Passive Design Analysis for Grimshaw Lane, Manchester, M40 2AX

Development Design Analysis

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-	11.12.20	Passive Design Analysis	SWH	AB
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Please note that this report is intended for the Client only and has been produced at Stage 2 for the purposes of evidencing BREEAM credits. This report does not constitute detailed design and has not considered all factors that might be involved with implementing any of the strategies mentioned. Any cost implications over implementing any of the described strategies are a risk for the contractor to bear alone. The contractor should make an allowance in his tender to cover any changes that might be required to obtain any energy performance rating required by the client. Thermal modelling, SBEM and the National Calculation Method are for benchmarking purposes only. The simplifications involved in these methodologies are known to have unavoidable inaccuracies involved within the procedures and any carbon emissions result may not be indicative of real-world performance in use figures.

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1. Introduction

This report has been commissioned by Hive Consultants to undertake a thermal modelling and passive design analysis for the new built warehouse at Grimshaw Lane, Manchester. The modelling is required to discharge the credits for a 2018 BREEAM New Construction assessment. Targeting, designing and constructing the building in the way described in this report is likely to improve the thermal comfort of the occupants and in conditioning the building passively, also reduce its carbon emissions.

The BREEAM credits targeted are Hea 04 Thermal Comfort – Thermal Modelling and Ene 01Low Carbon Design – Passive Design Analysis. The requirements of the credits are as follows:-

1.1. Hea 04 Thermal comfort

Aim

To ensure that appropriate thermal comfort levels are achieved through design, and controls are selected to maintain a thermally comfortable environment for occupants within the building.

Assessment criteria

The following is required to demonstrate compliance: One credit - Thermal modelling

1. Thermal modelling has been carried out using software in accordance with CIBSE AM11[1] Building Energy and Environmental Modelling.

2. The software used to carry out the simulation at the detailed design stage provides full dynamic thermal analysis. For smaller and more basic building designs with less complex heating or cooling systems, an alternative less complex means of analysis may be appropriate (such methodologies must still be in accordance with CIBSE AM11).

3. The modelling demonstrates that:

a. For air-conditioned buildings, summer and winter operative temperature ranges in occupied spaces are in accordance with the criteria set out in CIBSE Guide A Environmental design[2], Table 1.5; or other appropriate industry standard (where this sets a higher or more appropriate requirement/level for the building type).

b. For naturally ventilated/free running buildings:

i. Winter operative temperature ranges in occupied spaces are in accordance with the criteria set out in CIBSE Guide A Environmental design, Table 1.5; or other appropriate industry standard (where this sets a higher or more appropriate requirement/level for the building type).

ii. The building is designed to limit the risk of overheating, in accordance with the adaptive comfort methodology outlined in CIBSE TM52: The limits of thermal comfort: avoiding overheating in European buildings[3].

4. For air-conditioned buildings, the PMV (predicted mean vote) and PPD (predicted percentage of dissatisfied) indices based on the above modelling are reported via the BREEAM assessment scoring and reporting tool.

1.2. Ene 04 Low carbon design

Aim

To encourage the adoption of design measures, which reduce building energy consumption and associated carbon emissions and minimise reliance on active building services systems.

Assessment criteria

This issue is split into two parts:

- Passive design (2 credits)
- Low or zero carbon technologies (1 credit).

The following is required to demonstrate compliance:

Passive design

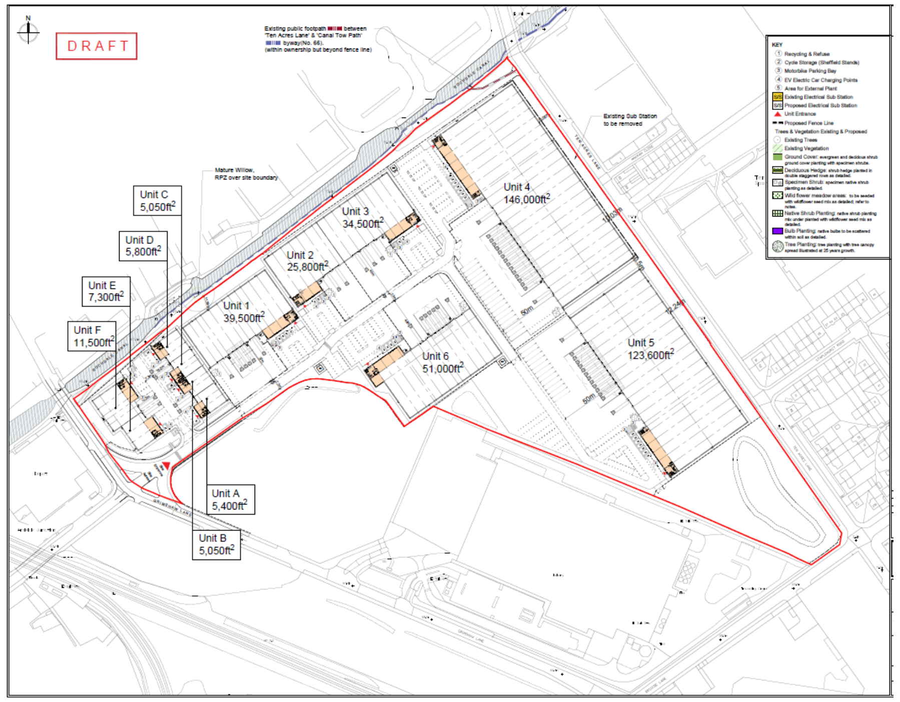
One credit - Passive design analysis

1. The first credit within issue Hea 04 Thermal comfort has been achieved to demonstrate the building design can deliver appropriate thermal comfort levels in occupied spaces.
2. The project team carries out an analysis of the proposed building design/development to influence decisions made during Concept Design stage (RIBA Stage 2 or equivalent) and identify opportunities for the implementation of passive design solutions that reduce demands for energy consuming building services (see compliance note CN2).
3. The building uses passive design measures to reduce the total heating, cooling, mechanical ventilation and lighting loads and energy consumption in line with the findings of the passive design analysis and the analysis demonstrates a meaningful reduction in the total energy demand as a result (see compliance note CN3.12).

2. The Development

This development consists of a new build development of warehouse spaces on Grimshaw Lane, Manchester

The site is located in a commercial urban environment, close to existing transport infrastructure. The existing site as can be seen from the location plan.



The existing site as can be seen from the air. There is little scope to change the orientation of the buildings as these have been placed to maximise the lettable floor area in what is quite a tight site for long goods vehicles. The canal forms a natural axis for the site along which the buildings align

3. BREEAM Ene04 Thermal Comfort Modelling

This section reports the thermal modelling that was undertaken to comply with the BREEAM criteria for Hea04.

A thermal comfort assessment of the site a Grimshaw Lane is required. The Project is located near Manchester

The purpose of this report is to establish a strategy for maintaining thermal comfort throughout the facility. This is done considering the Project's anticipated usage, architecture, and HVAC servicing strategy.

Tools and Methods

A dynamic simulation model (DSM) as described in CIBSE AM11 has been used.

- Network airflow was modelled.
- Near field shading and overhangs has not been modelled.
- Shading devices have been modelled.
- HVAC was modelled with basic 'Apache systems. Software used: IES Virtual Environment 2019

The assessment was undertaken by a Low Carbon Energy Assessor

3.1. Compliance with Credit Criteria

Hea 04 Thermal comfort

Aim

To ensure that appropriate thermal comfort levels are achieved through design, and controls are selected to maintain a thermally comfortable environment for occupants within the building.

Assessment criteria

The following to demonstrate compliance:

1. Thermal modelling has been carried out using software in accordance with CIBSE AM11[1] Building Energy and Environmental Modelling.
2. IESVE is capable of full Dynamic Simulation Analysis meaning

- Hourly weather data with time step control
- Building (and PV etc) orientation and inclination modelled at 1-degree increments
- Ability to model geometry for better results
- More control over modelling of thermal bridging
- Inclusion of internal openings
- Improved modelling of glazing, daylight and solar shading, and also reflection
- Inter-zone heat transfer and better modelling of thermal mass

3. The HVAC strategy for the building is currently still to be designed therefore modelling shall show how the building would perform in free- running mode natural ventilation mode and how thermal comfort would be achieved if air conditioned. Spaces which modelling will be performed on are the office spaces. Even at the lower end of the office real estate market there is a general expectation that new build offices are air conditioned. This makes sense when other regulator factors are moving building heating away from technologies like on –site gas boilers to air source heat pumps.

3.2. Design Inputs – Weather Data

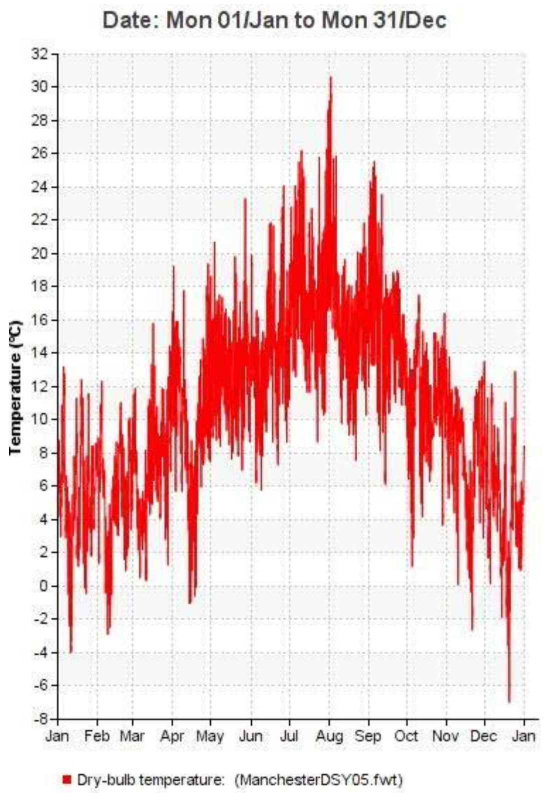
Weather data

ManchesterDSY05.fwt is used as per CIBSE Guide A recommendation. The TRY has been used for the winter simulations

Statistics

- Minimum temperature -7°C
- Maximum temperature 30.6°C

The following figure charts the distribution of external temperature occurrences throughout the year.



3.3. Design Inputs - Geometry

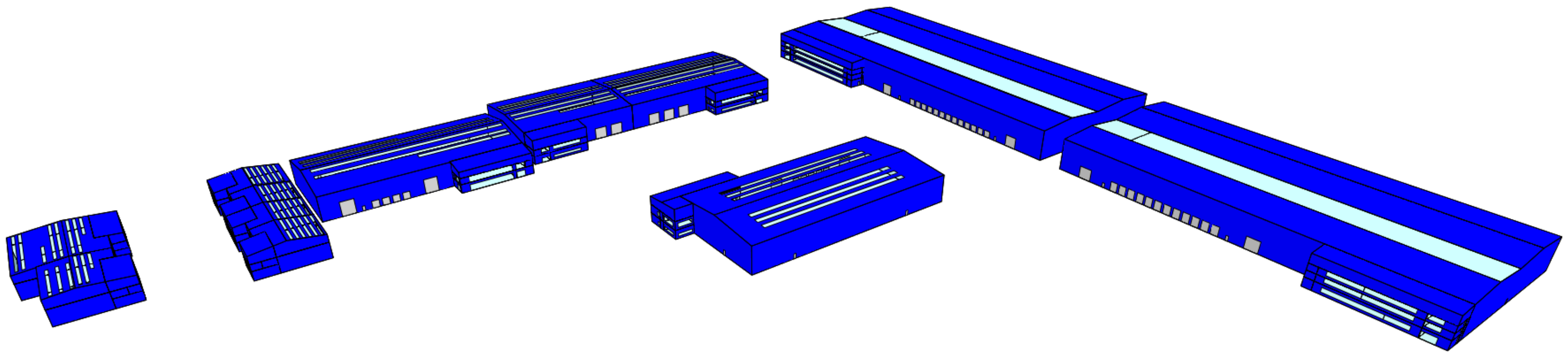
Geometry

The building orientation and form have been taken from .dwg and .pdf drawings provided by Hale Architecture.

The structure is steel frames with insulated wall and roof panels in the style of a Kingspan trapezoidal type.

The floor is a ground bearing slab. Intermediate floors in the office areas are currently shown as concrete with a large ceiling void. The tops of the office areas, below the warehouse space roof appear to be separated from the larger volume by just a lay in grid tiled ceiling.

The building is moderately glazed; enough to have views and daylight but not enough to have excessive solar gain.



3.4. Design Inputs – Construction

Envelope and constructions

For the purposes of this report the Kingspan trapezoidal wall panels will be taken as having a thermal performance in line with the notional building of Part L however in the actual building there are likely to perform much better thermally.

The strategy depends on spectrally selective solar control glazing. A g-value of 0.4 has been used. In comparison to reflective or absorptive solar control, spectrally selective glazing retains a relatively neutral appearance (it's usually slightly tinted) whilst simultaneously filtering out solar gain and allowing daylight in.

U-values used in the thermal comfort model shown in green below.

Element	$U_{a\text{-}Limit}$	$U_{a\text{-}Calc}$
Wall**	0.35	0.26
Floor	0.25	0.14
Roof	0.25	0.18
Windows***, roof windows, and rooflights	2.2	1.6
Personnel doors	2.2	2.2
Vehicle access & similar large doors	1.5	1.5
High usage entrance doors	3.5	-

3.5. Design Inputs – Services

Servicing strategy Key features:

The occupied hours are Monday to Friday 8:00-18:00.

The heating set point has been modelled at 22°C year-round for the mechanically cooled simulation.

Cooling is assigned to the office spaces for the CIBSE Guide A calculations. Cooling density to meet them temperatures in Guide A were approximately 60-70w/m2

Auxiliary ventilation was set to run at night to provide about 1ACH of night cooling

Internal gains

Lighting

Lighting has been modelled at 15W/m2

Lighting is modelled for a typical 8:00-18:00 week

A simple schedule representation of daylight dimming control has been applied to the lighting shown below

Occupancy and small power are modelled as 72W sensible and 50W latent gain

Occupant profile is also a typical 8:00-18:00 week

Occupancy density is set at 10m2/person in all occupied zones

Small power gain is modelled as:

12W/m2 in the workstations,

No small power gains in circulation, toilets, and the rest of the spaces,

Small power profile is also on a typical 8:00-18:00 week.

Window and Door Openings

Office window

Modelled as approximately 1/20 of floor area opening 30 degrees

Unit 1-4 windows were modelled as approximately 1/10 floor area opening.

Formula used was gt(ta,20,0) .

This means the window will start to open at 19°C and will be fully open at 21°C

An iteration was run with night cooling windows left open. This was modelled as 20% of the daytime opening windows. Windows would have to be left open in a secure manner to deter vandalism and theft.

3.6. Comfort Criteria

CIBSE TM 52:2013 – The limits of thermal comfort is the new primary reference for establishing thermal comfort – especially in 'free running' buildings (i.e. those that do not depend on a cooling system). For the sake of familiarity and simplicity other recognised guidelines are also presented later in the results.

The comfort assessments considered in this report are:

1.CIBSE TM 52

2.CIBSE Guide A

Operative temperature

The temperature that you 'feel'…

- Most thermal comfort criteria use operative temperature rather than air temperature.
- Operative temperature can be thought of as the 'average' between a zone's air temperature and its mean radiant temperature.
- Mean radiant temperature is related to the temperature of surrounding surfaces. It is often dominated by the surface temperature of larger elements such as floors, soffits, ceilings and walls (especially curtain wall).

1. CIBSE TM 52:2013 – The limits of thermal comfort

The most recent standard suitable for the assessment of thermal comfort in 'free running' buildings. It is based on BS EN 15251:2007. It uses multiple indicators to assess overheating risk based on a 'running mean' temperature:

Criteria 1: ΔT should not exceed 1K for more than 3% of occupied hours.

Criteria 2: ΔT maximum daily weighted exceedance (daily degree hours) should not exceed 6-degree hours in any one day.

Criteria 3: ΔT should never exceed 4K

Any single zone that exceeds two or more of these criteria is deemed to have failed the requirements.

Considerations:

The TM52 report assesses occupied periods only. It is important to be aware that TM52 should be conducted for occupied and/or "available hours".

Use of educational NCM profiles may be seen as inappropriate due to prolonged unoccupied periods during summer months.

See Section 6.1.2 (a) of TM52 for further information.

Most software vendors have implemented a test function to establish TM 52 compliance. However, significant differences in compliance have been witnessed when attempting to match different software's results for the same test studies.

CIBSE Guide A (2006)

For most space types: exceedance of 25°C for more than 5% of occupied period is classified as 'WARM'.

For most space types: exceedance of 28°C for more than 1% of occupied period is classified as 'HOT'.

For bedrooms: exceedance of 26°C for more than 1% of occupied period is classified as 'HOT'.

Occupied hours will vary from building to building. 1% typically equates to between 30 and 60 hours.

British Council for Offices (BCO)

The BCO takes the CIBSE recommendation further by denoting each of these limits as a requirement.

CIBSE Guide A (2015), table 1.5 (including winter comfort)

CIBSE Guide A (2015), table 1.5 gives general guidance and recommendations, based on professional experience and judgement, on suitable winter and summer temperatures (together with outdoor air supply rates, filtration grades, maintained illuminances and suggested maximum noise ratings) for a range of room and building types.

5. PMV & PPD

The PMV/PPD model was developed by P. O. Fanger using heat balance equations and empirical studies about skin temperature to define comfort. Fanger's equations are used to calculate the PMV of a large group of subjects for a particular combination of air temperature, mean radiant temperature, relative humidity, air speed, metabolic rate and clothing insulation vote (on a scale from-3/cold to

+3/hot). On the other hand, the PPD index is used to estimate the part of the population that will feel dissatisfied with the conditions of the internal environment of a space. Those that have voted outside the -1 and +1 range (i.e. those that have voted -3,-2 +2 or +3) have been counted as dissatisfied.

3.7. Results

TM52

Overall	
Passed:	15 rooms:
Failed:	0 rooms:
Unoccupied:	0 rooms:

Data:			
Building category:	Category II (new builds.)		
Weather file:	ManchesterDSY05.fwt		
Days data=	365	01-Jan	31-Dec
Days (summer)=	153	01-May	30-Sep
Data OK?	OK	Full summer	

Passed:	15 rooms:						
Room Name	Room ID	Occupied	Criteria 1	Criteria 2	Criteria 3	Criteria fa	Pass Fail
Warehouse 2 Upper office	WR00002	100	2	20	3	2	✓
Warehouse 3 Upper office	WR00003	100	1.4	16	3	2	✓
Warehouse 4 mid office	WR00003	100	1.6	14	3	2	✓
Warehouse 4 top office	WR00004	100	2.2	18	4	2	✓
Warehouse 5 top office	WR00005	100	2.2	18	4	2	✓
Warehouse 5 mid office	WR00005	100	1.6	14	3	2	✓
Warehouse 1 office	WR00006	100	1.3	16	3	2	✓
Warehouse D office	WR00007	100	2	16	3	2	✓
Warehouse C office	WR00007	100	1.9	16	3	2	✓
Warehouse B office	WR00007	100	2	16	3	2	✓
Warehouse A office	WR00008	100	2	16	3	2	✓
Warehouse E office	WR00008	100	1.1	14	3	2	✓
Warehouse F office	WR00008	100	1.1	14	3	2	✓
Unit 6 Warehouse office	NT000000	100	1	10	2	2	✓
Unit 6 Warehouse Office	NT00000B	100	1.2	16	3	2	✓

CIBSE Guide A (2006)

Winter operative temperature range 21-23°C

		Operative	Operative	Operative	Operative	Operative temperature (TM 52/CIBSE) (°C) - % hours in range			
File	Location	> 21.00	> 21.50	> 22.00	> 22.50	> 23.00		Capacity (kW) (Real)	Capacity (W/m²) (Real)
Thermal n	Warehouse 2 Upper office	100	100	100	100	63.4		14.2	48.3
Thermal n	Warehouse 3 Upper office	100	100	100	100	65		10.69	59.36
Thermal n	Warehouse 4 mid office	100	100	100	100	68.7		13.68	61.07
Thermal n	Warehouse 4 top office	100	100	100	100	98.9		21.53	52.42
Thermal n	Warehouse 5 top office	100	100	100	100	99.2		19.99	48.67
Thermal n	Warehouse 5 mid office	100	100	100	100	70.8		15.32	52.11
Thermal n	Warehouse 1 office	100	100	100	98.2	59.6		14.7	64.99
Thermal n	Warehouse D office	100	100	100	100	56.5		6.03	63.26
Thermal n	Warehouse C office	100	100	100	100	56.1		4.74	63.15
Thermal n	Warehouse B office	100	100	100	100	56.3		4.74	63.15
Thermal n	Warehouse A office	100	100	100	99.9	55.8		5.38	63.58
Thermal n	Warehouse E office	100	100	100	100	50.7		7.79	62.5
Thermal n	Warehouse F office	100	100	100	99.9	50.2		9.18	63.22
Thermal n	Unit 6 Warehouse office	100	100	100	99.5	53.9		5.22	72.2
Thermal n	Unit 6 Warehouse Office	100	100	100	100	54		16.3	62.45
Thermal n	Total hours (% of sum)	41.7	41.7	41.7	41.6	26.6			

CIBSE Guide A (2006)

Summertime operative temperature range 22-25°C

		Operative	Operative	Operative	Operative	Operative	Operative	Operative temperature (TM 52/CIBSE) (°C) - % h		
File	Location	> 22.00	> 22.50	> 23.00	> 23.50	> 24.00	> 24.50	> 25.00	Fixed Cooling Capacity (kW)	Fixed Cooling Capacity (W/m²)
Thermal n	Warehouse 2 Upper office	100	100	66.8	51.4	44.2	7.7	0.1	18.49	62.9
Thermal n	Warehouse 3 Upper office	100	100	68	53	45.8	9.7	0.2	13.45	74.65
Thermal n	Warehouse 4 mid office	100	100	72.1	46.3	39.4	2.8	0	17.25	77.02
Thermal n	Warehouse 4 top office	100	100	98.7	60.2	52.2	5.5	0	28.59	69.62
Thermal n	Warehouse 5 top office	100	100	99.1	60	52.1	4.3	0	26.41	64.32
Thermal n	Warehouse 5 mid office	100	100	74.2	46.2	39.3	2.3	0	20.12	68.42
Thermal n	Warehouse 1 office	100	98	63.4	53.2	47.2	16.1	2.7	20.93	92.54
Thermal n	Warehouse D office	100	99.9	59.8	47.5	41.6	9.9	0.8	9.15	95.97
Thermal n	Warehouse C office	100	99.9	59.4	47.1	41.1	9.2	0.7	7.33	97.57
Thermal n	Warehouse B office	100	99.9	59.5	47.2	41.2	9.4	0.8	7.33	97.52
Thermal n	Warehouse A office	100	99.9	59.4	46.9	40.9	9.4	0.8	8.19	96.87
Thermal n	Warehouse E office	100	99.9	54.8	44.8	40.1	4.1	0.1	8.26	66.31
Thermal n	Warehouse F office	100	99.9	53.8	44.5	40.1	4.6	0.1	9.79	67.42
Thermal n	Unit 6 Warehouse office	100	99.3	57.8	44.4	37.5	7.6	0	6.4	88.57
Thermal n	Unit 6 Warehouse Office	100	100	58.8	43.3	36.5	0.6	0	15.59	59.74
Thermal n	Total hours (% of sum)	41.7	41.6	27.9	20.4	17.8	2.9	0.2		

PPD values for the summertime simulation have for at least 99% of the time the percentage of people dissatisfied is 20% or less

PPD values for the wintertime simulation show that for 99% of occupied hours the PPD is 25% or less

PMV values for both summertime and wintertime simulations 99% of the time OMV is not less than - 1

Discussion

A satisfied population falls between -1 to 1 on the PMV scale which has been achieved

A PPD below 25% is the equivalent of a PMV score between -1 and 1. between 20-25% has been achieved

All office spaces pass TM52 when modelled in free running mode, without air conditioning however some tweaks have been made to the design as was provided by the architect.

To achieve a pass in Units A-D and 4-5 a larger amount of opening area was provided in the model than shown on the elevations. Spaces were run with a night cooling strategy. Additionally, the lay in grid ceiling that separates the office from the warehouse volume was modelled with insulation as though it were an external wall. This helps keep heat out of the office in summer and keeps heat in in winter. Office 4-5 top floor struggled to pass TM52 this could be because they are west facing. A means of user-controlled shade or blinds should be provided.

Heating and cooling systems should be installed and set up to work at the temperatures modelled from CIBSE Guide A

4. BREEAM Ene04 Low Carbon Design – Passive Design

This section reports the thermal modelling that was undertaken to comply with the BREEAM criteria for Ene04a.

4.1. Compliance with credit criteria

Ene04 Low Carbon Design

Aim

To encourage the adoption of design measures, which reduce building energy consumption and associated carbon emissions and minimise reliance on active building services systems.

Assessment criteria

This issue is split into two parts:

•Passive design (2 credits)

•The following is required to demonstrate compliance:

Passive design

One credit - Passive design analysis

- The first credit within issue Hea 04 Thermal comfort has been achieved to demonstrate the building design can deliver appropriate thermal comfort levels in occupied spaces. Please see the previous section for details of this credit.
- The project team carries out an analysis of the proposed building design/development to influence decisions made during Concept Design stage (RIBA Stage 2 or equivalent) and identify opportunities for the implementation of passive design solutions that reduce demands for energy consuming building services (see compliance note CaN2).
- The building uses passive design measures to reduce the total heating, cooling, mechanical ventilation and lighting loads and energy consumption in line with the findings of the passive design analysis and the analysis demonstrates a meaningful reduction in the total energy demand as a result (see compliance note CN3.12). This is to be confirmed post construction.

4.2. Area of Passive Design to be Assessed

As a minimum, the passive design analysis should cover:

1.Site location

2.Site weather

3.Microclimate

4.Building layout

5.Building orientation

6.Building form

7.Building fabric

8.Thermal mass or other fabric thermal storage

9.Building occupancy type

10.Daylighting strategy

11.Ventilation strategy

12.Adaptation to climate change

The report shall now detail by each point how these passive design elements can be incorporated into the design and there how they can be modelled.

4.3. Interrogation of Passive Design

- Site location

The site location has already been selected and therefore this is fixed. The model shall use weather location of Manchester.

- Site weather

Given that the site location is fixed then it is deemed appropriate that the weather file that will be used for the dynamic model shall be selected in compliance with the SBEM location spreadsheet. Both Design Summer and Test Reference Years have been used for Manchester have been used which is the closest SBEM location and these weather files are deemed appropriate to reflect the weather on this particular site.

- Microclimate
  - Potentially the site is affected by the urban heat island effect from urban Manchester's city centre. The site is generally located in an industrial area, however there are many fields and parks in the environs which will help mitigate the effects of the urban heat island. For the purposes of the simulation the site is modelled as a suburban site.
  - The site has a good view of the sky and is not unduly overshadowed by surrounding development, there should be no impediment to good daylighting of the top lit spaces from the surroundings.
  - It is presumed that the site is influenced by the prevailing winds generally and there are no natural or manmade obstructions that would for the wind in any other direction.
  - There is likely to be a reasonable amount of dust and pollution given the industrial neighbours though this should be somewhat offset by the surrounding green areas.

The sites acoustic environment is unknown though likely to be influenced by the neighbouring sites and adjacent roads.

- Building layout

The layout of the building has been selected by the architect and so will be modelled as is shown on the architect's general arrangement, however given the nature of warehouse type buildings, and especially those that need HGV access bays, and the nature of the site, the buildings' layouts are fixed save for minor alterations such as moving lift cores as appears to have happened between the revisions of drawings that have been received

- Building orientation

The buildings' orientations are somewhat governed by the access road and the boundaries of the site, one being a canal, and so for the purposes of this modelling exercise shall be taken as being fixed.

- Building form

The building form is somewhat governed by the type of use that dominates the scheme. Warehouse spaces inevitably need to be taken to accept storage racking which leads to their boxy shape. This shape lends itself to being efficient in terms of heat losses as there is a low amount of surface area of fabric to floor area. This shape does not however lend itself to being daylight from the side or from being naturally ventilated. The natural position for the administrative areas of the warehouses to be near the fronts of the building from where the goods vehicles gain access to the warehouses.

- Building fabric

In line with the BREEAM requirements a standard building fabric specification shall be modelled to produce a baseline and then an improve fabric specification will be modelled to see whether any carbon emission gains can be made through improvements in this area.

- Thermal mass or other fabric thermal storage

The lightweight fabric of a warehouse lends little thermal mass to the scheme, however the significant volume of air captured within the warehouse does have thermal inertia when compared with the low infiltration rate that is present in newly constructed warehouses. The proposed ground bearing slab will have thermal mass.

The office spaces as they currently stand are constructed of concrete floors encapsulated from the conditioned areas by a ceiling void which effectively removes the ability of the thermal mass to effectively store and release coolth in a diurnal way. The current scheme shall form the baseline model and then an improved thermal mass model shall be run to see the effect on reduction in heating and/or cooling. The ceiling shall be modelled as with the ceiling tiles removed to produce this effect.

- Building occupancy type

The building occupancy type is assumed to be in line with a typical warehouse. The office will have regular internal gains between 8am to 6 pm in line with the internal gains in the National Calculation Method

- Daylighting strategy

The package of information does not include detail whether rooflights have been included within the scheme for the main warehouse areas. Rooflights shall be modelled with an area above that detailed in the NCM modelling guide which is 12% of surface area of roof for a top-lit space. Daylighting will then be used to dim the electric lighting in the warehouse and hall so that the electric light does not take the daylight surfaces of the design lux levels. At design lux electric light will be dimmed to 20% of the installed power output

- Ventilation strategy

The building will be modelled with MVHR in the office areas for comparison with a naturally ventilated scheme so that the effect auxiliary energy and reduction in heating load can be seen.

- Adaptation to climate change

There is no specific option in SBEM to measure the performance of a building against a climate change weather file as the weather used is standardised to produce a consistent baseline for compliance purposes. That said a building which has managed to reduce its cooling load as demonstrated on a BRUKL is going to be better adapted to climate change than one that has not. The building form, fabric, thermal mass and ventilation strategy all play their part in adaption to climate change and so this section will be demonstrated by looking at those other results.

4.4. Carbon Savings

	Change in CO2 emissions from notional building to designed building kgCO2 per annum
Site Location	-
Site Weather	-
microclimate	-
Building layout	-
Building orientation	-
Building form (blinds)	690
Building Fabric Walls Roof	57584
Building fabric Floor	17718
Thermal mass	53155
Building Occupancy	-
Daylighting Strategy	-
Ventilation Strategy	602420

1. Site location

No change between notional and designed.

2. Site weather

No change between notional and designed.

3. Microclimate

No change between notional and designed.

4. Building layout

No change between notional and designed.

5. Building orientation

No change between notional and designed.

6. Building form

No change between notional and designed.

7.Building fabric

Changes to the building fabric from the notional building fabric standard to an improved designed standard gave a large decrease in carbon performance. Changing the wall and roof u-value gave an improvement of around 57 tonnes and the floor around 53 tonnes. The u-values which were chosen for the improved building were calculated by measuring the thickness of the insulation shown in the detailed drawings of the walls and roof that accompanied the planning information. It would be possible to go further on improving the fabric by improving the glazing specification, which was left as notional. Improvements to the air tightness from 10 to 2 could save 17 tonnes of CO2.

8. Thermal mass or other fabric thermal storage

Somewhat surprisingly changes to the thermal mass gave a slightly worse carbon performance. It was also seen during the thermal comfort modelling that changes to the thermal mass in the office areas had little effect on stabilizing temperatures and reducing overheating. In this type of building and with this climatic data what seems to be the most important consideration is ventilation rate. No effort should be paid to improving mass in the actual design of the offices and there is naturally thermal mass I the warehouse with the proposed concrete floor and the volume of air contained.

9. Building occupancy type

No change between notional and designed.

10. Daylighting strategy

Blinds did have a small effect of cooling energy consumption. What would probably have a bigger effect would be external shading though this has not been modelled. Blinds should be included in the designed building so that occupants can modify the solar gains getting into the occupied space and to help prevent glare.

Use of natural light should be made to reduce the amount of electric lighting. Rooflights were modelled in the warehouse spaces at approximately 25%, roof area, over and above the 12% of is used in the notional building. Lighting controls were then modelled that dimmed the lighting power down to 20% of the maximum installed when the room lux level was satisfied by natural light only.

This passive design strategy saved an enormous amount of carbon. The lighting power usage was half the notional building, and this gave an improvement in carbon over the whole site of 600 tonnes per annum, larger than allof the other improvements combined.

Lighting tends to be the dominant end use of electricity in warehouse spaces and so smart controls with daylight dimming and constant illuminance should be used in the actual design. It should be noted however that a reduction in lighting power did lead to an increase in heating energy consumption though for most of the year this waste heat does not contribute to the heating load.

Note that the lighting savings also include the change from the NCM default luminaire to a good luminaire which has been used to demonstrate the effect of improved daylighting without the change in internal gains which the default lighting causes to the space heating.

11. Ventilation strategy

There was a small increase in carbon with the introduction of MVHR due to its specific fan power though having auxiliary ventilation does allow you more control over ventilation and permits the air tightness to be lowered which was not explored.

Whether MVHR is included should be investigated at the next stage of design, - if cooling is proposed it can work well with MVHR or in a mixed mode strategy.

12. Adaptation to climate change

There is no specific option in SBEM to measure the performance of a building against a climate change weather file as the weather used is standardised to produce a consistent baseline for compliance purposes. That said a building which has managed to reduce its cooling load as demonstrated on a BRUKL is going to be better adapted to climate change than one that has not. The building form, fabric, thermal mass and ventilation strategy all play their part in adaption to climate change and so this section will be demonstrated by looking at those other results.

4.5. Results

Passive design measures have been shown to produce a 6% reduction in carbon emissions when compared to a notional building model. This decrease is by no means the least as further passive reductions could be made.

4.6. BRUKL Documents

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

Project name

Grimshaw Lane Industrial Estate Rev 2 MVHR — As designed

Date: Mon Feb 08 23:48:49 2021

Administrative information

Building Details

Address: Floor Wall Roof Air Tightness 2 Daylighting Blind Srvs MVHR, City, Postcode

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.13

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.13

BRUKL compliance check version: v5.6.b.0

Certifier details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

Criterion 1: The calculated CO_2 emission rate for the building must not exceed the target

CO_2 emission rate from the notional building, $kgCO_2/m^2$.annum	14.9
Target CO_2 emission rate (TER), $kgCO_2/m^2$.annum	14.9
Building CO_2 emission rate (BER), $kgCO_2/m^2$.annum	14.3
Are emissions from the building less than or equal to the target?	BER =< TER
Are as built details the same as used in the BER calculations?	Separate submission

Criterion 2: The performance of the building fabric and fixed building services should achieve reasonable overall standards of energy efficiency

Values which do not achieve the standards in the Non-Domestic Building Services Compliance Guide and Part L are displayed in red.

Building fabric

Element	$U_{a-Limit}$	U_{a-Calc}	U_{i-Calc}	Surface where the maximum value occurs*
Wall**	0.35	0.15	0.17	WR000003:Surf[5]
Floor	0.25	0.15	0.22	WR000000:Surf[0]
Roof	0.25	0.11	0.11	BH000005:Surf[3]
Windows***, roof windows, and rooflights	2.2	1.96	2	NT00000C:Surf[10]
Personnel doors	2.2	2.2	2.2	WR00002A:Surf[3]
Vehicle access & similar large doors	1.5	-	-	No Vehicle access doors in building
High usage entrance doors	3.5	-	-	No High usage entrance doors in building

$U_{a-Limit}$ = Limiting area-weighted average U-values [W/(m²K)]
U_{a-Calc} = Calculated area-weighted average U-values [W/(m²K)]
U_{i-Calc} = Calculated maximum individual element U-values [W/(m²K)]

* There might be more than one surface where the maximum U-value occurs.
** Automatic U-value check by the tool does not apply to curtain walls whose limiting standard is similar to that for windows.
*** Display windows and similar glazing are excluded from the U-value check.
N.B.: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

Air Permeability	Worst acceptable standard	This building
$m^3/(h.m^2)$ at 50 Pa	10	2

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BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

Project name

Grimshaw Lane Industrial Estate Rev 2.2 Without Passive Measures — As designed

Date: Tue Feb 09 00:24:09 2021

Administrative information

Building Details

Address: Srvs No Skylights, City, Postcode

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.13

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.13

BRUKL compliance check version: v5.6.b.0

Certifier details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

Criterion 1: The calculated CO_2 emission rate for the building must not exceed the target

The building does not comply with England Building Regulations Part L 2013

CO_2 emission rate from the notional building, $kgCO_2/m^2$.annum	16.1
Target CO_2 emission rate (TER), $kgCO_2/m^2$.annum	16.1
Building CO_2 emission rate (BER), $kgCO_2/m^2$.annum	25.3
Are emissions from the building less than or equal to the target?	BER > TER
Are as built details the same as used in the BER calculations?	Separate submission

Criterion 2: The performance of the building fabric and fixed building services should achieve reasonable overall standards of energy efficiency

Values which do not achieve the standards in the Non-Domestic Building Services Compliance Guide and Part L are displayed in red.

Building fabric

Element	$U_{a-Limit}$	U_{a-Calc}	U_{i-Calc}	Surface where the maximum value occurs*
Wall**	0.35	0.26	0.26	WR000003:Surf[5]
Floor	0.25	0.22	0.22	WR000000:Surf[0]
Roof	0.25	0.18	0.18	BH000005:Surf[3]
Windows***, roof windows, and rooflights	2.2	1.6	1.6	WR000003:Surf[1]
Personnel doors	2.2	2.2	2.2	WR00002A:Surf[3]
Vehicle access & similar large doors	1.5	-	-	No Vehicle access doors in building
High usage entrance doors	3.5	-	-	No High usage entrance doors in building

$U_{a-Limit}$ = Limiting area-weighted average U-values [W/(m²K)]
U_{a-Calc} = Calculated area-weighted average U-values [W/(m²K)]
U_{i-Calc} = Calculated maximum individual element U-values [W/(m²K)]

* There might be more than one surface where the maximum U-value occurs.
** Automatic U-value check by the tool does not apply to curtain walls whose limiting standard is similar to that for windows.
*** Display windows and similar glazing are excluded from the U-value check.
N.B.: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

Air Permeability	Worst acceptable standard	This building
$m^3/(h.m^2)$ at 50 Pa	10	10

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Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Area [m^2]	47268.1	47268.1
External area [m^2]	109747	109747
Weather	MAN	MAN
Infiltration [m^3/hm^2@ 50Pa]	2	3
Average conductance [W/K]	38989.3	32795.6
Average U-value [W/m^2K]	0.36	0.3
Alpha value* [%]	10	10

* Percentage of the building's average heat transfer coefficient which is due to thermal bridging

Building Use

% Area	Building Type
	A1/A2 Retail/Financial and Professional services
	A3/A4/A5 Restaurants and Cafes/Drinking Est./Takeaways
6	**B1 Offices and Workshop businesses**
	B2 to B7 General Industrial and Special Industrial Groups
94	**B8 Storage or Distribution**
	C1 Hotels
	C2 Residential Institutions: Hospitals and Care Homes
	C2 Residential Institutions: Residential schools
	C2 Residential Institutions: Universities and colleges
	C2A Secure Residential Institutions
	Residential spaces
	D1 Non-residential Institutions: Community/Day Centre
	D1 Non-residential Institutions: Libraries, Museums, and Galleries
	D1 Non-residential Institutions: Education
	D1 Non-residential Institutions: Primary Health Care Building
	D1 Non-residential Institutions: Crown and County Courts
	D2 General Assembly and Leisure, Night Clubs, and Theatres
	Others: Passenger terminals
	Others: Emergency services
	Others: Miscellaneous 24hr activities
	Others: Car Parks 24 hrs
	Others: Stand alone utility block

Energy Consumption by End Use [kWh/m^2]

	Actual	Notional
Heating	24.14	17.95
Cooling	0.79	1.21
Auxiliary	0.4	0.14
Lighting	11.96	17.59
Hot water	4.04	4.22
Equipment*	42.77	42.77
TOTAL**	**41.33**	**41.11**

* Energy used by equipment does not count towards the total for consumption or calculating emissions.
** Total is net of any electrical energy displaced by CHP generators, if applicable.

Energy Production by Technology [kWh/m^2]

	Actual	Notional
Photovoltaic systems	0	0
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m^2]	78.07	73.85
Primary energy* [kWh/m^2]	82.96	83.71
Total emissions [kg/m^2]	14.3	14.9

* Primary energy is net of any electrical energy displaced by CHP generators, if applicable.

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Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Area [m^2]	47268.1	47268.1
External area [m^2]	109747	109747
Weather	MAN	MAN
Infiltration [m^3/hm^2@ 50Pa]	10	3
Average conductance [W/K]	26838.7	35513.8
Average U-value [W/m^{2}K]	0.24	0.32
Alpha value* [%]	10	10

* Percentage of the building's average heat transfer coefficient which is due to thermal bridging

Building Use

% Area	Building Type
	A1/A2 Retail/Financial and Professional services
	A3/A4/A5 Restaurants and Cafes/Drinking Est./Takeaways
6	**B1 Offices and Workshop businesses**
	B2 to B7 General Industrial and Special Industrial Groups
94	**B8 Storage or Distribution**
	C1 Hotels
	C2 Residential Institutions: Hospitals and Care Homes
	C2 Residential Institutions: Residential schools
	C2 Residential Institutions: Universities and colleges
	C2A Secure Residential Institutions
	Residential spaces
	D1 Non-residential Institutions: Community/Day Centre
	D1 Non-residential Institutions: Libraries, Museums, and Galleries
	D1 Non-residential Institutions: Education
	D1 Non-residential Institutions: Primary Health Care Building
	D1 Non-residential Institutions: Crown and County Courts
	D2 General Assembly and Leisure, Night Clubs, and Theatres
	Others: Passenger terminals
	Others: Emergency services
	Others: Miscellaneous 24hr activities
	Others: Car Parks 24 hrs
	Others: Stand alone utility block

Energy Consumption by End Use [kWh/m^2]

	Actual	Notional
Heating	22.76	23.81
Cooling	0.5	1.03
Auxiliary	0.01	0.01
Lighting	34.23	17.59
Hot water	4.04	4.22
Equipment*	42.77	42.77
TOTAL**	**61.54**	**46.66**

* Energy used by equipment does not count towards the total for consumption or calculating emissions.
** Total is net of any electrical energy displaced by CHP generators, if applicable.

Energy Production by Technology [kWh/m^2]

	Actual	Notional
Photovoltaic systems	0	0
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m^2]	72.06	90.77
Primary energy* [kWh/m^2]	148.3	90.27
Total emissions [kg/m^2]	25.3	16.1

* Primary energy is net of any electrical energy displaced by CHP generators, if applicable.

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