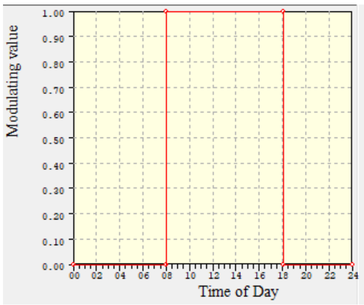


Amenity areas

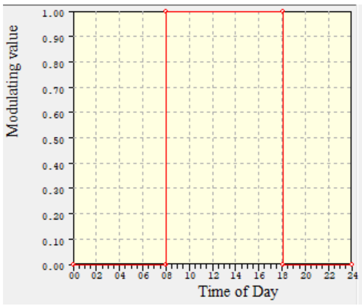
Occupancy



Lighting



Equipment



Acoustic considerations

Measurements of the existing sound environment around the proposed development were taken in 2017 and 2019, with additional spot measurements taken in 2021. It is expected that these levels are indicative of the current sound environment, as they were taken before COVID lockdowns and before there were work-from-home/hybrid working plans put into place by industries. Therefore, it is expected that vehicle and rail traffic levels were at a peak. Further, for there to be a noticeable increase in background and ambient noise levels a 3 dB increase would be needed, which correlates to a doubling of traffic flow. Based on this, it is expected that the measurements are still valid.

The analysis that was undertaken in 2021 for the planning application of the Printworks included a section on overheating guidance, which was based on the *Acoustics, Ventilation and Overheating Guide* (AVO Guide, January 2020). This guidance can be reduced to the following daytime and night-time categories (green = low risk, amber = medium risk, red = high risk):

Daytime	**Night-time**
• **$\leq L_{Aeq,07:00\text{-}23:00}$ 52 dB**	• **$\leq L_{Aeq,23:00\text{-}07:00}$ 47 dB**
• **$L_{Aeq,07:00\text{-}23:00}$ 53 – 61 dB**	• **$L_{Aeq,23:00\text{-}07:00}$ 48 – 56 dB**
• **$\geq L_{Aeq,07:00\text{-}23:00}$ 62 dB**	• **$\geq L_{Aeq,23:00\text{-}07:00}$ 57 dB**

These risk categories indicate the likelihood of adverse effects due to noise through open window ventilation. As seen for a night-time level, the low risk category is $L_{Aeq,8hours} \leq 47$ dB. In the previous analysis the lowest expected ambient level at the façade of the development, based on 3D modelling in CadnaA, is $L_{Aeq,8hours} \leq 45$ dB at night-time. The lowest expected max level at the façade of the development, based on 3D modelling in CadnaA, is $L_{AF,max} \leq 59$ dB.

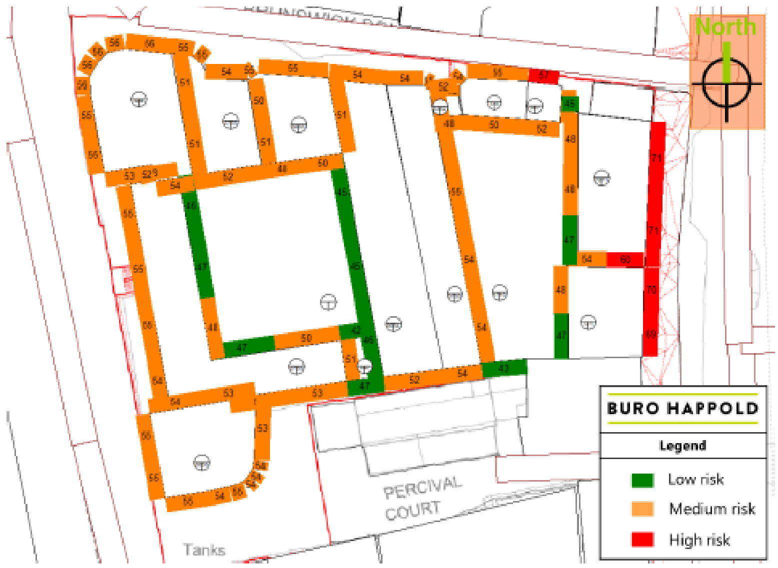


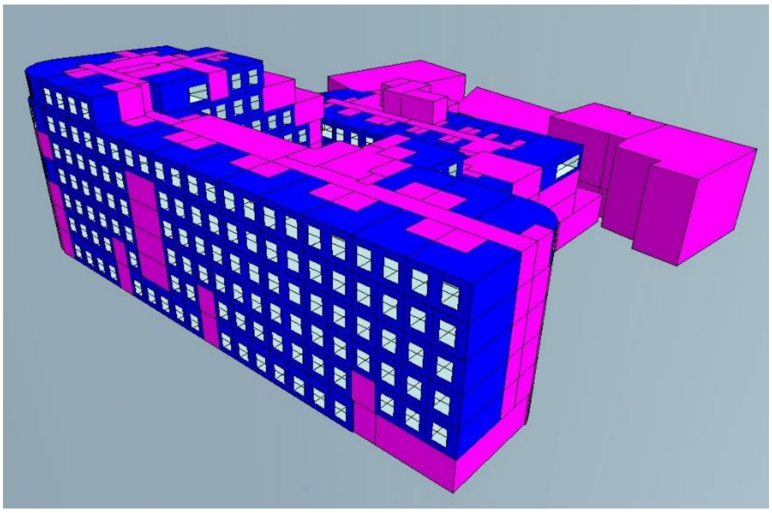
Figure 0-1: Night-time level 1 risk assessment

Under the new *Overheating: Approved Document O* building regulations, the Internal Ambient Noise Level (IANL) for a bedroom at night-time is $L_{Aeq,8hours} \leq 40$ dB. The expected sound reduction of an open window (in London) is 4 dB. This performance has been taken from the joint publication form the Associate of Noise Consultants (ANC) and the Institute of Acoustics (IOA) *Guide to Demonstrating Compliance with the Noise Requirements of Approved Document O* and is based on the window openings necessary to satisfy the simplified method of AD-O for developments in dense cities such as London. Therefore, the façade level would have to be $L_{Aeq,8hours} \leq 44$ dB to allow for open windows as a natural ventilation solution for the development. Further for max levels, the façade level would have to be $L_{AF,max} \leq 59$ dB. Based on the new building regulations it is expected that the majority of the development would not meet the Approved Document O noise break-in criteria with open windows as the natural ventilation strategy. The acoustic restrictions imposed by the recently implemented Part O mean that the scheme cannot assume that windows can be opened at night in the student bedrooms for much of the building.

Overheating results

Bedrooms

All the main bedroom areas in the development have been assessed against the overheating criteria – see model image below. The assessment takes into account the Part O constraints of the site, with openable windows utilised at night time only for the bedrooms that have a low acoustic risk. For all bedrooms, MVHR has been utilised as operating 24 hours a day for all scenarios with a provision of 15 l/s per room. This is an enhanced ventilation rate exceeding minimum Part F ventilation rates for residential bedrooms.



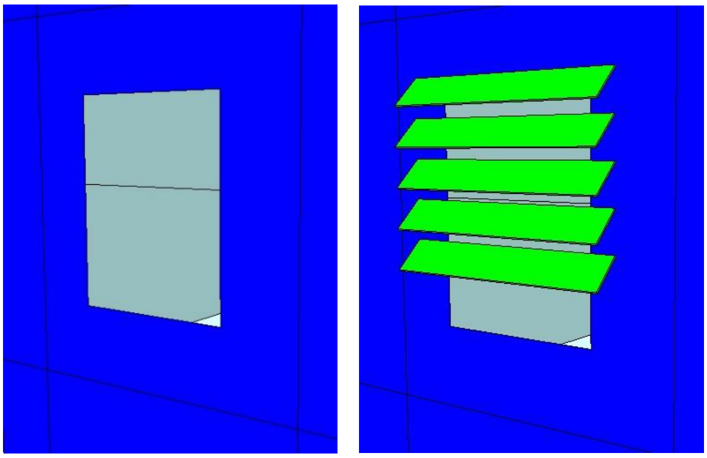
The table below outlined the results of the assessment against the relevant weather files.

Weather file	Bedrooms assessed	Bedrooms passing TM59 criteria		
		Natural ventilation criteria		Mechanical ventilation criteria
		Day time	Night-time	
DSY1 2020	269	268	27	0
DSY2 2020	269	59	0	0
DSY3 2020	269	35	0	0
DSY1 2050	269	70	0	0
DSY1 2080	269	0	0	0

For the baseline scenario DSY1 2020, the assessment demonstrates that all most of the rooms are compliant with the day time criteria for natural ventilation. A limited number of rooms are compliant with the night-time criteria where window opening is not restricted by acoustic constraints. All rooms that have restricted window opening at night are unable to comply with the night-time criteria.

Provision of additional shading

The restriction of window opening at night for most of the bedrooms has resulted in a low pass rate against DSY1 2020. This is in spite of an efficient façade design which already minimises solar gains through glazing areas, window reveals and glazing g-values. However, in order to demonstrate compliance with the cooling hierarchy, assessments have been undertaken to understand the potential impacts of integrating additional external shading to the design. The shading arrangement below was tested against DSY1 2020 to understand the sensitivity of the overheating results to additional shading.



This arrangement shows a significant portion of the window covered by the shading device. It should be noted that such a device would result in lowering of natural light levels in the space, with impacts both for daylighting and heating energy demand which were not specifically assessed. The modelling was undertaken on the acoustically restricted south facing bedroom L02-C2-07, which failed the TM59 criteria in the overheating assessment above. The enhanced MVHR ventilation rate of 15 l/s was also utilised for both the day and night time assessments.

	Shades	Natural Ventilation Criteria			Mechanical Ventilation Criteria	
		A: % occupied hours (Max 3 %)	B: Night Hours > 26C (Max 32)	TM59 Pass/Fail	% occupied hours (max 3%)	TM59 Pass/Fail
L02-C2-07 Bedroom	With	1.4	210	**Fail**	7.4%	**Fail**
L02-C2-07 Bedroom	Without	1.8	221	**Fail**	8.1%	**Fail**

The results show that the TM59 impact of extensive additional shading is very small and does not achieve compliance with TM59. This clearly demonstrates that the failure on the night criteria is due to insufficient levels of ventilation due ti the restricted windows rather than an excess of solar gains. The results above demonstrate that compliance with TM59(b) is not possible with closed or restricted windows at night, given the acoustic requirements of Part O.

KDL, Amenity and Corridors

A sampling approach was taken to modelling the Kitchen Dining Living (KDL) areas, Amenity spaces and corridors in the development. These were selected based on the likely high risk areas to demonstrate worst-case scenarios for compliance purposes. The selected areas are highlighted in the figures below.

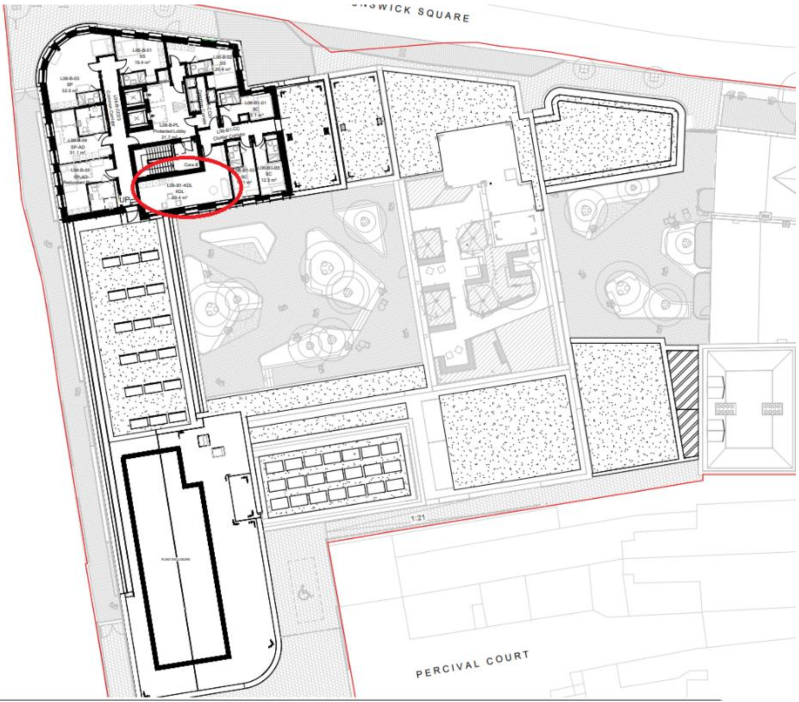


Figure 0-1: Level 6 sample KDL

Figure 0-2: Level 3 sample corridor and amenity space

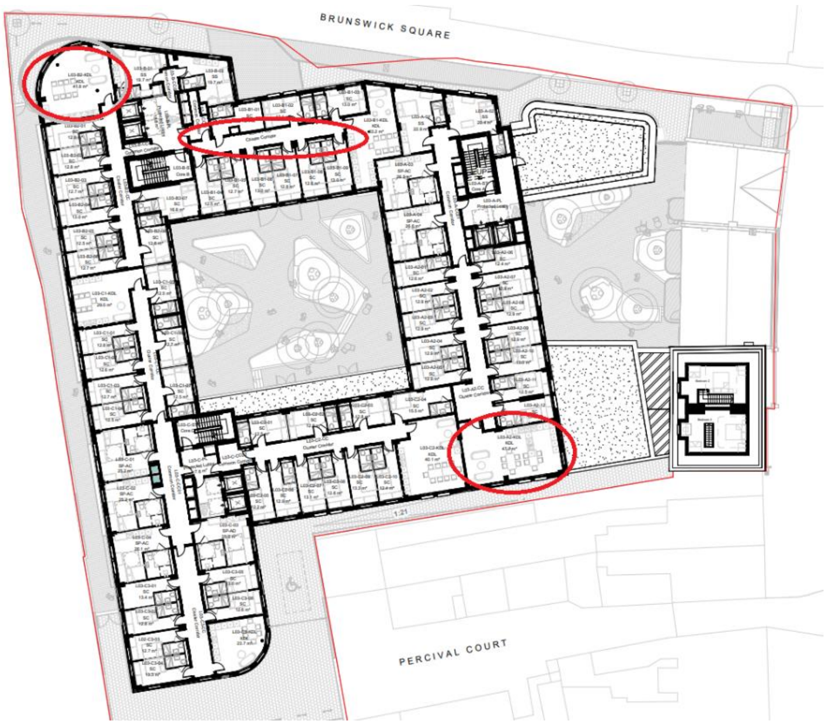


Figure 0-3: Level 0 sample corridor and KDLs

KDL and Amenity results

The tables below outline the results for the KDL and Amenity areas against all current and future weather files. These demonstrate that all of the spaces sampled comply with TM52 using natural ventilation under the DSY1 2020 scenario. As such, there will be no provision of active cooling for these spaces as part of the design.

DSY1 2020				
Location	**TM52 C1 Hours of Exceedance % (Max 3)**	**TM52 C2 Daily Weighted Exceedance deg.hrs (Max 6)**	**TM52 C3 Upper Limit Temperature (Max 4)**	**TM52 Pass/Fail**
L03-B2 KDL	1.6	24	3	**Pass**
L03-A2 KDL	2.4	28	3	**Pass**
L06-B1 KDL	2.2	27	3	**Pass**
L00-25 Amenity	0.8	12	3	**Pass**

DSY2 2020				
Location	**TM52 C1 Hours of Exceedance % (Max 3)**	**TM52 C2 Daily Weighted Exceedance deg.hrs (Max 6)**	**TM52 C3 Upper Limit Temperature (Max 4)**	**TM52 Pass/Fail**
L03-B2 KDL	4.3	51	7	**Fail**
L03-A2 KDL	5.4	61	7	**Fail**
L06-B1 KDL	5	62	7	**Fail**
L00-25 Amenity	2.2	26	6	**Fail**

DSY3 2020				
Location	**TM52 C1 Hours of Exceedance % (Max 3)**	**TM52 C2 Daily Weighted Exceedance deg.hrs (Max 6)**	**TM52 C3 Upper Limit Temperature (Max 4)**	**TM52 Pass/Fail**
L03-B2 KDL	5.3	47	6	**Fail**
L03-A2 KDL	6.2	49	5	**Fail**
L06-B1 KDL	5.9	49	5	**Fail**
L00-25 Amenity	3.4	20	5	**Fail**

DSY1 2050				
Location	**TM52 C1 Hours of Exceedance % (Max 3)**	**TM52 C2 Daily Weighted Exceedance deg.hrs (Max 6)**	**TM52 C3 Upper Limit Temperature (Max 4)**	**TM52 Pass/Fail**
L03-B2 KDL	5.3	38	5	**Fail**
L03-A2 KDL	6.3	42	5	**Fail**
L06-B1 KDL	5.9	40	5	**Fail**
L00-25 Amenity	2.6	18	4	**Pass**

DSY1 2080				
Location	**TM52 C1 Hours of Exceedance % (Max 3)**	**TM52 C2 Daily Weighted Exceedance deg.hrs (Max 6)**	**TM52 C3 Upper Limit Temperature (Max 4)**	**TM52 Pass/Fail**
L03-B2 KDL	10.6	58	6	**Fail**
L03-A2 KDL	14.5	63	6	**Fail**
L06-B1 KDL	13.3	62	6	**Fail**
L00-25 Amenity	5.6	27	5	**Fail**

Corridor results

A sample of two communal corridors was selected for assessment against DSY1 2020. Based on a maximum of 5 W/m of heat gain from LTHW and DHW pipework and 5.2 W/m2 lighting, the assessment shows that the sampled corridors exceed an operative temperature of 28°C by 20% and 34% of annual hours respectively. TM59 recommends a maximum exceedance of only 3%, although this is not a requirement. As such, this is a risk that will be monitored throughout further design stages, with opportunities explored to reduce corridor heat gains or improve ventilation rates to the corridor areas.

Location	TM 52 - Operative temperature Hours in range > 28.00°C	% of annual hours
L00-24 Corridor	1,792	20%
L03-B1 Corridor	2,962	34%